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Abstract Book

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Invited Keynote Presentations

Space science from polar regions

Prof Michael Kosch (IAGA)
Chief Scientist – South African National Space Agency
Extraordinary Professor – University of Western Cape, South Africa
Professor of Experimental Space Science – Lancaster University, UK
Director – EnviroVision Solutions, South Africa

Polar regions provide an excellent opportunity to perform high-quality but relatively low-cost space science from the ground. The focus is on coherent and incoherent scatter radar, as well as multi-wavelength optical, observations of the ionosphere and thermosphere from Antarctica and the Arctic. Novel studies include (1) the phenomenon of black as well as anti-black auroras, which are quite distinct from the normal white auroras, (2) how thermospheric neutral winds are strongly influenced by the auroras, and (3) the wave-plasma interaction resonances associated with artificially-induced auroras.

The Dynamics of Nitrogen and Sulphur cycles and impacts on Southern African ecosystems

Prof Mary Scholes (IAMAS)
Professor and Research Chair in Systems Analysis
University of the Witwatersrand, South Africa

South Africa contributes significantly to atmospheric carbon dioxide concentrations due to the reliance on fossil fuel burning power stations for electricity. Sustainable development in South African involves a number of trade-offs between economic growth and the negative impacts on the environment and human health. Data will be presented on sulphur emissions from power stations and the associated nitrogen and sulphur deposition. Lichen distributions show a sensitivity to deposition, grasses are less sensitive than trees to additional nitrogen and sulphur applications. Water bodies and soils are not yet showing a declining trend in pH. There is a correlation between atmospheric pollution, socio-economic status and human health. A brief overview of the Sea-Earth-Atmosphere Linkages Study in Southern Africa will also be given.

Investing in the blue economy: why now?

Dr Essam Yassin Mohammed (IAPSO)
Senior Economist and Programme Lead, Ocean and Fisheries Economics
International Institute for Environment and Development (IIED), UK

Marine and coastal ecosystems provide us with a range of critical services, from fishery production to flood protection, from recreation and tourism to ecosystem based adaptation and carbon storage. Yet pollution, overfishing, climate change and habitat destruction are rapidly degrading these ecosystems. Greater investment needs to be directed towards conserving, restoring and enhancing these ecosystems. Dr Mohammed will discuss the why and what of investing in marine and coastal ecosystems. He will also present some innovative financing mechanisms including: fiscal allocations (public), decentralized funds, impact investment (private) and public private partnerships.

Oral Presentations

JP1 - Turbulence, Internal Waves, And Mixing On All Scales (IAPSO, IAGA, IAMAS)

Abyssal plain hills and internal wave turbulence

Abstract ID : 76

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Hans van Haren[1]
1 - NIOZ

An 400-m long array with 200 high-resolution NIOZ temperature sensors has been deployed twice above abyssal plains for about 2-3 months each. The sensors sampled at a rate of 1 Hz. Sites were in the north-equatorial 'NEP' and south-equatorial Pacific 'SEP'. The aim is to study internal waves and turbulent bottom boundary layers away from large-scale ocean topography. At both sites, bottom topography consists of small (~< 100 m) hills.
In contrast with observations over large-scale topography, these data show a well-defined near-homogeneous bottom-boundary layer extending 50-150 m above the bottom. This is also visible in shipborne CTD-observations. The CTD observations were necessary to correct the T-sensor data for electronic drift. Data analysis is difficult because of the very small temperature ranges of only a few mK over 400 m, which is well below the adiabatic lapse rate. This also demands noise reduction in the T-sensors, of which about 40% had to be interpolated due to various calibration and electro-technical reasons. Examples are shown from the two sites, demonstrating sudden frontal variations in the bottom boundary layer that turns out to be very non-homogeneous, in time (and thus space). The bottom boundary layer thins occasionally, but internal wave upshoots of 150 m above the bottom also occur. Typical turbulence dissipation rates are 10-10 to 10-9 m2s-3, while eddy diffusivities are O(10-3 m2s-1). The turbulence effects of flow-interaction with small-scale hills and with internal waves are discussed.

Tipping points in Southern Ocean ventilation

Abstract ID : 102

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Dr. Andreas Klocker[1]
1 - Australia ,Hobart

The Southern Ocean with its steeply sloping isopycnals acts as a control valve through which tracers such as heat, salt, nutrients, and CO2 are transferred between the atmosphere and the ocean. The process which transports these climatically important tracers from the surface mixed layer into the ocean interior is known as ocean ventilation, and its dynamics are thought to be important for both the abrupt reorganisation of the ocean's global overturning circulation between glacial and interglacial periods in Earth's past, and the uptake and storage of excess heat and CO2, produced as a consequence of anthropogenic climate change, in Earth's current and future climate. Here I show how the interaction between the main Southern Ocean fronts, which are closely related to jets - narrow regions of strong ocean currents - through geostrophic balance, and topographic features can lead to abrupt changes in mixed layer depth due to small changes in wind forcing. These abrupt changes in mixed layer depth push Southern Ocean ventilation into either an "on" or "off" mode, allowing for a transfer of tracers between the surface mixed layer and the ocean interior or not. These results imply a prominent role for jet dynamics in understanding both past and future climate change.

A regime diagram for ocean geostrophic turbulence

Abstract ID : 103

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Content Motivation : None
Additional Information : None

Dr. Andreas Klocker[1], Mr Shane R. Keating[2], Mr David P. Marshall[3], Mr Peter L. Read[3]
1 - 2 - University of New South Wales 3 - University of Oxford

A two-dimensional regime diagram for geostrophic turbulence in the ocean is constructed by plotting observation-based estimates of the non-dimensional eddy length-scale against a nonlinearity parameter equal to the ratio of the root-mean-square eddy velocity and
baroclinic Rossby phase speed. Two estimates of the eddy length-scale are compared: the equivalent eddy radius inferred from the area enclosed by contours of sea-surface height, and the 'unsuppressed' mixing length, based on an estimate of the eddy diffusivity with
mean flow effects removed. For weak nonlinearity, as found in the Tropics, the mixing length mostly corresponds to the stability threshold for baroclinic instability whereas the eddy radius corresponds to the Rhines scale; it is suggested that this mismatch is indicative of the inverse energy cascade that occurs at low latitudes in the ocean and the zonal elongation of eddies. At larger values of nonlinearity, as found at mid- and high latitudes,
the eddy length-scales are much shorter than the stability threshold, within a factor of 2.5 of the Rossby deformation radius.

Parameterization of Langmuir Circulation in the Ocean Mixed Layer Model Using LES and its Application to the OGCM

Abstract ID : 153

Conflict Declaration : None
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Additional Information : None

Prof. Yign Noh[1]
1 - Yonsei University

The effect of Langmuir circulation (LC) on vertical mixing is parameterized in the ocean mixed layer model (OMLM), based on the analysis of large eddy simulation (LES) results. Parameterization of LC effects is carried out in terms of the modifications of the mixing length scale as well as the inclusion of the contribution from the Stokes force in momentum and TKE equations. The performance of the new OMLM is examined by comparing with LES results, together with sensitivity tests for empirical constants used in the parameterization. The new OMLM is then applied to the ocean general circulation model (OGCM) MRI.COM and its effect is investigated. The new OMLM helps to correct too shallow MLDs in the high-latitude ocean, which has been a common error in most OGCMs, without making the thermocline in the tropical ocean more diffused. The parameterization of LC effects is found to affect mainly the high-latitude ocean, in which MLD is shallow in summer and stratification is weak in winter.

The relative impacts of temporal variability in dissipation and mixing efficiency on diapycnal fluxes.

Abstract ID : 260

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Matthew Palmer[1], Prof. Stephen Monismith[2], Prof. Mark Inall[3], Prof. Tom Rippeth[4], Dr. Holly Pelling[5], Dr. Jeff Polton[5], Dr. Matt Toberman[3]
1 - UK National Oceanography Centre 2 - Stanford University 3 - Scottish Association for Marine Science 4 - Bangor University 5 - National Oceanography Centre, UK

Four decades of ocean microstructure measurements have provided strong qualitative evidence to link the rate of dissipation of turbulent kinetic energy (ε) and mixing in the ocean interior to a variety of forcing mechanisms, such as wind, tides and internal waves. To quantitatively link these mechanisms to diapycnal fluxes of physical and biogeochemical properties however, requires thorough consideration of 1) the variability of ε and 2) the efficiency with which this energy is able to irreversibly mix across stratified interfaces.
Turbulence has been shown to vary by many orders of magnitude over relatively short timescales in all stratified ocean settings, suggesting that isolated profiles provide little understanding of the true nature of ocean turbulence. Instead, systematic sampling and appropriate averaging is required to capture the relative variability of turbulent parameters. Furthermore, while a canonical value of mixing efficiency (*Rf* = 0.17) is often assumed, there remains considerable debate over the true variability in *Rf* and its functional form over differing values of buoyancy Reynolds number.
In this presentation we present over 2000 profiles of shear and thermal microstructure measurements from the Ocean Microstructure Glider (OMG) to examine coincident behavior of ε and thermal variance (χ) to derive *Rf* over a range of forcing scenarios. With this extensive dataset we will quantify the relative impacts of the temporal variability in ε and *Rf* on the diapycnal heat flux and discuss implications for future studies.

Enhanced mixing in the equatorial thermocline induced by inertia-gravity waves

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Additional Information : None

Prof. Kelvin Richards ,rkelvin@hawaii.edu ,(Director) ,United States ,Honolulu ,Presenting[1]
Dr. Andre Natarov ,natarov@hawaii.edu ,(None) ,United States , ,Not Presenting[1]
Dr. Yanli Jia ,yjia@hawaii.edu ,(None) ,United States , ,Not Presenting[1]
1 - University of Hawaii 2 - University of Hawaii 3 - University of Hawaii

Observations show turbulence activity is enhanced in and above the equatorial thermocline. This enhancement is brought about in part by the generation, propagation and dissipation of wind-driven inertia-gravity waves (IGWs). Numerical experiments show that in a zonally symmetric model of a tropical ocean forced by a transient wind stress both IGW activity and the energy dissipation have a pronounced maximum in the thermocline close to the equator regardless of the latitudinal distribution of the energy input into the ocean's mixed layer by the wind. We show that this equatorial enhancement is caused by a combination of a number of factors that include: a stronger superinertial component of the wind forcing close to the equator, amplification due to refraction at the top of the thermocline, wave action convergence at turning latitudes for various equatorially trapped waves, and nonlinear wave-wave interactions between equatorially trapped waves. In the presence of strong equatorial currents observations and models show strong evidence of critical layer absorption. Given the complexity of the situation it is not obvious how to parameterize the impact of IGWs if they are unresolved in a model. We demonstrate, however, that with an attainable vertical and horizontal resolution it is possible to capture the observed characteristics of IGWs close to the equator and their impact on mixing.

Generation and propagation of atmospheric internal waves caused by volcanic eruptions

Abstract ID : 293

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Additional Information : None

Dr. Peter Baines ,p.baines@unimelb.edu.au ,(Senior Fellow) ,Australia ,Melbourne ,Not Presenting[1]
1 - None

Observations from the island of Montserrat in the Caribbean have shown that volcanic eruptions (particularly explosive ones) can generate internal waves in the atmosphere that can be observed by microbarographs at ground level. It is possible that observations of such waves may give early information about volcanic eruptions when other methods are unavailable (because of bad weather, nocturnal eruptions, poor visibility or remoteness), if it is possible to interpret them. This paper describes a dynamical model of the forcing of internal waves in which the eruption is modelled as a turbulent plume, forced by a source of buoyancy at ground level, that specifies the total height and relevant properties of the eruption. Specifically, the rising plume entrains environmental air from ground level to 70% of its maximum height z_M, and above $0.7z_M$ the rising fluid spreads radially. During the eruption, this flow forces horizontal motion in the surrounding fluid that generates internal waves, which may be computed by assuming that this is due to a linear dynamical process. Properties of the resulting waves are described for a variety of parameters that include the strength and height of the eruption, the effect of the tropopause, generation in the stratosphere for large eruptions, and the differing effects of the duration of the eruption.

The role of submesoscale instabilities in regulating turbulence in the upper ocean

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Conflict Declaration : None
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Additional Information : None

Dr. Alberto Naveira Garabato ,acng@noc.soton.ac.uk ,(None) ,United Kingdom , ,Presenting[1]
Dr. Christian Buckingham ,chrcki@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Prof. Tom Rippeth ,t.p.rippeth@bangor.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
Dr. Natasha Lucas ,n.lucas@bangor.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
Prof. Stephen Belcher ,s.e.belcher@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[5]
Mr. Xiaolong Yu ,Xiaolong.Yu@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
1 - University of Southampton 2 - British Antarctic Survey 3 - Bangor University 4 - Bangor University 5 - University of Reading 6 - University of Southampton

The role of submesoscale frontal instabilities in regulating the seasonal cycle of upper-ocean turbulence is investigated through the analysis of a year-long record of hydrographic and velocity measurements, collected from a cluster of 9 moorings deployed in 2012 - 2013 in the open-ocean Northeast Atlantic under the auspices of the U.K. OSMOSIS experiment. The mooring cluster consisted of two nested arrays with horizontal spacings of ~1.5 km and ~15 km that provided resolution of submesoscale and mesoscale flows, respectively, and included point measurements of the rate of turbulent kinetic energy dissipation using high-frequency ADCPs. The measurements reveal that the experimental area is riddled with submesoscale turbulence throughout the year, despite hosting only weak mean and moderate mesoscale eddying flows. Submesoscale turbulence exhibits a significant annual cycle, with intensified (reduced) submesoscale activity in winter (summer). A major portion of the upper-ocean turbulent kinetic energy dissipation and de-stratification in the late autumn and winter is associated with the gravitational and symmetric instabilities triggered by winds blowing down submesoscale density fronts. These submesoscale instabilities contrast with the more familiar gravitational instabilities resulting from seasonal surface buoyancy forcing, which are generally well represented in ocean general circulation models. Our findings suggest that parameterisation of the turbulence triggered by winds at ocean fronts is essential to the realistic representation of the annual cycle of mixed layer turbulence in climate-scale ocean models.

Ridges, Seamounts, Troughs and Bowls: Topographic Control of the Diapycnal Circulation in the Abyssal Ocean

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Additional Information : None

Dr. Ryan Holmes ,ryan.holmes@unsw.edu.au ,(Research Associate) ,Australia ,Sydney ,Not Presenting[1]
Dr. Casimir De Lavergne ,c.delavergne@unsw.edu.au ,(None) ,Australia , ,Not Presenting[2]
Dr. Trevor McDougall ,Trevor.McDougall@unsw.edu.au ,(None) ,Australia ,None ,Not Presenting[3]
1 - University of New South Wales 2 - School of Mathematics and Statistics, University of New South Wales 3 - UNSW

Turbulence observations made over the last several decades have shown that the intensity of turbulent mixing in the abyssal ocean is enhanced towards the seafloor. Consequently, a new paradigm has emerged whereby *dianeutral downwelling* dominates in the ocean interior and *dianeutral upwelling* only occurs within thin boundary layers near the sloping seafloor. This new paradigm suggests that the topography of the global ocean has a controlling influence on the return of dense bottom waters towards the surface. In this study, the authors investigate the relationship between the geometry of the seafloor and the abyssal diapycnal circulation when turbulent mixing is bottom-intensified. By examining simple topographic geometries, including two-dimensional ridges and troughs and three-dimensional seamounts and bowls, we show that the abyssal circulation can depend on quite subtle differences in the shape of topography. Under an assumption of vertically-uniform dianeutral upwelling, small changes in the curvature of the seafloor, which controls the vertical distribution of the buoyancy flux integrated over a neutral surface, can result in interior stratification that is bottom-intensified, uniform, or surface intensified. Further, when the assumption of uniform upwelling is relaxed changes in the slope and circumference of bathymetric contours with height can drive lateral exchange between the boundary layers and interior, with particularly strong lateral out-flows predicted at the crests of mid-ocean ridges. Finally, we suggest that in the real ocean the increase in the *perimeter* of neutral density surfaces with height drives much of the diapycnal upwelling of abyssal waters, while the increase in the *slope* of topography above the abyssal plains acts to oppose this upwelling. These results add to a growing body of literature suggesting that our knowledge of the abyssal overturning circulation is still in its infancy.

Internal waves and mixing over the Mid-Atlantic Ridge

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Additional Information : None

Dr. Clement Vic ,c.vic@soton.ac.uk ,(Post-doctoral researcher) ,United Kingdom ,Southampton ,Not Presenting[1]
1 - University of Southampton

The generation, radiation and breaking of semi-diurnal internal tides over the Mid-Atlantic Ridge (MAR) is investigated with a collection of microstructure turbulence measurements and high temporal and vertical resolution mooring data from the MAR sector south of the Azores, obtained under the auspices of the U.K. RidgeMix project. Pressure perturbation inferred from 36 moored thermistors is combined with ADCP-measured velocity perturbation to compute a time series of energy density and flux over the ridge. Conducting a vertical mode decomposition of these variables sheds light onto the fate of semi-diurnal internal tides, i.e. the relative significance of far-field propagation and near-local dissipation. The energy flux is dominated by mode 1, which appears to be the only freely propagating mode. However, the mode-1 internal tide contains comparable energy to the combination of modes 2-10 (1 kJ m−2). These higher modes account for most of the shear variance and are thus poised to cascading locally to turbulence and dissipation. This picture of strongly dissipative high-mode internal tides is endorsed by microstructure measurements, which show elevated dissipation at the same location on the MAR (O(1)mW m−2). Mooring-derived energy fluxes are compared to linear spectral model predictions of barotropic-to-baroclinic tidal conversion, which indicate a conversion at the mooring site of 3.0 mW m−2 using ETOPO2 (2' resolution) topography and 5.0 mW m−2 using SRTM30-PLUS (0.5' resolution) topography. This points to the importance of topographic features with horizontal scales of 1-10-km in enhancing tidal conversion. The mooring-derived vertical energy flux is 3.2 mW m−2 , which is significantly lower than the conversion predicted from SRTM30-PLUS and thus suggestive of the onset of direct breaking of high-mode internal tides at the site. Local dissipation infered from microstructure measurements is 0.7-1.3 mW m−2 - following a spring-neap cycle -, thus supporting direct breaking of high modes.

Temporal variability of the internal wave spectrum in the interior tropical North Atlantic

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Additional Information : None

Dr. Janna Köhler ,jannak@uni-bremen.de ,(Postdoc) ,Germany ,Bremen ,Not Presenting[1]
Mrs. Maren Walter ,mwalter@physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]
Mr. Georg S. Völker ,voelker@uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]
1 - University of Bremen 2 - University of Bremen 3 - University of Bremen

The tropical North Atlantic is an area of relatively low energy input from the mean wind field into the internal wave field rendering hurricanes in the Caribbean the main energy source for near-inertial waves. Additionally the trade winds induce a seasonal cycle in surface swell with potential implications for the high-frequency part of the internal wave field
Using five-year mooring time series in the interior of the tropical North Atlantic at 16° N the temporal variability of internal wave energy south of the main hurricane track in different frequency bands is studied and the magnitude of its variability along with possible energy transfer mechanisms is analyzed. The data show that changes in near-inertial energy are dominated by the passage of waves generated by hurricanes centered several hundred kilometers north of the mooring. This is supported by an extended slab model that takes the horizontal divergence of the near-inertial current field at the mixed layer base into account.
A seasonal cycle is observed at the high-frequency end (frequencies above 6cpd) of the internal wave spectrum. It is not in phase with the near-inertial energy variability but covaries with changes in the local surface waves. This high-frequency internal waves are most energetic during times when large amplitude surface swell with long periods and correspondingly long wavelengths is observed.

Enhanced water mass property changes due to salt finger evolution in the Tyrrhenian Sea

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Ms. Sara Durante ,sara.durante@ts.ismar.cnr.it ,(research fellowship) ,Italy ,Trieste ,Presenting[1]
Dr. Katrin Schroeder ,katrin.schroeder@ve.ismar.cnr.it ,(None) ,Italy , ,Not Presenting[2]
Dr. Stefania Sparnocchia ,stefania.sparnocchia@ts.ismar.cnr.it ,(None) ,Italy , ,Not Presenting[1]
Dr. Luca Mazzei ,mazzei.luca@gmail.com ,(None) ,Italy , ,Not Presenting[4]
Mr. Mireno Borghini ,mireno.borghini@sp.ismar.cnr.it ,(None) ,Italy , ,Not Presenting[1]
Prof. Stefano Pierini ,stefano.pierini@uniparthenope.it ,(None) ,Italy , ,Not Presenting[6]
1 - ISMAR - CNR 2 - CNR - ISMAR 3 - ISMAR - CNR 4 - ISMAR - CNR, now at IIT, Genova 5 - ISMAR - CNR 6 - University of Naples, Parthenope

The salt finger phenomenon is an important feature of the Tyrrhenian Sea basin, leading to a typical step-like profile of the water column both in Conservative Temperature (CT) and in Absolute Salinity (SA). The analyzed dataset (from 2003 to 2016) contains hydrological time series obtained in two deep control stations up to a depth of about 3500 m. In each profile, four key steps can be recognized between 400 m and 2500 m, the main one having a thickness of about 400 m.
Since the Tyrrhenian Sea is not a particularly perturbed basin, the staircases show large hydrological and depth changes; in particular, an increase of CT and SA and an uplifting are observed after 2010. This variability in the water mass properties can be inferred by studying the evolution of the staircases thanks to a suitable method [1], that aims to discern if the observed changes are related to either internal or external forcings. Changes in SA are found to be similar along both isobars and neutral surfaces, so they can be ascribed to an external forcing. On the other hand, the CT shows different trends along isobars and neutral surfaces: this suggests that internal forcing can play an important role.
The new Western Mediterranean Deep Water formed in the Gulf of Lion in severe winters after 2004-2005 and later on (the so-called Western Mediterranean Transition [2]) is suggested to be due to an external forcing. Oscillatory movements of the neutral surfaces can also be observed after 2010. Computation of heat and salt fluxes (both for the whole water column and for each single step) sheds light on the conservative character of hydrological parameters of the step-like system.
[1] Bindoff, N.L., McDougall, T.J., 1994. J. Phys. Oceanogr. 24, 1137-1152.
[2] Schroeder, K., G. P.Gasparini, M. Tangherlini, and M. Astraldi, 2006. Geophys. Res. Lett., 33, L21607, doi:10.1029/2006GL027121.

Turbulent cooling of an UCDW eddy on the Antarctic continental slope

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Dr. Yueng Lenn ,y.lenn@bangor.ac.uk ,(SeniorLecturer) ,United Kingdom ,Menai Bridge ,Not Presenting[1]
Ms. Jess Silvester ,j.mead.silvester@bangor.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. Jeff Polton ,jelt@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
Dr. Miguel Morales Maqueda ,Miguel.Morales-Maqueda@newcastle.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]
1 - Bangor University, Wales 2 - School of Ocean Sciences, Bangor University 3 - National Oceanography Centre, UK 4 - Newcastle University

Water mass transformation of Upper Circumpolar Deep (UCDW) upwelling in the Southern Ocean is a critical driver for the Meridional Overturning Circulation that in turn mediates global climate. How the warm salty UCDW encroaches and then is transformed onto the Antarctic continental shelves where it can impact the sea-ice processes driving Antarctic Bottom Water (AABW) formation remains a key question. Recent observations provide evidence that mesoscale and sub-mesoscale eddies contribute to the overturning by fluxing CDW across the Antarctic Peninsula and Weddell Sea Continental slopes [*Thompson et al, 2014, Stewart et al., 2016, Ericksen et al., 2016*]. We present EM-APEX float observations of a UCDW bolas propagating along the Antarctic continental slope north of the Antarctic Peninsula. The float captures direct heat exchange between a parcel of UCDW and Lower Circumpolar Deep Waters (LCDW) at mid-depths over the course of several days. Heat fluxes peak across the top and bottom boundaries of the UCDW parcel and peak diffusivities across the bottom boundary are associated with shear instability. Estimates of diffusivity from shear-strain finestructure parameterisation and heat fluxes are found to be in reasonable agreement. The two-dimensional Ertel potential vorticity is elevated both inside the UCDW parcel and along its bottom boundary, with a strong contribution from the shear term in these regions and instabilities associated with gravitational through symmetric forcing arising from the interaction of the eddy with the barotropic tide. Hence waters mix vertically across the bottom boundary of the UCDW parcel, injecting heat at mid-depths and transforming as heat, mass and buoyancy are lost from UCDW to LCDW. This has implications for our understanding of rates of upwelling and ocean- atmosphere exchange of heat and carbon at this critical location.

Mathematical versus physical constraints on ocean small-scale mixing parameterisations

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Additional Information : None

Mr. Remi Tailleux ,R.G.J.Tailleux@reading.ac.uk ,(None) ,United Kingdom ,Reading ,Not Presenting[1]
1 - University of Reading

The development of turbulent mixing parameterisations in numerical ocean models relies on two distinct approaches: the first one is theoretical in nature and is primarily concerned with rooting the parameterisations in sound physical principles; the second one is empirical in nature, and seeks to exploit available observations to optimally constrain the various adjustable parameters and constants that inevitably enter most mixing parameterisations. In the first part of this work, we investigate which components of rotated diffusion tensors can be inferred --- at least in principle --- from the knowledge of the full turbulent heat and salt fluxes, assuming that the latter can be constrained from observations. Surprisingly, he answer is found to depend on whether equal or different diapycnal diffusivities are assumed for heat and salt. If identical diffusivities are assumed, as is most commonly done, then the knowledge of the turbulent heat and salt fluxes (referred to as 'observations' in the following) is found to constrain both the anti-symmetric and symmetric parts of rotated diffusion tensors. Regarding the latter, observations constrain not only the isopycnal and diapycnal mixing coefficients, but also the unit vector controlling the isopycnal and diapycnal mixing directions. If different diffusivities are assumed, which corresponds to so-called differential diffusion, then observations are able to constrain the isopycnal as well as the two diapycnal diffusivities; in that case, the values obtained depends on the choice of mixing directions, which can be a priori be chosen arbitrarily either to align with isopycnal and diapycnal directions, or with the horizontal/vertical directions. In the second part of this work, we will investigate the feasibility of using observations for constraining the full turbulent heat and salt fluxes. One important implication of the work is to demonstrate unambiguously that the so-called Veronis effect --- which in early ocean models was responsible for spurious upwelling in western boundary currents --- was caused by the lack of meso-scale eddy-induced advection, rather than by mixing horizontal/vertically rather than along and across isopycnals, in contrast to what is often believed.

Synoptic-to-planetary scale wind variability enhances phytoplankton at ocean fronts

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Conflict Declaration : None
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Additional Information : See Files

Dr. Daniel Whitt ,dwhitt@ucar.edu ,(Post-doctoral Researcher) ,United States ,Boulder ,Not Presenting[1]
Mr. John Taylor ,jrt51@cam.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. Marina Levy ,marina.levy@upmc.fr ,(None) ,France , ,Not Presenting[3]
1 - National Center for Atmospheric Research 2 - University of Cambridge 3 - LOCEAN-IPSL

In nutrient limited conditions, phytoplankton growth at fronts is enhanced by winds, which drive upward nutrient fluxes via enhanced turbulent mixing and upwelling. Hence, depth-integrated phytoplankton can be ten times greater at isolated fronts.

Using theory and two-dimensional simulations with a coupled physical-biogeochemical ocean model, this presentation builds conceptual understanding of the physical processes driving upward nutrient fluxes at fronts forced by unsteady winds with timescales of 4-16 days.

The largest vertical nutrient fluxes occur when the surface mixing layer penetrates the nutricline, which fuels phytoplankton in the mixed layer. At a front, mixed layer deepening depends on the magnitude and direction of the wind stress, cross-front variations in buoyancy and velocity at the surface, and potential vorticity at the base of the mixed layer, which itself depends on past wind events. Consequently, mixing layers are deeper and more intermittent in time at fronts than outside fronts. Moreover, mixing can decouple in time from the wind stress, even without other sources of physical variability.

Wind-driven upwelling also enhances depth-integrated phytoplankton at fronts; when the mixed layer remains shallower than the nutricline, this results in enhanced subsurface phytoplankton. Oscillatory along-front winds induce both oscillatory and mean upwelling.

The mean effect of oscillatory vertical motion is to transiently increase subsurface phytoplankton over days to weeks, whereas slower mean upwelling sustains this increase over weeks to months. Taken together, these results emphasize that wind-driven phytoplankton growth is both spatially and temporally intermittent and depends on a diverse combination of physical processes.

Observed Scaling and Energetics of Langmuir Turbulence in Shallow Coastal Sea

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Dr. Yutaka Yoshikawa ,yosikawa@kugi.kyoto-u.ac.jp ,(Associate Professor) ,Japan ,Kyoto ,Not Presenting[1]
1 - None

To measure near-surface turbulence under various winds, surface waves and (primarily weak destabilizing) surface buoyancy fluxes, field experiments were conducted at the marine tower station near the southern coast of Japan. In this experiment, upward-looking ADCP and horizontally-looking ADCPs were used to capture horizontal coherent structure of turbulence (such as Langmuir cell), turbulent velocity magnitude, and turbulent kinetic energy budget (production and dissipation), as well as mean flows and surface waves. Atmospheric momentum and heat fluxes were measured at the tower. The observed vertical velocity magnitudes are found to be larger when Langmuir number ($La=(U_*/U_S)^{1/2}$, where U_* is the friction velocity and U_S is the surface Stokes velocity) and Hoennikker number ($Ho=BH/U_*^2U_S$ where B is surface buoyancy flux and H is the water depth) are low. The vertical velocity normalized by the friction velocity depends on *La* and *Ho* as the previous numerical simulation of Langmuir turbulence shows. Such large vertical velocities are often accompanied by streak coherent structure in horizontal velocity and echo intensity measured with the horizontally-looking ADCPs. These results indicate that the observed flow is Langmuir turbulence. The total production (shear production + Stokes production) of turbulent kinetic energy (estimated using the variance method) agrees fairly well with the dissipation rate of turbulent kinetic energy (estimated from the spectral method). Noteworthy is that the shear production is as large as the Stokes production and contribute in producing turbulent kinetic energy. Misalignment of Stokes drift direction and wind direction seems responsible for this large shear production.

Deep overturning circulation shaped by basin geometry

Abstract ID : 905

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Casimir de Lavergne ,casimir.delavergne@gmail.com ,(None) ,Australia ,Sydney ,Not Presenting[1]
Dr. Ryan Holmes ,ryan.holmes@unsw.edu.au ,(Research Associate) ,Australia ,Sydney ,Not Presenting[2]
Dr. Fabien Roquet ,roquet@misu.su.se ,(Research associate) ,Sweden ,Stockholm ,Not Presenting[3]
Dr. Gurvan Madec ,gurvan.madec@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[4]
Dr. Trevor McDougall ,Trevor.McDougall@unsw.edu.au ,(None) ,Australia ,None ,Not Presenting[1]
1 - UNSW 2 - University of New South Wales 3 - MISU 4 - LOCEAN / CNRS 5 - UNSW

The deep ocean is broadly characterized by northward flow of densest waters in the abyss and southward flow of lighter waters at mid-depths. Understanding what controls the strength and structure of these inter-hemispheric flows, referred to as the deep overturning circulation, is key to quantifying the deep ocean's ability to store carbon and heat. Here we show that the depth-distribution of ocean floor, by shaping the diffusive density flux descending into the abyss, sets the depth level of meridional flow reversal and the vertical extent of abyssal upwelling. Backed by a new analysis of historical radiocarbon measurements, the findings imply that the geometry of the Pacific, Indian and Atlantic basins places strong external constraints on the overturning structure.

Eddy dissipation by interaction with internal waves in the Drake Passage

Abstract ID : 967

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Mr. Jesse Cusack ,jc3e13@soton.ac.uk ,(PhD student) ,United Kingdom ,Southampton ,Not Presenting[1]
Mr Alex Brearley ,jambre@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. Alberto Naveira Garabato ,acng@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Mr. David Smeed ,das@noc.ac.uk ,(None) ,United Kingdom ,Southampton ,Not Presenting[4]
1 - University of Southampton 2 - British Antarctic Survey 3 - University of Southampton 4 - National Oceanography Centre

Mesoscale eddy motions dominate the kinetic energy budget of the ocean at mid and high latitudes. It has been suggested that interaction of the eddy field with the internal wave field may result in a transfer of energy from eddies to waves. The importance of this potential sink of eddy energy remains unknown due to the limited amount of previous observational work on the subject. We treat the interaction as a viscous coupling and characterise the process in detail using data from an array of 5 moorings deployed in the Drake Passage in 2009, which provide a full depth, 439 day record. The magnitude of the energy sink will be presented and compared to that of other potential sinks, such as bottom boundary layer dissipation, lee wave generation and mean flow interaction; their relative importance will be discussed.

Mixing and Circulation in Two Tropical Oxygen Minimum Zones determined by Tracer Release Experiments

Abstract ID : 983

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. Martin Visbeck ,mvisbeck@geomar.de ,(Professor) ,Germany ,Kiel ,Presenting[1]
Dr. Toste Tanhua ,ttanhua@geomar.de ,(None) ,Germany , ,Not Presenting[2]
Dr. Donata Banyte ,Donata.Banyte@newcastle.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
Mrs. Manuela Koellner ,mkoellner@geomar.de ,(None) ,Germany , ,Not Presenting[4]
Mrs. Madeleine Freund ,mfreund@geomar.de ,(None) ,Germany , ,Not Presenting[1]
1 - GEOMAR Helmholtz Zentrum für Ozeanforschung Kiel 2 - GEOMAR 3 - Newcastle University 4 - Federal Maritime and Hydrographic Agency, Hamburg 5 - GEOMAR Helmholtz Zentrum für Ozeanforschung Kiel

Tropical Oxygen Minimum Zones have shown to expand in the last 50 years and are arguably key regions were ocean de-oxygenation matters to the marine biogeochemistry and ecology. We have conducted three Tracer Release Experiments in the context of these regions. Two in the Tropical North Atlantic and one in the Tropical South Pacific.
For the Guinea dome Upwelling Tracer Release Experiment (GUTRE ,2008) 92 kg of SF_5CF_3 were injected at 8°N, 23°W in the upper part of the oxygen minimum zone (OMZ). Three surveys measured the tracer distribution 7, 20 and 30 months later. The experiment was designed to estimate the time-mean diapycnal mixing rate at the upper boundary of the OMZ and was $1.19 \pm 0.18 \times 10^{-5}$ m^2 s^{-1} (Banyte et al., 2012). For the second Oxygen Supply Tracer Release Experiment (OSTRE, 2012) 88.5 kg of CF_3SF_5 (tracer) were released in the center of the oxygen minimum zone at 10° 30' N and 21° W at the depth of the lowest oxygen values. Three surveys measured the tracer distribution approximately 7, 15 and 29 months later and found the vertical diffusivity at the center of the OMZ to be insignificantly smaller with $1.06 \pm 0.22 \times 10^{-5}$ m^2 s^{-1} in the OMZ core (Köllner et al., 2016). The horizontal spreading of the tracer was compared to a tracer release in a high resolution ocean circulation model and showed some rather striking similarities. Estimation of the strength of zonally alternating jets that ventilate the OMZ from the western part of the basin will be presented using a simple jet dispersion model.
The Peruvian OMZ System Tracer Release Experiment (POSTRE) was intended to investigate the benthic-pelagic coupling with a tracer release experiment in the Peruvian Margin. At three location near the sea floor (12°S, 14°S and 15°S) at a water depth of 250m a total of 75kg SF_5CF_3 were injected. The tracer distribution was surveyed extensively in March 2017 and the first results highlighting, mixing and advective pathways from the recent data will be discussed in the context of regional ocean model simulations.

The contribution of internal waves to continental shelf seas turbulence and mixing

Abstract ID : 1119

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Miss. Anastasiia Domina ,Anastasiia.Domina@liverpool.ac.uk ,(PhD student) ,United Kingdom ,Liverpool ,Not Presenting[1]
Dr. Matthew Palmer ,rolm@noc.ac.uk ,(Physical Oceanographer) ,United Kingdom ,Liverpool ,Not Presenting[2]
Dr. Vasyl Vlasenko ,vasyl.vlasenko@plymouth.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
Dr. Nataliya Stashchuk ,nataliya.stashchuk@plymouth.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
Prof. Jonathan Sharples ,Jonathan.Sharples@liverpool.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Dr. J. A. Mattias Green ,m.green@bangor.ac.uk ,(None) ,United Kingdom , ,Not Presenting[6]
1 - University of Liverpool 2 - UK National Oceanography Centre 3 - Plymouth University 4 - Plymouth University 5 - University of Liverpool 6 - Bangor University

In this study we aim to increase our understanding of Internal wave (IW) dynamics and their impact on turbulence and mixing over continental shelf seas using a combination of observational (moorings, gliders) and modelling methods (MITgcm). In most cases, low frequency, low mode IWs are considered dominant contributors to shelf sea baroclinic energy and mixing. We demonstrate how high-frequency, high-mode IWs can provide a significant input to baroclinic horizontal kinetic energy (HKE) under certain circumstances dependent on variable local and remote forcing. We use a super-high-resolution (50m horizontal) MITgcm configuration to investigate the distribution of baroclinic energy within a shelf sea domain and identify the generation and propagation characteristics of IWs under different Froude number scenarios. Our model suggests that under increasing stratification, the IW field becomes more energetic at all frequencies, however the increase in energy is not evenly distributed. While energy in the dominant low frequency IWs increases by 20-40%, energy associated with high frequency waves increases by as much as 80-90%. We compare model results with observations via the available potential energy (APE) and gradient Richardson number to assess the impact that this varying wavefield has on internal mixing. Lastly, we use the results under changing stratification to assess the likely impact of changing climate forcing scenarios on IW generation and internal mixing on continental shelf seas.

The impacts of ocean bottom roughness and tidal flow amplitude on abyssal mixing

Abstract ID : 1217

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. Toshiyuki Hibiya ,hibiya@eps.s.u-tokyo.ac.jp ,(Professor of Physical Oceanography) ,Japan ,Tokyo ,Presenting[1]
Dr. Takashi Ijichi ,ijichi@eps.s.u-tokyo.ac.jp ,(None) ,Japan , ,Not Presenting[1]
Ms. Emiri Kobori ,kobori@eps.s.u-tokyo.ac.jp ,(None) ,Japan , ,Not Presenting[1]
1 - The University of Tokyo 2 - The University of Tokyo 3 - The University of Tokyo

Existing parameterizations of tidal mixing over rough bathymetry have plenty of room for improvement. For example, they do not take into account the fact that, as tide-topography interactions strengthen ($k_H U_0/\Omega > 1$), the generated internal waves transform from linear internal tides to quasi-steady internal lee waves where U_0 is the amplitude of the tidal flow dominating the background flow in the Garrett-Munk (GM) internal wave field, k_H is the horizontal wavenumber of the bottom topography, and Ω is the semidiurnal tidal frequency.

In the present study, we perform a series of eikonal calculations to examine the transfer of energy from upward propagating quasi-steady internal lee waves to dissipation through nonlinear interactions with the background GM internal waves in a vertical two-dimensional plane. It is shown that the vertical structure of the mixing hotspot becomes dominated by U_0 rather than k_H. As U_0 increases, the fraction of energy dissipated at the ocean bottom decreases and the vertical extent of the energy dissipation region above the ocean bottom increases.

The validity of the parameter dependence of the vertical structure of the mixing hotspots thus obtained is assessed through microstructure observations down to the ocean bottom as well as simultaneous surveys of high-resolution bathymetric features.

The OSMOSIS ocean boundary layer model

Abstract ID : 1436

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. George Nurser ,agn@noc.ac.uk ,(Principal scientist) ,United Kingdom ,Southampton ,Not Presenting[1]
1 - NOC

Wave motions collude with turbulence motions to drive so called Langmuir turbulence over much of the ocean surface boundary layer (OSBL). As shown by recent Large Eddy Simulation (LES) results, this Langmuir turbulence differs from standard shear turbulence in having a greater fraction of the turbulent kinetic energy in the vertical component of the flow, and relatively weaker vertical gradients of momentum, heat and salinity. A new parameterization of the effect of Langmuir turbulence on the OSBL is presented here. It is different from, but in the spirit of, the K-profile parameterization (KPP). It involves a prognostic equation for the OSBL depth, together with a flux-gradient model involving KPP-style structure functions for the vertical variation of the diffusivity thoughout the OSBL, and countergradient vertical fluxes in temperature, salinity and momentum. The design of this model has been informed by the results of a large number of LES experiments, run with a range of different forcing conditions. When run in 1-D, this parameterized model gives realistic simulations of observational datasets such as the OSMOSIS cruise data and the seasonal cycle at Ocean Weather Station PAPA. The parametrized model has been implemented into the NEMO ocean model and has been run for multi-annual simulations of the global ocean; results from these runs are presented here.

Observations of eddy suppression in the Antarctic Circumpolar Current

Abstract ID : 1483

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Helen Phillips ,h.e.phillips@utas.edu.au ,(Senior Research Fellow) ,Australia ,Hobart ,Not Presenting[1]
Dr. Kurt Polzin ,kpolzin@whoi.edu ,(None) ,United States , ,Not Presenting[2]
Dr. Alberto Naveira Garabato ,acng@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
Prof. Nathan Bindoff ,n.bindoff@utas.edu.au ,(None) ,Australia , ,Not Presenting[4]
Dr. Stephanie Waterman ,swaterman@eos.ubc.ca ,(None) ,Canada , ,Not Presenting[5]
1 - University of Tasmania - IMAS 2 - Woods Hole Oceanographic Institution 3 - University of Southampton 4 - Institute for Marine & Antarctic Studies, University of Tasmania 5 - University of British Columbia

We present a unique highly-resolved, along-stream view of temperature, salinity and velocity within the upper 1600 meters of the ACC where the mean flow is strong. These semi-Lagrangian EM-APEX observations provide a sharp contrast to the way we traditionally observe the Southern Ocean, where cross-frontal transects and strong meridional gradients dominate the picture. Rather, what we find are thermohaline filaments that trail along the ACC for many hundreds of kilometres. This coherence is inconsistent with the traditional view of thermohaline variability in the ocean. Moreover, we find a striking behaviour of the thermohaline anomalies in crossing isopycnals to converge near the bottom of the thermocline.
Our interpretation of these data is that the floats are tracking anomalies that originate with relatively large vertical scales, and these vertical scales are diminished as the thermal wind shear of the ACC differentially advects the anomalies to tilt them in the vertical. We present a simple kinematic model that assumes production of thermohaline variance by barotropic motions at large horizontal scales, a suppression of eddy stirring by smaller horizontal scale motions and a spatially uniform thermal wind shear that mimics the behavior seen by the floats. We also examine the trajectories of particles seeded into the time-varying SatGEM climatology at the time and location of our observations. We find the production of filaments at crests and troughs of ACC meanders that are sheared and stretched to form coherent ribbons of fluid many 100s of km long. The coherence of the anomalies in the observations, kinematic model and particle tracking results argues for eddy suppression in the ACC and a long dissipation time scale.

JP2 - Polar Oceanography And Meteorology (IAPSO, IAMAS)

Observations of surface momentum exchange over the marginal-ice-zone and recommendations for its parameterization

Abstract ID : 86

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. Ian Renfrew ,i.renfrew@uea.ac.uk ,(Professor) ,United Kingdom ,Norwich ,Not Presenting[1]
Dr. Tom Lachlan Cope ,tlc@bas.ac.uk ,(None) ,United Kingdom ,None ,Not Presenting[2]
Dr. Alexandra Weiss ,aiw@bas.ac.uk ,(None) ,United Kingdom ,Cambridge ,Not Presenting[2]
Mr Ian Brooks ,i.brooks@see.leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]
Mr Andy Elvidge ,a.elvidge@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[5]
Mr John King ,jcki@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
1 - University of East Anglia 2 - BAS 3 - BAS 4 - U. Leeds 5 - UEA 6 - BAS

Comprehensive aircraft observations are used to characterise surface roughness over the Arctic marginal ice zone (MIZ) and consequently make recommendations for the parameterization of surface momentum exchange in the MIZ. These observations were gathered in the Barents Sea and Fram Strait from two aircraft as part of the Aerosol-Cloud Coupling And Climate Interactions in the Arctic (ACCACIA) project. They represent a doubling of the total number of such aircraft observations currently available over the Arctic MIZ. The eddy covariance method is used to derive estimates of the 10-m neutral drag coefficient (CDN10) from turbulent wind velocity measurements, and a novel method using albedo and surface temperature is employed to derive ice fraction. Peak surface roughness is found at ice fractions in the range 0.6 to 0.8 (with a mean interquartile range in CDN10 of 1.25 to 2.85 ×10-3). as a function of ice fraction is found to be well approximated by the negatively skewed distribution provided by a leading parameterization s cheme (Lüpkes et al., 2012) tailored for sea ice drag over the MIZ in which the two constituent components of drag - skin and form drag - are separately quantified. Current parameterization schemes used in the weather and climate models are compared with our results and the majority are found to be physically unjustified and unrepresentative. The Lüpkes et al. (2012) scheme is recommended in a computationally simple form, with adjusted parameter settings. A good agreement holds for subsets of the data from different locations, despite differences in sea ice conditions. Ice conditions in the Barents Sea, characterised by small, unconsolidated ice floes, are found to be associated with higher CDN10 values - especially at the higher ice fractions - than those of Fram Strait, where typically larger, smoother floes are observed. Consequently, the important influence of sea ice morphology and floe size on surface roughness is recognised, and improvement in the representation of this in parameterization schemes is suggested for future study.

Anatomy of a glacial meltwater discharge event in an Antarctic cove

Abstract ID : 91

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. Michael Meredith ,mmm@bas.ac.uk ,(Science Leader) ,United Kingdom ,Cambridge ,Not Presenting[1]
Mr Ulrike Falk ,ufalk@uni-bremen.de ,(None) ,Germany , ,Not Presenting[2]
Mr Kerstin Jerosch ,kerstin.jerosch@awi.de ,(None) ,Germany , ,Not Presenting[3]
Mr Andreas Mackensen ,andreas.mackensen@awi.de ,(None) ,Germany , ,Not Presenting[3]
Mr Irene Schloss ,ischloss@dna.gov.ar ,(None) ,Argentina , ,Not Presenting[5]
Mr Doris Abele ,doris.abele@awi.de ,(None) ,Germany , ,Not Presenting[3]
Mr Adrián Silva Busso ,silvabusso@yahoo.com.ar ,(None) ,Argentina , ,Not Presenting[7]
Mr Valeria Bers ,valeria_bers@hotmail.com ,(None) ,Germany , ,Not Presenting[8]
Mr Eduardo Ruiz Barlett ,eruizbarlett@yahoo.com.ar ,(None) ,Argentina , ,Not Presenting[9]
1 - British Antarctic Survey 2 - University of Bremen 3 - Alfred Wegener Institute 4 - Alfred Wegener Institute 5 - Instituto Antártico Argentino, Buenos Aires 6 - Alfred Wegener Institute 7 - University of Buenos Aires 8 - Leibniz Center for Tropical Marine Ecology 9 - Instituto Antártico Argentino

The discharge to the ocean of glacial meltwater from Antarctica is a key influence on the marine environment, with the potential to greatly impact circulation, sea level, primary production and the pelagic and benthic ecosystems. The nature of the impacts depends strongly on the detailed characteristics of the meltwater releases, in terms of their timing, spatial structure, particle load and persistence, thus it is important to resolve the fine-scale complexity of the controlling processes in order to reliably contrain budgets and to generate the mechanistic understanding required for improved predictive skill. Here we use a sequence of oxygen isotope and other oceanographic data to reveal the time-varying spatial pattern of meltwater during a discharge event into Potter Cove, northern Antarctic Peninsula. Contemporaneous meteorological data and glacial discharge modelling are used to elucidate the causes and timing of the freshwater release. We find that under low-turbulence conditions the meltwater released accumulates rapidly in an extremely thin, buoyant layer at the ocean surface. This layer has comparatively high turbidity, indicative of a significant load of suspended particles, and the physical processes outlined here play important roles in determining the impact this has on the ecosystem. The persistence of the buoyant freshwater layer within the cove depends strongly on the directionality of the local winds, which are sensitive to large-scale forcing from coupled modes of climate variability, including the El Nino-Southern Oscillation phenomenon, and the Southern Annular Mode, and which have exhibited significant trends in recent decades associated with climatic change at the Peninsula. It was shown recently that the strong glacial melt that occurs along the west Antarctic Peninsula is driven primarily by intrusions of warm water at depth, with the implication of predominantly subsurface freshwater discharge. Strengthening of these intrusions is forcing glaciers to retreat rapidly; if this continues such that glaciers become increasingly grounded on land (such as happened recently to the Fourcade Glacier that discharges into Potter Cove), the structure and impact of their discharges to the marine environment are likely to increasingly resemble the patterns elucidated here.

Impact of Atmospheric Model Physics on Coupled Arctic Climate Simulations

Abstract ID : 111

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. John Cassano ,john.cassano@colorado.edu ,(Associate Professor) ,United States ,Boulder ,Not Presenting[1]
Dr. Wieslaw Maslowski ,maslowsk@nps.edu ,(None) ,United States , ,Not Presenting[2]
Dr. Mark Seefeldt ,mark.seefeldt@colorado.edu ,(None) ,United States , ,Not Presenting[1]
Dr. Bart Nijssen ,nijssen@uw.edu ,(None) ,United States , ,Not Presenting[4]
Dr. Andrew Roberts ,afrobert@nps.edu ,(None) ,United States , ,Not Presenting[2]
1 - University of Colorado 2 - Naval Postgraduate School 3 - University of Colorado 4 - University of Washington 5 - Naval Postgraduate School

The Regional Arctic System Model (RASM) is a fully-coupled, regional model designed for simulating and studying the Arctic climate system. RASM is used on a large pan-Arctic domain that encompasses the entire Arctic Ocean and all Arctic draining watersheds. The component models in RASM are coupled using the NCAR CESM coupling framework and include atmosphere (WRF), ocean (POP), sea ice (CICE), and land (VIC) component models. RASM is an ideal modeling tool for studying the impact of mesoscale processes on the Arctic climate system. Changes in RASM boundary layer, deep and shallow convection, and cloud parameterizations have been shown to significantly alter the radiation budget within the RASM domain with a cascade of impacts throughout the climate system. Changes in these parameterizations alter the surface energy budget and temperature, leading to changes in evaporation from the ocean which impacts domain-wide precipitation. Changes in precipitation alter the amount and duration of snow cover on both sea ice and land, altering the modeled sea ice and land climates. Analysis of RASM simulations has shown that different boundary layer, convection, and microphysics parameterizations are needed over the ocean and land portions of the model domain, reflecting differences in the dominant cloud-forming processes acting over sub-polar oceans, mid- and high-latitude land areas, and over the sea ice covered Arctic Ocean.

Cloud structure and phase at Cape Grim, Macquarie Island and over the Southern Ocean

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Simon Alexander[1], Dr. Alain Protat[2], Dr. Andrew Klekociuk[3]
1 - Australian Antarctic Division 2 - Bureau of Meteorology 3 - Australian Antactic Division

Using depolarisation lidars located for seasonal campaigns at Cape Grim and Macquarie Island, we present the first (sub)-seasonal climatology of cloud structure and phases at these latitudes. The Bureau of Meteorology's UV Raman lidar with polarization capability was located at Cape Grim, Tasmania and collected data from July 203 - February 2014. The Australian Antarctic Division's depolarisation lidar was deployed to Macquarie Island in March 2016. We will demonstrate how a depolarisation lidar may determine cloud phase and discuss how cloud occurrence fraction varies with time and height at Cape Grim. The presence of super-cooled liquid water clouds will be detailed and results on their occurrence and frequency of ice virga precipitating out of these clouds presented. We show how the surface-based lidar validates satellite-based observations of cloud (DARDAR) and detail where and why differences occur. We will quantify the regular occurrence of very low level clouds and investigate the presence of multiple levels of super-cooled liquid water clouds at Macquarie Island. Lastly, we detail some cases of clouds observed by lidar on the CAPRICORN Southern Ocean cruise (autumn 2016).

Localized rapid warming of West Antarctic subsurface waters by remote winds

Abstract ID : 197

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Paul Spence[1]
1 - Australia ,Sydney

The largest rates of Antarctic glacial ice mass loss are occurring to the west of the Antarctica Peninsula in regions where warming of subsurface continental shelf waters is also largest. However, the physical mechanisms responsible for this warming remain unknown. Here we show how localized changes in coastal winds off East Antarctica can produce significant subsurface temperature anomalies (>2°C) around much of the continent. We demonstrate how coastal-trapped Kelvin waves communicate the wind disturbance around the Antarctic coastline. The warming is focused on the western flank of the Antarctic Peninsula because the anomalous circulation induced by the coastal-trapped waves is intensified by the steep continental slope there, and because of the presence of pre-existing warm subsurface water. The coastal-trapped waves lead to an adjustment of the flow that shoals isotherms and brings warm deep water upwards onto the continental shelf and closer to the coast. This result demonstrates the unique vulnerability of the West Antarctic region to a changing climate.

Antarctic Peninsula Climate Variability and Change

Abstract ID : 308

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. John Turner ,jtu@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
1 - British Antarctic Survey

The Antarctic Peninsula is an area of remarkable climatic variability, having experienced a warming as large as any location in the Southern Hemisphere during the second half of the Twentieth Century and then subsequently cooled at an even greater rate since that time. The large inter-annual and inter-decadal variability comes about for a number of reasons. The area is to the east of the Amundsen Sea Low (ASL) and the region of large climate variability known as the 'pole of variability', which results in large changes in the meridional component of the winds arriving on the Peninsula. The ASL has deepened since the late 1970s as a result of the 'ozone hole' but there are indications that the deepening has been taking place since at least the 1950s. The ASL is also influenced by tropical climate variability, including the phases of the El Niño-Southern Oscillation and the Interdecadal Pacific Oscillation. The impact of these changes in atmospheric circulation are amplified because of variations in sea ice extent, which can change the magnitude of the flux of heat from the ocean, especially in winter. The large cooling during the Twenty First Century has been a result of a switch to more easterly winds bringing more cold air in from the Weddell Sea. These complex atmosphere-sea ice interactions are poorly represented in the current generation of global climate models. In this presentation I will assess past and possible future climate change across the Antarctic Peninsula and the potential impact on the glaciology of the region.

Wind-controlled export of Antarctic Bottom Water from the Weddell Gyre

Abstract ID : 314

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Alberto Naveira Garabato ,acng@noc.soton.ac.uk ,(None) ,United Kingdom , ,Presenting[1]
Dr. Christian Buckingham ,chrcki@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. Sonya Legg ,sonya.legg@noaa.gov ,(None) ,United States , ,Not Presenting[3]
Dr. Carl Spingys ,C.P.Spingys@soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Dr. Kurt Polzin ,kpolzin@whoi.edu ,(None) ,United States , ,Not Presenting[5]
Prof. Michael Meredith ,mmm@bas.ac.uk ,(Science Leader) ,United Kingdom ,Cambridge ,Not Presenting[2]
Dr. Keith Nicholls ,kwni@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. Alexander Forryan ,a.forryan@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Dr. Povl Abrahamsen ,epab@bas.ac.uk ,(Physical Oceanographer) ,United Kingdom ,Cambridge ,Not Presenting[2]
Dr. Eleanor Frajka-Williams ,E.Frajka-williams@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
1 - University of Southampton 2 - British Antarctic Survey 3 - Geophysical Fluid Dynamics Laboratory 4 - University of Southampton 5 - Woods Hole Oceanographic Institution 6 - British Antarctic Survey 7 - British Antarctic Survey 8 - University of Southampton 9 - British Antarctic Survey 10 - University of Southampton

The Weddell Gyre is one of the key regions of Antarctic Bottom Water (AABW) production by vigorous atmosphere - ice - ocean interactions on the Antarctic continental shelves. Upon sinking, AABW flows equatorward in deep boundary currents, navigates complex topographic barriers bounding the Gyre to the north, and pervades much of the global ocean abyss within the densest layers of the Meridional Overturning Circulation. In the last 2-3 decades, AABW has experienced a strinkingly rapid and widespread warming across much of the global ocean. The causes of this warming are unknown. Here, we analyse hydrographic and mooring-based observations of the AABW flow and properties in the Orkney Passage (one of the major sites of AABW export from the Weddell Gyre) to show that AABW temperature variations on intra-annual to inter-annual time scales are controlled primarily by wind forcing. The flow - topography interaction dynamics underpinning this wind control are assessed with fine- and microstructure measurements of the AABW flow through the Passage, obtained with a collection of moored, ship-deployed and AUV-mounted instrumentation as part of the DynOPO (Dynamics of the Orkney Passage Outflow) experiment. Initial results indicate that wind forcing perturbations alter the bottom Ekman flow along the sloping topography of the Passage, and that this in turn changes the intensity of the downward heat transport effected by turbulent mixing - thereby modifying the temperature of the AABW flowing through the Passage.

Change in Arctic Ocean freshwater content in response to a step change in wind forcing

Abstract ID : 371

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Helen Johnson ,helen.johnson@earth.ox.ac.uk ,(Associate Professor) ,United Kingdom ,Oxford ,Not Presenting[1]
Ms. Emma Beer ,emb17@hotmail.co.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. Camille Lique ,camille.lique@ifremer.fr ,(None) ,France , ,Not Presenting[3]
Dr. Yavor Kostov ,ykostov@gmail.com ,(None) ,United Kingdom , ,Not Presenting[1]
1 - University of Oxford 2 - None 3 - IFREMER 4 - University of Oxford

We investigate how freshwater storage in the Arctic Ocean responds to a change in atmospheric forcing, by examining the relationship between freshwater storage and sea-level pressure (SLP) in an unperturbed control simulation of the high-resolution coupled climate model, HiGEM. Multiple lagged regression is used to extract the response of integrated freshwater content to a hypothetical step increase in the Arctic Oscillation and other principle components of SLP. The results demonstrate that the freshwater content responds on a decadal timescale, consistent with our expectation that eddies set the timescale on which the Arctic Ocean adjusts to changes in surface forcing. The relationship between freshwater and sea-level pressure is then exploited in an attempt to predict the variability in freshwater content under greenhouse gas forcing applied to the same model.

Trends in surface meteorological conditions over West Antarctica during austral summer, 1979-2015 from a regional atmospheric model

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Additional Information : None

Dr. Pranab Deb ,prab@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Dr. Andrew Orr ,anmcr@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Prof. John Turner ,jtu@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Mr John King ,jcki@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]
Dr. David Bromwich ,bromwich@polarmet1.mps.ohio-state.edu ,(None) ,United States , ,Not Presenting[5]
1 - British Antarctic Survey 2 - British Antarctic Survey 3 - British Antarctic Survey 4 - BAS 5 - Polar Meteorology Group, Byrd Polar and Climate Research Center, The Ohio State University

West Antarctica (WA) has experienced significant climate changes in recent decades which include an acceleration in ice loss and a warming at the Byrd research station over central WA. However, long-term meteorological observations from WA are limited and the multiple reconstructions of WA temperature show a lack of consensus on seasonal and spatial scales. With an aim to produce an improved estimate of the recent meteorological trends over WA, hindcast simulations with the Polar Weather Research and Forecasting model were conducted at a high horizontal resolution of 15 km for the summer months (December-January-February) for the period 1979-2015. Our analyses reveal a significant cooling trend over WA in summer, with the strongest contribution coming during December. During December, a deepening of the surface pressure can be seen over the central WA as well as over the coastal Amundsen Sea sector. Consistent 10-m meridional wind trends show a southerly flow over central/west WA (to the west of 130W) and northerly flow over the central/east WA. The southerly flow in meridional wind explains the strong cooling seen over the west/central part of the domain. These circulation changes result in an overall negative trend in the resultant 10-m wind speed over most of the WA and a corresponding reduction in wind shear in the lower layer of the atmosphere. A reduced wind shear results in a stronger stratification (due to reduced vertical mixing with warmer upper layers), and thus to a cooler surface layer. The effect is pronounced at night when temperature inversions are common over most of WA. This is evident from the diurnal cycle in the cooling trend with stronger cooling at night. The cooling is consistent with a positive trend in SAM and a deepening and eastward movement of the Amundsen Sea low.

Synergy of Sea Surface Salinity, Sea Surface Height, and Ocean Bottom Pressure to Study Arctic Ocean Freshwater Changes

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Additional Information : None

Dr. Tong Lee ,tlee@jpl.nasa.gov ,(Principal Scientist) ,United States ,Pasadena, California ,Not Presenting[1]
Dr. Severine Fournier ,Severine.Fournier@jpl.nasa.gov ,(None) ,United States , ,Not Presenting[1]
Dr. Ronald Kwok ,Ronald.Kwok@jpl.nasa.gov ,(None) ,United States , ,Not Presenting[1]
1 - NASA JPL 2 - NASA JPL 3 - NASA JPL

Arctic Ocean freshwater content and distribution are changing due to the combined effects of river runoff, precipitation, sea-ice melt, and wind-driven ocean circulation. These changes can impact North Atlantic Ocean circulation and the related transports of heat, freshwater, carbon, and nutrients that have potential influence on climate and weather as well as water cycle and biogeochemistry. Satellite observations can alleviate the paucity of in-situ salinity observations in the Arctic Ocean. This study explores the complementarity of satellite observations of sea surface height anomaly (SSHA), ocean bottom pressure (OBP), and sea surface salinity (SSS) to characterize Arctic Ocean freshwater content, distribution, and pathways. SSH-OBP anomalies reflect steric change integrated over the water column, which is mostly due to salinity change in the upper Arctic Ocean. SSS is indicative of the effects of runoff, precipitation, and sea-ice melt as well as being affected by ocean dynamics. Due to the weak vertical stratification compounded by vertical mixing, SSS is expected to be coherent with halosteric height changes, thereby providing a potential proxy for freshwater content. Nevertheless, the current L-band radiometers used to measure SSS have relatively low sensitivity to salinity in cold waters. While technology advancement is being explored to improve the sensitivity, it is worthwhile to examine the capability of current satellite SSS in depicting the Arctic Ocean given the large magnitude of Arctic SSS signal that helps improve the signal-to-noise ratio. This presentation will highlight results of synergistic use of SSS, SSH, and OBP anomalies to study Arctic Ocean freshwater changes using the state estimate from a four-dimensional variational ocean data assimilation product as well as satellite-derived SSH, OBP, and SSS measurements. An approach to evaluate the quality of L-band SSS measurements using SSH and OBP is also discussed.

Surface Melting on the Greenland Ice Sheet: Recent Drivers, Future Scenarios

Abstract ID : 539

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Additional Information : None

Dr. David Reusch ,david.reusch@nmt.edu ,(Research Associate Professor) ,United States ,Socorro ,Not Presenting[1]
1 - None

Melting on the surface of the Greenland ice sheet has been changing dramatically as global air temperatures have increased in recent decades. Examples include melt extent frequently exceeding the 1981-2010 median through much of the melt season, including the ice-sheet-wide event of 2012, and the onset of intermittent melt moving to earlier in the year.
We investigate recent and future drivers of surface melting using the regional forecast model Polar WRF with different driving datasets. Polar WRF provides higher resolution regional modeling (here 15 km) and improved, polar-centric model physics. We first developed a Polar WRF-based 30-year (1986-2015) summer (JJA) reference climatology with the ERA-Interim reanalysis (ERAI). The 30-member CESM1.0-CAM5-BGC Large Ensemble (LENS) was then used for recent (1996-2005) and future (RCP 8.5, 2071-2080) WRF runs. Recent simulations were skill-tested against ERAI and AWS observations with results informing future interpretations. For example, LENS tends to overpredict both maximum (above-freezing) and minimum daily average surface temperatures compared to the GC-Net Swiss Camp AWS.
Intramodel uncertainty was also examined via ensemble variability in LENS daily data. For 1981-2000, spatially averaged climatological July temperature anomalies over a Greenland ice-sheet/ocean domain are mostly between +/- 0.2 °C, relative to the ensemble average. The spatial average hides larger local anomalies of up to +/- 2 °C. The ensemble average itself is ~2 °C cooler than ERAI.
Self-organizing maps (SOMs) extend our standard diagnostics and climatologies by providing a concise, objective summary of model variability as a set of generalized patterns. For LENS, the SOM patterns summarize the variability of multiple realizations of climate: changes in pattern frequency by ensemble member show the influence of initial conditions. For example, analysis of pattern frequency yields interquartile ranges of 2-4% for individual patterns across the ensemble. In climate terms, this tells us about climate state variability through the range of the ensemble, a potentially significant source of melt-prediction uncertainty.

Understanding the Structure of Atmospheric Boundary Layer in Response to the Synoptic Forcing over the Southern Ocean

Abstract ID : 541

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Additional Information : None

Prof. Steve Siems ,steven.siems@monash.edu ,(Associate Professor) ,Australia ,Melbourne ,Not Presenting[1]
Mr. Francisco Lang ,francisco.lang@monash.edu ,(None) ,Australia , ,Not Presenting[2]
Dr. Yi Huang ,vivian.huang@monash.edu ,(None) ,Australia ,Melbourne ,Not Presenting[2]
Prof. Michael Manton ,michael.manton@monash.edu ,(None) ,Australia , ,Not Presenting[2]
1 - Monash University 2 - Monash University 3 - Monash University 4 - Monash University

Boundary layer clouds over the oceans are one of the most important contributors to the global radiation budget due to their large shortwave radiative effects. In-situ observations of the atmospheric boundary layer (ABL) over the Southern Ocean (SO) suggest that a complex, multi-level structure is commonly present beneath the free troposphere (e.g. Russell et al., 1998), which presents a challenge to the coarse-resolution climate models and reanalysis data sets. Recent studies (e.g. Bodas-Salcedo et al., 2012; Williams et al., 2013) suggest that the poor representation of ABL and their clouds may be a major contributor to the large shortwave radiative bias in the cold sector of extra-tropical cyclones over the SO. Most studies have used satellite observations to characterize the influence of synoptic meteorology in the ABL (e.g. Huang et al. 2014, Naud et al. 2014). In this research, 16-year high resolution upper air soundings from Macquarie Island (54.62°S, 158.85°E) are used to explore the structure of the ABL over the SO in relation to the synoptic meteorology. Cyclones (Bauer and Del Genio, 2006) and fronts (Berry et al. 2011) identified with the ECMWF ERA-Interim data set are employed for a compositing analysis of ABL height and inversion strength, with a specific focus on the post-cold-frontal environment. Furthermore, thermodynamic profiles from the ERA-Interim reanalysis are compared against Macquarie Island soundings. Cyclone composites of observations indicate that the ABL is higher near/within the fronts and lower in the non-frontal conditions, with the highest heights present in the cold sector, being on average 550 meters higher than the warm sector. Evaluation of ERA-Interim profiles shows that the main temperature inversion heights under the influence of cold front passages are underestimated by the reanalysis data set. As direct consequence, significant differences are found in the moisture profiles within the ABL, under both pre- and post-cold-front conditions. At approximately between 500 and 2000 m, the observed relative humidity is between 8 to 16% higher than ERA-Interim. These results suggest that the ABL in the reanalysis data set is too shallow compared to the observations.

Arctic sea ice-ocean modeling study in collaboration with sediment trap measurements

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Dr. Eiji Watanabe ,ejnabe@jamstec.go.jp ,(Researcher) ,Japan ,Yokosuka ,Not Presenting[1]
1 - JAMSTEC

Seasonal and interannual variability in biogenic particle sinking was captured by the multi-year bottom-tethered sediment trap moorings in the Northwind Abyssal Plain (Station NAP: 75°N, 162°W, 1975 m water depth) of the Arctic Chukchi Borderland. The analysis of trap samples revealed early-winter flux peaks of the biogenic particle including fresh organic materials and lithogenic minerals. In this study, background mechanisms of the observed seasonality were investigated using a numerical modeling approach. A pan-Arctic sea ice-ocean general circulation model COCO is coupled with a lower-trophic marine ecosystem model NEMURO, which represents pelagic plankton species (i.e., diatom, flagellate, and copepod). The horizontal resolution is about 5 km so that mesoscale eddies and narrow boundary currents are resolved. A seasonal experiment for March-December 2010 demonstrated that the higher sinking flux of Particulate Organic Nitrogen (PON) was located along the pathways of mesoscale shelf-break eddies originating in the Barrow Canyon. The primary and secondary production of plankton still continued inside these eddies even after their separation from the Chukchi and Beaufort shelf breaks. A cold eddy with shelf bottom water reached Station NAP at the peak timing of PON flux in November. The model result suggested that relatively massive biogenic and lithogenic particles could be captured by the sediment trap via the eddy-induced transport. Sensitivity experiments with different sea ice condition suggested that the lateral transport of shelf-origin nutrient and biological materials toward the southern Canada Basin was promoted by the enhanced shelf bloom and more energetic eddy activity under less sea ice covers. Ongoing works with additional trap data newly obtained north of the Barrow Canyon (Station NBC), north of the Hanna Canyon (Station NHC), and in the Chukchi Abyssal Plain (Station CAP) will also be reported.

Increasing frequency and duration of Arctic winter warming events

Abstract ID : 606

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Additional Information : None

Dr. Robert Graham ,robert.graham@npolar.no ,(Postdoc) ,Norway ,Tromso ,Not Presenting[1]
Dr. Lana Cohen ,Lana.Cohen@npolar.no ,(None) ,Norway ,Tromsø ,Not Presenting[1]
Dr. Alek Petty ,alek.a.petty@nasa.gov ,(None) ,United States , ,Not Presenting[3]
Dr. Linette Boisvert ,linette.n.boisvert@nasa.gov ,(None) ,United States , ,Not Presenting[3]
Dr. Mats Granskog ,mats.granskog@npolar.no ,(None) ,Norway , ,Not Presenting[1]
Mr. Annette Rinke ,Annette.Rinke@awi.de ,(None) ,Germany , ,Not Presenting[6]
Dr. Stephen Hudson ,stephen.hudson@npolar.no ,(None) ,Norway , ,Not Presenting[1]
Dr. Marcel Nicolaus ,marcel.nicolaus@awi.de ,(None) ,Germany , ,Not Presenting[8]
1 - Norwegian Polar Institute 2 - Norwegian Polar Institute 3 - NASA 4 - NASA 5 - Norwegian Polar Institute 6 - AWI Potsdam 7 - Norwegian Polar Institute 8 - AWI

Near surface air temperatures close to 0?C were observed *in-situ* over sea ice in the central Arctic during the last three winter seasons. Here we use *in-situ* winter (December - March) temperature observations, such as those from Soviet North Pole drifting stations and ocean buoys, to determine how common Arctic winter warming events are. Observations of winter warming events exist over most of the Arctic Basin. Temperatures exceeding -5?C were observed during >30% of winters from 1954-2010 by North Pole drifting stations or ocean buoys. Using the ERA-Interim record (1979-2016), we show that the North Pole (NP) region typically experiences ten warming events (T2m>?10?C) per winter, compared with only five in the Pacific Central Arctic (PCA). There is a positive trend in the overall duration of winter warming events for both the NP region (4.25 days/decade) and PCA (1.16 days/decade), due to an increased number of events of longer duration.

What drives the variability of the Atlantic Water circulation in the Arctic Ocean?

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Additional Information : None

Dr. Camille Lique ,camille.lique@ifremer.fr ,(None) ,France , ,Not Presenting[1]
Dr. Helen Johnson ,helen.johnson@earth.ox.ac.uk ,(Associate Professor) ,United Kingdom ,Oxford ,Not Presenting[2]
1 - IFREMER 2 - University of Oxford

The Atlantic Water (AW) layer in the Arctic Basin is isolated from the atmosphere by the overlaying surface layer; yet observations of the AW pan-Arctic boundary current have revealed that the velocities in this layer exhibit significant variations on all timescales.
Here, analysis of a global ocean/sea ice model hindcast, complemented by experiments performed with an idealized process model, are used to investigate what controls the variability of AW circulation, with a focus on the role of wind forcing. The AW circulation carries the imprint of wind variations, both remotely over the Nordic and Barents seas where they force variability on the AW inflow to the Arctic Basin, and locally over the Arctic Basin through the forcing of the wind-driven Beaufort gyre, which modulates and transfers the wind variability to the AW layer. Our results further suggest that understanding variability in the large amount of heat contained within the AW layer requires a better understanding of the circulation within both AW and surface layers.

Glider experiment reveals enhanced submesoscale mixed layer instabilities in the Southern Ocean

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Additional Information : None

Mr. Marcel du Plessis ,marceldpl10@gmail.com ,(None) , , ,Not Presenting[1]
1 - UCT

The ocean influences climate by storing and transporting large amounts of heat and carbon, and exchanging these properties at the air-sea interface. The subduction of these properties from the ocean mixed layer to the interior is a key process for the regulation of the global climate. One way the ocean transports properties vertically and horizontally is through submesoscale (1-10 km) instabilities, which manifest in regions of large horizontal density gradients, of which the Southern Ocean is ubiquitous. This study investigates the impacts of submesoscale instabilities in the Subantarctic Zone using high-resolution (1-2 km, 2 hourly) autonomous glider observations collected over one full seasonal cycle. The results indicate strong frontal energetics in the upper ocean, with large horizontal density fronts present in the spring and summer months. We show that winds orientated along the flow of such fronts induce a destabilising flux via a horizontal Ekman buoyancy flux (EBF) towards the less dense domain of the front. EBF erodes the upper ocean stratification, deepens the mixed layer depth and reverses the sign of the potential vorticity, making the flow susceptible to submesoscale instabilities. Periods when the wind orientation reversed to up the frontal current, the mixed layer restratified. This restratifying flux is driven by the strength of the horizontal density gradients and the vertical extent of the mixed layer. Previous studies have shown that down-front EBF is associated with enhanced turbulent fluxes, which may have large implications for mixing and vertical transport in the Southern Ocean. Therefore, this study shows the need to incorporate submesoscale processes into global climate models.

Wind-driven mixing at intermediate depths in an ice-free Arctic Ocean

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Additional Information : None

Dr. Yueng Lenn ,y.lenn@bangor.ac.uk ,(SeniorLecturer) ,United Kingdom ,Menai Bridge ,Presenting[1]
Dr. Ben Lincoln ,ben.lincoln@bangor.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Prof. Tom Rippeth ,t.p.rippeth@bangor.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
Dr. Mary-Louise Timmermans ,mary-louise.timmermans@yale.edu ,(None) ,United States , ,Not Presenting[4]
Dr. William Williams ,Bill.Williams@dfo-mpo.gc.ca ,(None) ,Canada , ,Not Presenting[5]
Prof. Sheldon Bacon ,s.bacon@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[6]
1 - Bangor University, Wales 2 - School of Ocean Sciences, Bangor University, Wales 3 - Bangor University 4 - Yale University 5 - Fisheries and Oceans Canada, Institute of Ocean Sciences 6 - National Oceanography Centre

Recent seasonal Arctic Ocean sea ice retreat is a major indicator of polar climate change. The Arctic Ocean is generally quiescent with the interior basins characterized by low levels of turbulent mixing at intermediate depths. In contrast, under conditions of reduced sea ice cover, there is evidence of energetic internal waves that have been attributed to increased momentum transfer from the atmosphere to the ocean. New measurements made in the Canada Basin during the unusually ice-free and stormy summer of 2012 show previously observed enhancement of internal wave energy associated with ice-free conditions. However, there is no enhancement of mixing at intermediate depths away from significant topography. This implies that contrary to expectations of increased wind-induced mixing under declining Arctic sea ice cover, the stratification in the central Canada Basin continues to suppress turbulent mixing at intermediate depths and to effectively isolate the large Atlantic and Pacific heat reservoirs from the sea surface.

The surface energy budget in the sea ice zone

Abstract ID : 676

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Additional Information : None

Dr. Alexandra Weiss ,aiw@bas.ac.uk ,(None) ,United Kingdom ,Cambridge ,Not Presenting[1]
Dr. Tom Lachlan Cope ,tlc@bas.ac.uk ,(None) ,United Kingdom ,None ,Not Presenting[1]
Mr John King ,jcki@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Mr. Russ Ladkin ,rsla@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
1 - BAS 2 - BAS 3 - BAS 4 - BAS

Despite its key importance for the polar climate system the understanding of the surface energy balance over sea ice in Antarctica is still limited by uncertainties. In order to improve the understanding of the atmospheric surface energy budget in the sea ice region, airborne observations of the energy budget components, i.e. of radiation and turbulence fluxes, as well as of sea surface parameters were taken over sea ice, leads and coastal polynyas. The analysed observations show that the sea ice cover, its surface albedo and surface temperature play a crucial part in the alteration of the surface energy balance. In the austral summer the largest components of the surface energy budget in the sea ice area are the radiative components, whereas in comparison the non-radiative components, i.e. the sensible and latent turbulent heat fluxes, are both relatively small. Under warm air advection and Foehn events an Oasis effect can be observed over leads and polynyas with negative Bowen ratios, indicating melting of snow and ice, whereas under cold air advection over leads, polynyas and sea ice, we observed positive Bowen ratios and sea ice production. Over sea surfaces with relatively low albedo values the energy reached its maximum into the ocean/ice system, whereas over sea ice with high albedo values the energy into the ice ocean system reaches its minimum. On the basis of the observations we investigate the parameterization of the energy budget components, i.e. of the boundary layer heat and radiation fluxes and determined the effective roughness lengths of the ice-covered sea, which are needed as input parameter for describing the heat fluxes with bulk parameterizations in numerical models. Moreover, we determined the effective radiative fluxes over various sea ice conditions and investigate the parameterization of sea surface albedo with surface temperature data. Quality assessments of commonly used temperature-albedo parameterization schemes showed that different functions are appropriate for certain sea ice conditions.

The role of the interaction of storms and fronts in driving intraseasonal variability of primary production in the Southern Ocean

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Dr. Sarah Nicholson ,snicholson@csir.co.za ,(None) , , ,Not Presenting[1]
Dr. Marina Levy ,marina@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[2]
Dr. Pedro Monteiro ,pmonteir@csir.co.za ,(None) ,South Africa , ,Not Presenting[3]
Dr. Julien Jouanno ,julien.jouanno@legos.obs-mip.fr ,(None) ,France , ,Not Presenting[4]
Dr. Xavier Capet ,xclod@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[2]
Dr. Sebastiaan Swart ,sebastiaan.swart@marine.gu.se ,(None) ,Sweden , ,Not Presenting[6]
1 - CSIR 2 - LOCEAN-IPSL 3 - 1Southern Ocean Carbon-Climate Observatory (SOCCO), CSIR, and Department of Oceanography University of Cape Town, Cape Town, South Africa 4 - LEGOS 5 - LOCEAN-IPSL 6 - University of Gothenburg

The Southern Ocean is one of the stormiest places on earth; here strong mid-latitude storms frequently traverse large distances of this ocean. Their interaction with underlying meso to submesoscale dynamics has the potential to strongly impact the upper-ocean environment where phytoplankton live, yet exactly how remains unclear. Using a reentering zonal channel model representing an open ocean section of the Southern Ocean with mesoscale to sub-mesoscale turbulence and idealized storm forcing, we have shown how the interactions of these mechanisms may drive enhanced intraseasonal variability in primary production. These storms resulted in the generation of strong vertical mixing and post-storm wakes of increased vertical velocities associated with inertial wave activity lasting for more than two weeks. We show how this enhances the upward supply fluxes (advective and diffusive) of dissolved iron raising primary production by up to 20% from the background values during a storm event. What has emerged is an efficient coupled mechanism of vertical diffusion and advection allowing for the redistribution of surface and subsurface iron supplies during and between storm events.

Variability of the Antarctic slope current system in the northwestern Weddell Sea

Abstract ID : 740

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Additional Information : None

Ms. Marina do Valle Chagas Azaneu ,m.azaneu@uea.ac.uk ,(PhD student) ,United Kingdom ,Norwich ,Not Presenting[1]
Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[1]
Dr. Bastien Queste ,b.queste@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Prof. Andrew Thompson ,andrewt@caltech.edu ,(None) ,United States , ,Not Presenting[4]
1 - University of East Anglia 2 - University of East Anglia 3 - University of East Anglia 4 - California Institute of Technology

The dense water outflow from the Southern Ocean continental shelf is closely associated with the strength and position of the Antarctic Slope Front. We explore the short-term variability of the Antarctic Slope Front system and the mechanisms that regulate cross-slope exchange using high temporally- and spatially-resolved measurements from three ocean gliders deployed in 2012. Twenty-two sections along the eastern Antarctic Peninsula and west of the South Orkney Islands are grouped regionally and composited by isobaths. There is consistency in the front position around the Powell Basin, varying mostly between the 450 and 700m isobaths. The along-slope transport of the Antarctic Slope Current (upper 1000 m) varies between 0.2 and 5.9 Sv and does not exhibit a regional pattern. High eddy activity in the slope region contributes to the variability of the Slope Current. The magnitude of the velocity field shows substantial variability up to 2.2 times its mean value. In most of the study area the flow is bottom-intensified. Higher EKE (0.003m^2 s^{-2}) is observed on sections with dense water, possibly sourced by baroclinic instabilities at the bottom boundary layer. The vertical component of the planetary vorticity makes the main contribution to the potential vorticity, and is enhanced in the dense water layer. Glider transects west of the South Orkney Islands indicate a northward flow, which differs from previous estimates of the mean circulation's. This study provides some of the first observational confirmation of the high frequency variability associated with an active eddy field that has been suggested by recent numerical simulations in this region.

Evaluating Highest Temperature Extremes in the Antarctic

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Additional Information : None

Dr. Matthew Lazzara ,mattl@ssec.wisc.edu ,(None) ,United States ,Madison ,Not Presenting[1]
Dr. Maria de Los Milagros ,mms@smn.gov.ar ,(None) ,Argentina , ,Not Presenting[2]
Mr John King ,jcki@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
Dr. Randall Cerveny ,cerveny@asu.edu ,(None) ,United States , ,Not Presenting[4]
Dr. José Luis Stella ,jls@smn.gov.ar ,(None) ,Argentina , ,Not Presenting[2]
Dr. Susan Solomon ,solos@mit.edu ,(None) ,United States , ,Not Presenting[6]
Dr. Phil Jones ,p.jones@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]
Dr. David Bromwich ,bromwich.1@osu.edu ,(None) ,United States , ,Not Presenting[8]
Dr. James Renwick ,james.renwick@vuw.ac.nz ,(None) ,New Zealand , ,Not Presenting[9]
Mr. Chris Burt ,ccburt@earthlink.net ,(None) ,United States , ,Not Presenting[10]
Dr. Thomas Peterson ,thomas.carl.peterson@gmail.com ,(None) ,United States , ,Not Presenting[11]
Dr. Manola Brunet ,manola.brunet@urv.cat ,(None) ,Spain , ,Not Presenting[12]
Dr. Russell Vose ,russell.vose@noaa.gov ,(None) ,United States , ,Not Presenting[13]
Dr. Daniel Krahenbuhl ,daniel.krahenbuhl@asu.edu ,(None) ,United States , ,Not Presenting[14]
Dr. Fatima Driouech ,driouechfatima@yahoo.fr ,(None) ,Morocco , ,Not Presenting[15]
1 - University of Wisconsin-Madison 2 - Departamento Climatologia Servicio Meteorológico Nacional 3 - BAS 4 - School of Geographical Sciences, Arizona State University 5 - Departamento Climatologia Servicio Meteorológico Nacional 6 - Department of Earth, Atmospheric and Planetary Sciences, MIT 7 - Climate Research Unit, University of East Anglia 8 - Byrd Polar and Climate Research Center, Ohio State University 9 - Victoria University of Wellington 10 - The Weather Company, IBM 11 - World Meteorological Organization Commission for Climatology 12 - Centre for Climate Change, University of Rovira, Spain and Climatic Research Unit, University of East Anglia, UK 13 - NOAA's National Centers for Environmental Information 14 - Arizona State University 15 - Climate Studies Service, Direction de la Météorologie Nationale

As part of the ongoing work of the World Meteorological Organization (WMO) Commission for Climatology (CCl) in detection and documentation of global weather extremes (e.g., El Fadli et al. 2013), a WMO committee has gathered and carefully evaluated evidence for three temperature extremes associated with the Antarctic region, defined as all lands and ice shelves south of 60°S, and recommended acceptance of these extremes into the WMO World Archive of Weather and Climate Extremes (https://wmo.asu.edu/). The "Highest Temperature [Antarctic Region]" is the temperature of 19.8°C (67.6°F) observed on 30 January 1982 at Signy Research Station at Factory Cove, Borge Bay on Signy Island. Given acceptance of this extreme, one important goal that the committee has addressed is the improvement of public education regarding the Antarctic's distinct climatic regimes (specifically maritime versus plateau environments). Therefore, the committee has also recommended the establishment of two subregional temperature extremes and verified those observations: The temperature extreme of 17.5°C (63.5°F) recorded on 24 March 2015 at the Argentine Research Base Esperanza located near the northern tip of the Antarctic Peninsula is the highest temperature recorded for the Antarctic Region [continent only] and the observation of -7.0°C (19.4°F) made on 28 December 1989 at an Automatic Weather Station (AWS) site D-80 located inland of the Adélie Coast is accepted as the highest temperature recorded for the Antarctic Region [plateau, at or above 2500 meters]. The committee noted that the extremes at all three stations occurred during periods of warm

air advection. At Signy and Esperanza, föehn warming also contributed while, at D-80, solar heating under clear skies at high elevation was a major contributory factor.

Impacts of open-ocean deep convection in the Weddell Sea on coastal and bottom water temperature

Abstract ID : 768

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Additional Information : None

Prof. Zhaomin Wang ,wzm@nuist.edu.cn ,(None) ,China ,Nanjing ,Not Presenting[1]
1 - Hohai University

A high resolution global ocean-sea ice model is employed to investigate the impacts of open-ocean deep convection on coastal and bottom water temperature in the Weddell Sea. The imposed strong and persistent cyclonic wind forcing and the large loss of bottom water weaken the stratification and eventually trigger the occurrence of open-ocean deep convection in the southern limb of the Weddell Gyre in this model. The production rate of the bottom water induced by the deep convection is estimated to be about 5 Sv (1 Sv = 10^6 m^3/s) for a polynya with a similar size to that of the observed Weddell Polynya in the mid-1970s. The deep convection induced cooling at mid-depth is transported towards the shelf regions by standing meanders or eddies to affect the basal melting of ice shelves, and is transported westward by an intensified slope current; interior coastal temperature in regions with a broader continental shelf is less affected by the deep convection, as the intensified slope current acts to suppress heat exchanges across the shelf break. Also, the deep convection causes warming in the Weddell bottom water around the convection site, when the simulated polynya size is similar to that of the observed Weddell Polynya in the mid-1970s, with this finding shedding light on understanding the observed non-monotonic decadal change (cooling between 1984-1992 and warming between 1998-2008?in the Weddell bottom water temperature; when the simulated polynya further develops into a large size well across the Weddell Sea, the sustained broad deep convection causes large cooling in the bottom water in the western Weddell Sea and warming in the eastern Weddell Sea, with the bottom water temperature being also strongly modulated by a greatly intensified Weddell Gyre.

Interconnectivity between volume transports through Arctic straits

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Dr. Agatha de Boer ,agatha.deboer@geo.su.se ,(None) ,Sweden ,None ,Not Presenting[1]
Dr. David Hutchinson ,david.hutchinson@geo.su.se ,(Postdoctoral Researcher) ,Sweden ,Stockholm ,Not Presenting[1]
Dr. Qiong Zhang ,qiong.zhang@natgeo.su.se ,(None) ,Sweden , ,Not Presenting[1]
Dr. Leon Chafik ,leonchafik@gmail.com ,(None) ,Sweden , ,Not Presenting[1]
Dr. Louise Sime ,lsim@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[5]
Prof. David Stevens ,D.Stevens@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[6]
1 - Stockholm University 2 - Stockholm University 3 - Stockholm University 4 - Stockholm University 5 - British Antarctic Survey 6 - University of East Anglia

Volume transports through the Arctic-Subarctic straits have a major impact on Arctic heat and freshwater budgets. The drivers of each strait flow have typically been studied individually, however mass conservation demands that the strait flows balance each other. Here we study the interconnectivity of volume transports through Arctic Straits in a 130-year high resolution simulation from the coupled climate model HiGEM1.1. We find three main inter-strait connections, which we call modes of circulation. (1) The Atlantic-Pacific mode links the Nordic Seas throughflow to that of the Bering Strait. (2) The Greenland mode represents a strong correlation between the Nordic Seas and the Davis Strait throughflows. Finally, (3) the Svalbard mode relates the flow into the Arctic via the Barents Sea to that through the Fram Strait. Interestingly, the volume transports through the Bering Strait and the Davis Strait are not correlated. The Atlantic-Pacific mode, Greenland mode, and Svalbard mode operate in different frequency bands, namely within 3-7 year, 6-23 year, and 8-20 year periods respectively. All three modes are anomalously positive when the mean sea level pressure is lower in the Nordic seas. This is due to south-westerly winds that drive an anomalous volume transport from the Nordic Seas into the Arctic. That flow exits the Arctic through either the Fram Strait, Bering Strait or Davis Strait, depending on the strength of the Aleutian low in the North Pacific and the sea level in the Labrador Sea region. Comparisons with common climate indices show weak but significant correlations between the Atlantic-Pacific mode and the North Atlantic Oscillation (NAO) and between the Greenland mode and the Atlantic Meridional Overturning Circulation. While the Barents Sea throughflow correlates with the NAO, it co-varies with the Fram Strait on lower frequencies than the typical frequencies of the NAO. This suggests that the Svalbard mode is not driven by the NAO as has been previously suggested.

Climatic drivers of microalgae viability in Arctic seasonal sea ice

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Prof. Marcello Vichi ,marcello.vichi@uct.ac.za ,(Director of the Marine Research Institute) ,South Africa ,Cape Town ,Presenting[1]
Dr. Letizia Tedesco ,letizia.tedesco@ymparisto.fi ,(None) ,Finland , ,Not Presenting[2]
Mr. Enrico Scoccimarro ,enrico.scoccimarro@cmcc.it ,(None) ,Italy , ,Not Presenting[3]
1 - Department of Oceanography and Institute of Marine Research, University of Cape Town 2 - Finnish Environment Institute (SYKE) 3 - Centro Euromediterraneo sui Cambiamenti Climatici (CMCC)

Climate model projections of sea-ice changes in the Arctic Ocean are characterized by large spread and uncertainties that hamper their usage for predicting changes in sea-ice biogeochemistry. Despite sea-ice algae being a major contributor of Arctic marine production, scientists have not yet fully included sea-ice biogeochemistry in earth system models. The impact of climate change on microalgae habitat is mostly inferred through speculative conceptual models, combining what-if scenarios with the limited knowledge from field observations. We propose a hybrid quantitative approach to combine climate model projections and numerical models of sea-ice biogeochemistry to investigate the future changes in sea-ice algae and their habitat conditions. We focus on first-year sea ice given the importance that it plays in polar ecosystems and the expectation that the majority of the Arctic ocean may become seasonal at the end of the century. Daily simulations of sea-ice physical properties from the Climate Model Inter-comparison Project Phase 5 (CMIP5) for the historical (1961-2005) and scenario RCP8.5 (2061-2100) period have been used to derive empirical probablity density functions of sea-ice drivers from 18 models that have been verified against current remote sensing data. The ensemble of the median values of the distributions allowed to generate representative sea-ice seasons at different latitudes, which were used to force simple but physiologically comprehensive sea-ice biogeochemical models. Results indicate that the extent of first-year sea ice is expected to shrink from about 10^6 km^2 to half of this size at the lower latitudes, while the higher latitudes are likely to show an extent of seasonal sea ice that is similar to what is currently found at 60^oN. The changes in sea-ice permeability, light availability and sea-ice season duration are expected to develop a multi-faceted response of the algae to the mutated habitat conditions. Our quantitative analysis confirm the conceptual expectation of generalized increase in bulk biomass, although the role played by different degrees of snow-coverage impacts largely on the latitudinal response. The band between 65^oN and 75^oN that will experience the least changes in first-yar ice features is also the one with the smallest impact on sea-ice algae.

Seasonal changes in Circumpolar Deep Water in the Amundsen Sea, Antarctica, using seal-borne tags

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Content Motivation : None
Additional Information : None

Ms. Helen Mallett ,h.mallett@uea.ac.uk ,(PhD Student) ,United Kingdom ,Norwich ,Not Presenting[1]
Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[2]
Prof. David Stevens ,D.Stevens@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Mr Lars Boehme ,lb284@st-andrews.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]
Prof. Mike Fedak ,maf3@st-andrews.ac.uk ,(None) ,United Kingdom , ,Not Presenting[5]
1 - None 2 - University of East Anglia 3 - University of East Anglia 4 - Sea Mammal Research Unit 5 - University of St Andrews

In the Amundsen Sea, Antarctica, there have been suggestions that warm Circumpolar Deep Water (CDW) is increasingly crossing the continental shelf toward the Pine Island Glacier (PIG), contributing to increased ice mass loss. However, understanding of this process is limited by the difficulty of collecting data in this area, especially during the winter season when harsh conditions and sea ice cover limit traditional observation techniques. Presented here are the results of a seal tagging campaign on the Amundsen Sea continental shelf, producing the first near-year-round, full-depth sampling, and yielding an order of magnitude more profiles in one year than the entire historical CTD data set.

These data reveal that the warmest CDW reaches the continental shelf via the eastern trough. On the 27.77 isopycnal, representing CDW, water throughout much of the eastern Amundsen Sea is up to 0.08 more saline and up to 0.5ºC warmer in summer (February-May) than in winter (June-October). Seasonal variations in CDW are particularly prominent around Burke Island and in the northwest of Pine Island Bay. Below the mixed layer in the region around Burke Island, isopycnals are ∼100 m shallower in winter than summer.

In Pine Island Bay, a gyre circulation is revealed by doming isopycnals. In winter at the edge of the gyre, isopycnals are ∼50 m shallower, but at the same time at the centre of the gyre, isopycnals are deeper. This suggests a slowing of the Pine Island Bay gyre in winter, with associated reduction in the doming of the isopycnals. Here we discuss the changes in circulation that are suggested by the seasonal changes in isopycnal slopes and water mass properties.

Air-Sea-Ice Interaction Associated with the 2016 Weddell Polynya

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Additional Information : None

Prof. G.W.K. Moore ,gwk.moore@utoronto.ca ,(None) ,Canada , ,Presenting[1]
Ms. Ailin Brakstad ,Ailin.Brakstad@uib.no ,(None) ,Norway , ,Presenting[2]
Dr. Kjetil Vage ,kjetil.vage@gfi.uib.no ,(None) ,Norway , ,Presenting[3]
1 - University of Toronto 2 - University of Bergen 3 - Geophiscal Institute, University Bergen

Maud Rise, a seamount in the Weddell Sea, is a location where polynyas occasionally form. The most dramatic of these events was the ~300,000km^2 polynya that occurred over the 3-year period from 1974-1976. Another smaller polynya developed in August 1994 and there is evidence of a persistent halo of reduced ice cover in the vicinity of Maud Rise that may be a signature of a Taylor Cap. The presence of a polynya at high southern latitudes during the austral winter can lead to vigorous air-sea interaction resulting in a densification of the surface waters and a convective overturning of the water column that contributes to the formation of Antarctic Bottom Water. Although these events are important climatic phenomena, there is still much that is unknown regarding how they form as well as the characterization of the atmospheric forcing that occurs within them and the oceanic response. In August 2016, a polynya developed in late July and persisted for approximately 3 weeks with a maximum extent of open water in excess of 40,000km^2. Here we use new high resolution atmospheric, oceanic and cryospheric datasets to examine the air-sea interaction that occurred within the polynya. Sea ice growth in the Weddell Sea region was delayed by approximately one month during the early winter of 2016 resulting in anomalously large air-sea heat fluxes throughout the month of June that may have contributed to a pre-conditioning of the water column in the vicinity of Maud Rise. The development of the polynya was associated with the passing of several deep cyclones through the region with the maximum extent of open water occurring just after the passage of a system with a central pressure less than 950mb. There was an intermittency to the area of open water within the polynya that was associated with variability in the magnitude of the turbulent heat flux suggesting that ice formation and brine rejection was occurring within the polynya. The role that the atmospheric forcing as well as the contribution of this brine rejection to the deepening of the oceanic mixed layer will be examined with a 1d model.

Cloud-aerosol-precipitation processes over the Southern Ocean – what are we missing?

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Additional Information : None

Dr. Yi Huang ,vivian.huang@monash.edu ,(None) ,Australia ,Melbourne ,Presenting[1]
Dr. Alain Protat ,A.Protat@bom.gov.au ,(None) ,Australia , ,Not Presenting[2]
Dr. Ruhi Humphries ,Ruhi.Humphries@csiro.au ,(None) ,Australia , ,Not Presenting[3]
Dr. Simon Alexander ,simon.alexander@aad.gov.au ,(Research scientist) ,Australia ,Kingston ,Not Presenting[4]
Prof. Steve Siems ,steven.siems@monash.edu ,(Associate Professor) ,Australia ,Melbourne ,Not Presenting[5]
Prof. Michael Manton ,michael.manton@monash.edu ,(None) ,Australia , ,Not Presenting[1]
1 - Monash University 2 - Australian Bureau of Meteorology 3 - CSIRO 4 - Australian Antarctic Division 5 - Monash University 6 - Monash University

Global climate models continue to be challenged by large errors in energy and water budget over the Southern Ocean (SO). These errors can be traced to poor understanding of cloud-aerosol-precipitation processes over this remote, measurement-sparse region. In March-April 2016, comprehensive shipborne observations were made during the 40-day cruise of the Clouds, Aerosols, Precipitation Radiation and atmospherIc Composition Over the southeRN ocean (CAPRICORN) campaign. These fresh observations present a unique opportunity to advance our understanding of this poorly studied yet climatically significant region.
In this talk, a detailed case study is presented where measurements were made in the cold-air side of an extratropical cyclone - a condition where large errors are commonly found in climate model simulations. The radiosonde sounding, shipborne cloud radar and lidar observations revealed a multi-layer structure in lower troposphere, which was persistent for over 18 hours. A large field of weakly precipitating low-level cloud was observed below 2km, above which a uniform layer of non-precipitating cloud was detected between 3 and 5 km. The mid-level cloud was composed primarily of supercooled liquid water (SLW), as suggested by the lidar, residing in the temperature range of -5 to -15°C. Measurements of the cloud condensation nuclei revealed a pristine marine condition, with the median value constantly below 100 cm^{-3}. The shipborne measurements of near cloud-top properties are largely consistent with the retrieved variables from the concurrent Himawari-8 satellite observations. However, the satellite is challenged by the complex multi-layer structure hence unable to reveal the district cloud and precipitation features. In particular, the retrieved effective radius was biased towards the upper-layer non-precipitating SLW cloud whereas the low-level precipitating cloud was completely unseen.
Simulations with the operational Australian Community Climate and Earth-System Simulator (ACCESS) regional weather model are evaluated with the shipborne and satellite observations. It is found that the model is unable to produce the multi-layer structure and the associated cloud and precipitation processes. Instead, widespread convective precipitation associated with heavily glaciated clouds is commonly simulated.
The implication of this study to the ongoing efforts to better understand and simulate the cloud-aerosol-precipitation processes over the SO will be discussed.

Mechanisms driving variability in the ocean forcing of Pine Island Glacier

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Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Ben Webber ,B.Webber@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[1]
Prof. David Stevens ,D.Stevens@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Dr. Pierre Dutrieux ,Pierre Dutrieux <pierred@ldeo.columbia.edu> ,(None) ,United States , ,Not Presenting[4]
Dr. Povl Abrahamsen ,epab@bas.ac.uk ,(Physical Oceanographer) ,United Kingdom ,Cambridge ,Not Presenting[5]
Dr. Adrian Jenkins ,ajen@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[5]
Mr. Stanley Jacobs ,sjacobs@ldeo.columbia.edu ,(None) ,United States , ,Not Presenting[4]
Dr. SangHoon Lee ,hoonenator@icloud.com ,(None) ,South Korea , ,Not Presenting[8]
Prof. Ho Kyung Ha ,hahk@inha.ac.kr ,(None) ,South Korea , ,Not Presenting[9]
Dr. Tae-Wan Kim ,twkim@kopri.re.kr ,(None) ,South Korea , ,Not Presenting[8]
Dr. Satoshi Kimura ,satoshi.kimura@nersc.no ,(None) ,Norway , ,Not Presenting[11]
1 - University of East Anglia 2 - University of East Anglia 3 - University of East Anglia 4 - Lamont-Doherty Earth Observatory 5 - British Antarctic Survey 6 - British Antarctic Survey 7 - Lamont-Doherty Earth Observatory 8 - Korea Polar Research Institute 9 - Inha University 10 - Korea Polar Research Institute 11 - NERSC

Pine Island Glacier (PIG) terminates in a rapidly melting ice shelf, and ocean circulation and temperature are implicated in the retreat and growing contribution to sea level rise of PIG and nearby glaciers. However, the variability of the ocean forcing of PIG has been poorly constrained due to a lack of multi-year observations. Here we show, using a unique record close to the Pine Island Ice Shelf (PIIS), that there is considerable oceanic variability at seasonal and interannual timescales, including a pronounced cold period from October 2011 to May 2013. This variability can be largely explained by two processes: cumulative ocean surface heat fluxes and sea ice formation close to PIIS; and interannual reversals in ocean currents and associated heat transport within Pine Island Bay, driven by a combination of local and remote forcing. Local atmospheric forcing therefore plays an important role in driving oceanic variability close to PIIS.

Numerical modelling simulations conducted in a high-resolution regional configuration of the MITgcm are used to further investigate the dynamical links between surface forcing and ocean forcing of the glacial melt rates. Heat fluxes into the cavity beneath the Pine Island Ice shelf exhibit large variability on interannual and decadal time scales. At the decadal time scale, these variations are closely linked to heat fluxes onto the continental shelf driven by surface winds at the shelf break and surface-driven upwelling across the continental shelf. The barotropic circulation around the Pine Island Trough region spins up and down in response to this forcing. In addition, there is an overturning cell within Pine Island Trough that strengthens (weakens) during periods of large (small) heat fluxes towards Pine Island Bay.

Observations of clouds over the Weddell Sea during the Austral Summer

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Dr. Tom Lachlan Cope ,tlc@bas.ac.uk ,(None) ,United Kingdom ,None ,Presenting[1]
Dr. Constantino Listowski ,constantino.listowski@latmos.ipsl.fr ,(None) ,France , ,Not Presenting[2]
Dr. Sebastian O'shea ,sebastian.oshea@manchester.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
1 - BAS 2 - Laboratoire Atmosphères, Milieux, Observations Spatiales 3 - University of Manchester

There is a lack of in situ observations of clouds at high southern latitudes and this is reflected in the poor performance of numerical models, particularly in the long and short wave radiation at the surface. This study reports on the result of three airborne campaigns have been carried out over the Weddell Sea during the austral summer - two during 2010 and 2011 in the west close to the Antarctic Peninsula and one in the east close to the Brunt Ice shelf. Airborne observations were made at both locations of cloud particle size, number and phase. A comparison is made between both sides of the Antarctic Peninsula and the eastern side of the Weddell Sea. It found that source of the airmass in which the cloud is formed is more important than the actual location of the cloud. Airmasses that have passed close to the surface of the sea ice are found to have more cloud particles leading to the conclusion that the sea ice is a significant source of cloud nuclei. The importance of secondary ice production within these summertime clouds is also reported.
These observation have been compared to the clouds represented within the Weather Research and Forecast (WRF) model using several of the cloud parameterisation schemes available for that model. It is found that the Morison scheme produces the best results, however, further work is suggested to improve this by improving the representation of cloud nuclei within these schemes.

Observations of Submesoscale Instabilities and Frontal Structure in Drake Passage

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Content Motivation : None
Additional Information : None

Miss. Giuliana Viglione ,gviglion@caltech.edu ,(Graduate Student, Environmental Science and Engineering) ,United States ,Pasadena ,Not Presenting[1]
Prof. Andrew Thompson ,andrewt@caltech.edu ,(None) ,United States , ,Not Presenting[2]
Dr. Janet Sprintall ,jsprintall@ucsd.edu ,(Research Oceanographer) ,United States ,La Jolla ,Not Presenting[3]
Dr. Mar Flexas ,marf@caltech.edu ,(None) ,United States , ,Not Presenting[1]
Dr. Sebastiaan Swart ,sebastiaan.swart@marine.gu.se ,(None) ,Sweden , ,Not Presenting[5]
1 - Caltech 2 - California Institute of Technology 3 - Scripps Institution of Oceanography 4 - Caltech 5 - University of Gothenburg

Submesoscale motions may produce vertical velocities in the upper ocean that can either re-stratify the mixed layer or penetrate the strong, persistent buoyancy gradients found at the base of the mixed layer. Submesoscale motions in the Antarctic Circumpolar Current (ACC) remain largely uncharacterized due to a lack of observations, and simulated flows at these scales remain unvalidated. The ChinStrAP (Changes in Stratification at the Antarctic Peninsula) field campaign consisted of two four-month deployments of two gliders in Drake Passage. From December to April (2014-15), the gliders sampled on either side of Shackleton Fracture Zone (SFZ), a major bathymetric feature of the region, collecting over 2800 hydrographic profiles. These are used to examine the density structure and estimate potential vorticity (PV) in the region. The balanced Richardson angle (the ratio of the vertical to lateral buoyancy gradients) is used to classify submesoscale instabilities; comparison with a 1/48° resolution GCM is used to validate this approach. Significant differences in the lateral buoyancy gradients and mixed layer depths up- and down-stream of SFZ suggest dissimilar dynamics between the two regions. Intermittent instances of symmetric instability are identified downstream of SFZ throughout the summer. We propose that the differences are due enhanced variability downstream of the SFZ due to topographic steering upstream of the SFZ and the injection of Weddell Sea waters downstream of the SFZ. From May to September (2016) the gliders sampled in parallel, with a separation of ~15 km, from southern Drake Passage across the Polar Front. Multiple meridional sections reveal a series of submesoscale fronts across Drake Passage that had previously not been resolved. The sampling strategy permits reconstruction of a the three-dimensional (balanced) Ertel PV at scales of ~15 km. Deeper mixed layers in the winter season suggest a higher proclivity for submesoscale instabilities upstream of the SFZ than observed in the summer months. The results emphasize the significant role that submesoscale motions play in modulating the near-surface stratification and frontal structure at a key location for the ventilation of deep density classes.

Variability in Circulation and Hydrography in the Denmark Strait

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Content Motivation : None
Additional Information : None

Mr. Mattia Almansi ,mattia.almansi@jhu.edu ,(Ph.D. Student) ,United States ,Baltimore ,Not Presenting[1]
Prof. Thomas Haine ,thomas.haine@jhu.edu ,(Convener) ,United States ,Baltimore ,Not Presenting[1]
Dr. Robert S. Pickart ,rpickart@whoi.edu ,(None) ,United States , ,Not Presenting[3]
Dr. Marcello Magaldi ,marcello.magaldi@sp.ismar.cnr.it ,(None) ,Italy , ,Not Presenting[4]
Dr. Renske Gelderloos ,rgelder2@jhu.edu ,(None) ,United States , ,Not Presenting[1]
Dr. Dana Mastropole ,dmastropole@gmail.com ,(None) ,United States , ,Not Presenting[3]
1 - Johns Hopkins University 2 - Johns Hopkins University 3 - Woods Hole Oceanographic Institution
4 - CNR ISMAR 5 - Johns Hopkins University 6 - Woods Hole Oceanographic Institution

The Irminger Basin is dynamically relevant to the global climate system. Indeed, the exchange of freshwater between the east Greenland shelf and the basin
is a key element in the maintenance and variability of the Atlantic Meridional Overturning Circulation. Therefore, we have set up a high-resolution realistic model centered on the east Greenland shelf, the Iceland and Irminger Seas to interpret the sparse observations available for this area. The dynamics are simulated using the Massachussetts Institute of Technology general circulation model and results from a 12 month (from September 2007 to September 2008) simulation are presented. The model domain has been extended with respect to a previous version of this model to include the whole Iceland Sea in the north as well as Cape Farewell in the southwest: the regional configuration extends between 47°W-1°E and 57°N-77°N and the grid resolution over the center of the domain (the east Greenland shelf, the Iceland and Irminger Seas) is 2km with 216 vertical levels. The previous version of this model has also been improved: surface runoff and solid discharge from the Greenland Ice Sheet are now included.
Our analyses focuses on the Látrabjarg hydrographic section across the Denmark Strait. The model density at this section shows good agreement with a composite of hydrographic sections over a 20-year period. Temperature and salinity structures in our model are also similar to the structures identified from observations, although the model temperature values are slightly lower ($T \leq 1$°C in the trough) and the salinity values slightly higher ($S \leq 0.05$ in the trough). These biases can be due to (i) inter-annual variability, (ii) lack of observations on the Greenland side of the strait, and (iii) model errors. However, since previous studies found a significant decrease of the Denmark strait overflow, and a warming of the near bottom layer during the early 2000s, inter-annual variability may be the predominant factor. We also study and compare with observations the size, location and hydrographic properties of "boluses" and "pulses": these important dense waters travel at high speeds increasing the transport of the overflow across the Denmark Strait.

Comparison on A-Train cloud microphysical properties with in-situ measurements over the winter-time Southern Ocean

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Additional Information : None

Prof. Steve Siems ,steven.siems@monash.edu ,(Associate Professor) ,Australia ,Melbourne ,Presenting[1]
Dr. Yi Huang ,vivian.huang@monash.edu ,(None) ,Australia ,Melbourne ,Not Presenting[2]
Prof. Michael Manton ,michael.manton@monash.edu ,(None) ,Australia , ,Not Presenting[2]
Ms. Eunmi Ahn ,jenny.ahn@monash.edu ,(None) ,Australia , ,Presenting[2]
1 - Monash University 2 - Monash University 3 - Monash University 4 - Monash University

Clouds over the Southern Ocean remain poorly appreciated, primarily due to a lack of in-situ observations. Ahn (2017) details in-situ observations of the microphysics of low-level, Southern Ocean clouds measured over 20 flights taken off the coast of Tasmania during the winter season (June - October, 2013 - 2015). Consistent with the early findings of the Southern Ocean Cloud Experiment (SOCEX-I), these clouds were commonly found to have very low cloud droplet number concentration (10-40 cm-3) and large effective radius (11-16 ?) except when closed mesoscale cellular convection was encountered. (Such clouds were more consistent with the summer observations reported for SOCEX-II.) Opposed to the early SOCEX-I observations mixed phase clouds were predominantly encountered, instead of strictly supercooled liquid water clouds. In this work, we employ these in-situ observations (9 flights, 2013-2015) to be appreciate satellite retrievals made over the Southern Ocean. In particular, the effective radius and cloud droplet number concentration retrieved or calculated from MODIS observations (2.1 ?), the thermodynamic phase from CALIPSO and the precipitation rate from CloudSat are contrasted against in-situ calculations. Overall, both MODIS retrieved effective radius and cloud number concentration[VH1] were larger than those from the in-situ measurements (~5 - 10 ?for CAS+CIP and ~5 - 15 ? for CAS only)[VH2] when little drizzle was present[VH3] . Despite the various sources of uncertainties of the satellite retrievals, initial results suggest that the presence of drizzle/light precipitation was a dominant factor in the in-situ observations, but were poorly captured/characterised by MODIS-based calculations.

Arctic warming via moist intrusions

Abstract ID : 1303

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Content Motivation : None
Additional Information : None

Prof. Rodrigo Caballero ,rodrigo@misu.su.se ,(None) ,Sweden , ,Not Presenting[1]
Dr. Cian Woods ,cian@misu.su.se ,(None) ,Sweden , ,Not Presenting[1]
Prof. Gunilla Svensson ,gunilla@misu.su.se ,(None) ,Sweden , ,Not Presenting[1]
Dr. Gabriele Mesori ,gabriele@misu.su.se ,(None) ,Sweden , ,Not Presenting[1]
1 - Stockholm University 2 - Stockholm University 3 - Stockholm University 4 - Stockholm University

The Arctic is the region where the most dramatic climate change is expected. There is increasing observational evidence that the Arctic winter climate is strongly controlled by filamentary intrusions of moist, warm air--akin to the atmospheric rivers of lower latitudes--which cross the entire basin. The passage of a moist intrusion over the Arctic leads to large surface temperature anomalies of up to 20 K, which affect seasonal-mean temperature and can lead to extreme warming events. They also reduce or eliminate the low-level temperature inversion which normally prevails over the Arctic. Cumulatively, intrusions yield a surface-amplified warming which previous work has associated with positive lapse-rate feedback in the high latitudes. I will discuss the synoptic-scale structure of intrusion events and the physical processes involved in shaping their surface impact. I will also discuss how the statistical distribution of intrusions is affected by large-scale atmospheric circulation, particularly midlatitude storm track activity, blocking events, and possibly by interaction with the stratosphere. I will also explore the how the statistics of moist intrusions are represented in CMIP5 models, and how biases and future changes in model-simulated large-scale circulations are reflected in moist intrusion statistics and surface climate in the Arctic basin.

Identifying glacial meltwater and upper ocean processes using noble gases in the Amundsen Sea

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Additional Information : None

Dr. Louise Biddle ,louise.biddle@marine.gu.se ,(Postdoctoral Researcher) ,Sweden ,Gothenburg ,Not Presenting[1]
Dr. Brice Loose ,bloose@uri.edu ,(None) ,United States , ,Not Presenting[2]
Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[3]
1 - University of Gothenburg 2 - University of Rhode Island 3 - University of East Anglia

Pine Island Ice Shelf, in the Amundsen Sea, is losing mass due to warm ocean water penetrating beneath the ice shelf and causing basal melt. Tracing this warm deep water and the resulting glacial meltwater it produces can help identify changes in melt rate, feedbacks onto the circulation across the continental shelf, and the regions most affected by the increased input of this freshwater. Here, optimum multi-parameter analysis is used to deduce glacial meltwater fractions from water mass characteristics (standard hydrographic observations, noble gases and oxygen isotopes), collected during a ship-based campaign in the eastern Amundsen Sea in February-March 2014. Noble gases (neon, argon, krypton and xenon) and oxygen isotopes are used to trace the meteoric (precipitation and glacial melt) water found in seawater. A comparison of the results from water mass analysis using hydrographic observations (temperature, salinity, dissolved oxygen) with analysis using strictly noble gases reveals trade offs in each suite of tracers. The presence of glacial meltwater is shown to erode the hydrographic WW properties, resulting in differences between the water mass analyses of up to 4 per mil glacial meltwater content. This is accounted for by simulating a "pure" WW endpoint, and remaining disparities between the analyses reflect how upper ocean processes can affect individual tracers through sea ice formation/melt, biological productivity and air-sea gas exchange. The corrected glacial meltwater content values show a persistent signature in the upper 400 m of the water column across all of the sample locations (up to 500 km from Pine Island Ice Shelf), with increased concentration towards the west along the coastline.

Southern Ocean diabatic eddy heat flux response to altered northern boundary conditions.

Abstract ID : 1341

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Miss. Helen Burns ,H.Burns@noc.soton.ac.uk ,(PhD Student) ,United Kingdom ,Southampton ,Not Presenting[1]
Prof. Sybren Drijfhout ,S.S.Drijfhout@soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
1 - 2 - University of Southampton

When considering the Southern Ocean (SO) in isolation, the Southern Ocean residual overturning circulation (SO ROC) can only be closed with an open northern boundary condition, or with very strong diapycnal mixing in the SO. For the upper cell, which largely consists of an adiabatic pole-to-pole circulation, diabatic forcing outside the SO appears essential. When the northern boundary is closed, this cell vanishes. An evaluation of the buoyancy budget shows that this is achieved through a response in the diabatic eddy heat flux, causing the effective buoyancy forcing to become zero. Using a series of idealised channel model runs we show how the diabatic eddy heat flux is altered in response to the changing stratification in the north.
With strong diabatic forcing at the northern boundary, the diabatic eddies counteract the heat transport convergence by the residual circulation. With weak diabatic forcing the residual circulation decreases, but diabatic eddies and heat transport divergence by the ROC increase. A sharp internal boundary layer is established with large vertical temperature gradient and a dipole in heat flux divergence. As a result, the vertical sum of the heat flux divergence decreases, with the diabatic eddy heat flux divergence matching the surface forcing. This result, however, depends on the surface boundary condition. When a restoring boundary condition is used instead of a flux boundary condition, meridional and vertical temperature gradients are more constrained. The internal boundary layer does not develop and the pattern of diabatic eddy fluxes changes accordingly.

Physical processes involved in the response of Southern Ocean sea ice to increased freshwater release from antarctic glaciers.

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Dr. Julien Le Sommer ,julien.lesommer@univ-grenoble-alpes.fr ,(None) ,France ,Grenoble ,Not Presenting[1]
Dr. Nacho Merino ,ignacio.merino@univ-grenoble-alpes.fr ,(None) ,France , ,Not Presenting[1]
Dr. Durand Gaël ,Gael.Durand@univ-grenoble-alpes.fr ,(None) ,France , ,Not Presenting[1]
Dr. Nicolas C. Jourdain ,nicolas.jourdain@univ-grenoble-alpes.fr ,(None) ,France , ,Not Presenting[4]
Dr. Pierre Mathiot ,pierre.mathiot@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[5]
Dr. Hugues Goose ,hugues.goosse@uclouvain.be ,(None) ,Belgium , ,Not Presenting[6]
Dr. Gurvan Madec ,gurvan.madec@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[7]
1 - IGE, CNRS 2 - IGE, CNRS 3 - IGE, CNRS 4 - Univ. Grenoble Alpes, CNRS, IRD, IGE, F-38000 Grenoble, France. 5 - Met Office Hadley Centre 6 - UCL 7 - LOCEAN / CNRS

Antarctic outlet glaciers are undergoing rapid transitions. Induced changes in freshwater release to the Southern Ocean have been suggested to contribute to ongoing trends in Southern Ocean water mass properties and sea ice regimes. However, ocean/sea-ice models disagree as to the quantitative response of the Southern Ocean to changes in glacial freshwater forcing.
In this study, a series of ocean/sea-ice modeling experiments is undertaken with a global 1/4° NEMO model configuration in order to study the physical processes involved in the changes of Southern Ocean sea ice over recent decades. Perturbation experiments are carried out with respect to atmospheric and freshwater forcings over recent decades. The freshwater forcing scenario explicitly takes into account the observed changes in the volume of Antarctic ice shelves, which is found to be a key component of changes in freshwater release.
Our results show that the increase in glacial freshwater release overall increases Antarctic sea ice extent, but with distinctive regional patterns and with large changes in sea-ice thickness. The physical processes involved in the response may differ substantially from region to region depending on the local conditions. Our results suggest that up to one half of the observed total changes in sea ice extent over recent decades might be due to changes in freshwater release, the other half being induced by atmospheric changes. This study emphasizes the need for improving the representation of freshwater sources and their evolution in climate models.

Effects of the Antarctic glacial runoff and icebergs calving on the Southern Ocean dynamics and sea ice

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Dr. Yevgeny Aksenov ,yka@noc.ac.uk ,(Senior Research Fellow) ,United Kingdom ,Southampton ,Presenting[1]
Prof. Sheldon Bacon ,s.bacon@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. George Nurser ,agn@noc.ac.uk ,(Principal scientist) ,United Kingdom ,Southampton ,Not Presenting[3]
Dr. Craig Rye ,C.Rye@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]
Dr. Alex Megann ,apm@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. Joakim Kjellsson ,joakim.kjellsson@physics.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[6]
Dr. Paul Holland ,pahol@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]
Dr. Jeff Ridley ,jeff.ridley@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[8]
Dr. Andrew Coward ,acc@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. Gareth Marshall ,gjma@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]
Prof. Robert Marsh ,robert.marsh@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[11]
Dr. Pierre Mathiot ,pierre.mathiot@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[12]
1 - National Oceanography Centre, UK 2 - National Oceanography Centre 3 - NOC 4 - University of Southampton 5 - National Oceanography Centre 6 - University of Oxford 7 - British Antarctic Survey 8 - Uk Met Office 9 - National Oceanography Centre 10 - British Antarctic Survey 11 - Univesrity of Southampton 12 - Met Office Hadley Centre

This study effect of freshwater glacial runoff and iceberg calving from the Antarctic on ocean stratification and circulation in the Southern Ocean. The changes in the ocean circulation could potentially modify transports of the warm subsurface waters onto the continental shelves and increase ice sheet melting. We investigate impacts of the increased freshwater discharge in the 1990s-2000s on the subsurface waters in the South- ern Ocean in the NEMO 1? global sea ice-ocean model. In the simulations, the warming signal is largely circum-Antarctic, with "hot spots" in the Bellingshausen-Amundsen and Ross seas. The warming of the subsurface waters in the Bellingshausen-Amundsen Sea exceeds 0.5?C/decade. Differences in spreading of the liquid freshwater and icebergs in the Southern Ocean are investigated. Hindcasts and forward projections with the eddy-admitting global NEMO 1/4? model are diagnosed to examine regional trends in the ocean and sea ice states and to attribute these to the changes in the freshwater forcing and wind. The study contributes to the "Poles Apart" research project and is funded by the Natural Environment Research Council UK (Grant NE/K011561/1).

JP3 - The Second International Indian Ocean Expedition (Iioe-2) And Related Oceanic And Coupled Atmospheric Research In The Indian Ocean (IAPSO, IAMAS)

Indian Ocean sources of Agulhas leakage

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Additional Information : None

Dr. Jonathan Durgadoo ,jdurgadoo@gmail.com ,(Post-doctoral Researcher and Scientific Coordinator) ,Germany ,Kiel ,Not Presenting[1]
Miss. Siren Rühs ,sruehs@geomar.de ,(PhD candidate) ,Germany ,Kiel ,Not Presenting[1]
Prof. Claus Böning ,cboening@geomar.de ,(None) ,Germany , ,Not Presenting[1]
Prof. Arne Biastoch ,abiastoch@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[1]
1 - GEOMAR Helmholtz Centre for Ocean Research Kiel 2 - GEOMAR Helmholtz Centre for Ocean Research Kiel 3 - GEOMAR Helmholtz Centre for Ocean Research Kiel 4 - GEOMAR Helmholtz Centre for Ocean Research Kiel

We examine the mean pathways, transit timescales, and transformation of waters flowing from the Pacific and the marginal seas through the Indian Ocean (IO) on their way toward the South Atlantic within a high-resolution ocean/sea-ice model. The model fields are analysed from a Lagrangian perspective where water volumes are tracked as they enter the IO. The IO contributes 12.6 Sv to Agulhas leakage, which within the model is 14.1 ± 2.2 Sv, the rest originates from the South Atlantic. The Indonesian Through-flow constitutes about half of the IO contribution, is surface bound, cools and salinificates as it leaves the basin within 10-30 years. Waters entering the IO south of Australia are at intermediate depths and maintain their temperature-salinity properties as they exit the basin within 15-35 years. Of these waters, the contribution from Tasman leakage is 1.4 Sv. The rest stem from recirculation of Subantarctic Mode Water formed within the IO. The marginal seas export 1.0 Sv into the Atlantic within 15-40 years, and the waters cool and freshen on-route. However, the model's simulation of waters from the Gulfs of Aden and Oman are too light and hence overly influenced to upper ocean circulations. In the Cape Basin, Agulhas leakage is well mixed. On-route, temperature-salinity transformations occur predominantly in the Arabian Sea and within the greater Agulhas Current region. Overall, the IO exports at least 7.9 Sv from the Pacific to the Atlantic, thereby quantifying the strength of the upper cell of the global conveyor belt.

The seasonal cycle of the tropical south Indian Ocean and its impact on intraseasonal and interannual variability

Abstract ID : 286

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Additional Information : None

Prof. Kelvin Richards ,rkelvin@hawaii.edu ,(Director) ,United States ,Honolulu ,Not Presenting[1]
Dr. Saulo Soares ,saulo@hawaii.edu ,(None) ,United States , ,Not Presenting[1]
1 - University of Hawaii 2 - University of Hawaii

Scale interactions in the coupled ocean/atmosphere of the tropics play a crucial role in shaping the climate state and its spatial and temporal variability. Here we revisit the mechanisms driving the seasonal cycles of mixed-layer (ML) temperature and salinity in the south tropical Indian Ocean (STIO) and their impact on shorter and longer time scale variability in the region. The seasonal cycle in the region is very much influenced by the basin-scale adjustment in response to monsoon winds in the eastern side of the basin. Our results highlight the prominent role of the zonal advection, which is part of the adjustment process, in bringing fresher/colder waters from the east to the central and western STIO during the austral Spring. This water mass drives a re-stratification of the upper ocean and plays a key role in the shallowing of the ML while maintaining a depressed thermocline. As a consequence, during austral Spring and early Summer, the uppermost STIO becomes decoupled from the thermocline. The water mass is found to arrive in complex pulses, induced by a combination of eddy and wave activity and the history of forcing, mixing and stirring along its trajectory. We further demonstrate that the zonal advection is at the heart of important intraseasonal and interannual variability in SST. At intraseasonal scales, the re-stratification induced by the fresher water mass acts as a positive feedback to the formation of diurnal warm layers by limiting the depth penetration of convection. At the interannual scale it contributes to the development of negative IOD events.

Lagrangian evolution of Madagascar cyclonic eddies from two dedicated Argo floats experiments

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Additional Information : None

Ms. Tamaryn Morris ,tammy@saeon.ac.za ,(ASCA Coordinator) ,South Africa ,Cape Town ,Presenting[1]
Dr. Borja Aguiar Gonzalez ,borja.aguiar.gonzalez@gmail.com ,(None) ,Netherlands , ,Not Presenting[2]
Dr. Juliet Hermes ,juliet@saeon.ac.za ,(None) ,South Africa ,None ,Not Presenting[1]
1 - SAEON 2 - 2NIOZ Royal Netherlands Institute for Sea Research, Department of Ocean Systems Sciences and Utrecht University 3 - SAEON

In this work we use Argo floats, satellite tracked drifters and satellite altimeter data to investigate the lagrangian evolution and water mass transport capabilities of two cyclonic eddies generated as lee-eddies on the cyclonic flank of the East Madagascar Current.
The first experiment was initiated in April 2013 with five Argo floats (daily profiles) and two drifters deployed across a cyclonic eddy, approximately two months old. The eddy was located southwest of Madagascar, and had reached maximum nonlinearity. The park depths of the Argo floats were 300 m and subsequently configured to range between 300 and 650 m; drifters were drogued to 15 m. This configuration accounts for the study of surface and subsurface retention capabilities of the eddy as reference to key biological species, which may make use of these nutrient-rich pathways from the upwelling areas south of Madagascar.
An eddy detection and tracking scheme is applied to altimeter data to monitor the lagrangian evolution of the eddy, propagating southwestward up to its interaction with the Agulhas Current (AC). After arrival at the western boundary, the Argo floats merge into the AC and are shown to slow down their southwestward propagation for about 10 days before accelerating as they progress down the east coast of South Africa with the AC. We suggest this phenomenon responded to the counter-interaction of the inshore flank of the cyclonic eddy with the AC. Interestingly, before their merger to the AC, the high-resolution sampling of both Argo floats and drifters reveals a pulsating mode of the eddy along the five complete loops (~9 days of periodicity) of observation.
The second experiment took place in July 2013 with the deployment of four Argo floats (500 m park depth, five-day profiling) across a younger Madagascar cyclonic eddy (approximately one month old). This second experiment supports results from the experiment performed in April 2013, demonstrating the lagrangian evolution and eddy properties of the Madagascar cyclonic eddies. This work represents a pioneering effort, which explores the capabilities of Argo dedicated experiments of eddy interactions with western boundary currents and ecological implications of *eddy retention* in the open *ocean*.

Nitrous oxide and hydroxylamine measurements in the southwest Indian Ocean

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Dr. Damian L. Arévalo-Martínez ,darevalo@geomar.de ,(Postdoc) ,Germany ,Kiel ,Presenting[1]
Prof. Hermann W. Bange ,hbange@geomar.de ,(None) ,Germany , ,Not Presenting[1]
Mr. Xiao Ma ,mxiao@geomar.de ,(None) ,Germany , ,Not Presenting[1]
Miss. Gesa K. Eirund ,gesa.eirund@env.ethz.ch ,(None) ,Germany , ,Not Presenting[4]
1 - GEOMAR Helmholtz Centre for Ocean Research Kiel 2 - GEOMAR Helmholtz Centre for Ocean Research Kiel 3 - GEOMAR Helmholtz Centre for Ocean Research Kiel 4 - Institute for Atmospheric and Climate Science, ETH Zurich

The southwestern basin of the Indian Ocean (SWIO) remains a rather under-sampled region with regards to nitrogen cycle processes. Here we present the results of extensive surface and water column nitrous oxide (N_2O) measurements as well as the first reported open ocean measurements of hydroxylamine (NH_2OH). Wind-driven upwelling in the zonal band between 5°S and 10°S led to an enhanced efflux of N_2O to the atmosphere with saturation values up to 122% and a maximum sea-to-air flux of 2.3 nmol m^{-2} s^{-1}. N_2O depth profiles showed supersaturation conditions throughout the water column with a distinct maximum (~ 30 nmol L^{-1}) at about 1000 m. Excess N_2O (ΔN_2O) was positively correlated with apparent oxygen utilization (AOU) and nitrate concentrations although different slopes of the ΔN_2O/AOU relationships could be identified above and below the concentration maxima. Although the vertical distribution of NH_2OH was highly variable, combined analysis with N_2O and nutrient data suggests nitrification as the major formation pathway of N_2O in the SWIO. Our observations suggest that the SWIO is a rather weak, yet, perennial source of atmospheric N_2O which should be considered in future efforts aiming to long-term monitoring of greenhouse gases in the Indian Ocean.

Space Observation of Surface Hydrodynamics and Carbon Cycle in North Indian Ocean

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Additional Information : None

Dr. W. Timothy Liu ,w.t.liu@jpl.nasa.gov ,(Senior Research Scientist) ,United States ,Pasadena, CA 91109 ,Not Presenting[1]
Dr. Xiaosu Xie ,xiaosu.xie@jpl.nasa.gov ,(None) ,United States , ,Not Presenting[2]
1 - None 2 - Jet Propulsion Laboratory

We used the phase difference of monsoon onsets between the Bay of Bengal and Arabian Sea to explain the annual occurrence of 'pre-monsoon drought', which causes human fatality and agricultural damage. The drought lasts for one to two weeks just before the summer monsoon onsets in the center of the Indian subcontinent. Moisture over land moves out to the Bay of Bengal before they could be replenished from the Arabian Sea.   We found that summer monsoon (southwest) wind onsets in the Arabian Sea and Bay of Bengal are preceded by sea surface temperature rises above threshold of deep convection, and the onsets occur earlier in Bay of Bengal than in the Arabian Sea. The onsets are also manifested in rainfall and intra-seasonal changes of surface salinity on top of the seasonal salinity advection. The observations are consistent with the hypothesis that, during boreal summer, intra-seasonal convective systems propagate eastward in the equatorial Indian Ocean and then move northward into Bay of Bengal to trigger the southwest monsoon. We are linking the change of surface ocean carbon dioxide fugacity and total alkalinity determined from spacebased data through our statistical models to the monsoonal thermodynamics and hydrodynamics.

BoBBLE (Bay of Bengal Boundary Layer Experiment): Exploring the ocean-atmosphere system in the southern Bay of Bengal during the summer monsoon

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Additional Information : None

Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Presenting[1]
Prof. Adrian Matthews ,a.j.matthews@uea.ac.uk ,(Professor of Meteorology) ,United Kingdom ,Norwich ,Not Presenting[2]
Dr. K Vijaykumar ,kvkumar@nio.org ,(None) ,India , ,Not Presenting[3]
Miss. V Thushara ,thushara@caos.iisc.ernet.in ,(None) ,India , ,Not Presenting[4]
Dr. Alejandra Sanchez-Franks ,alsf@noc.ac.uk ,(None) ,United Kingdom ,Southampton ,Not Presenting[5]
Dr. V. Vijith ,vijithvnair@gmail.com ,(Assistant Professor) ,India ,Kochi ,Not Presenting[6]
Dr. Jenson George ,jensonvgeorge@gmail.com ,(Post Doctoral Fellow) ,India ,Bangalore ,Not Presenting[1]
Prof. Ganapati Bhat ,bhat@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[8]
Dr. Ben Webber ,B.Webber@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. Bastien Queste ,b.queste@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. Rajdeep Roy ,rajdeeproy2003@yahoo.com ,(None) ,India , ,Not Presenting[11]
Dr. Amit Sarkar ,amitsarkar81@gmail.com ,(None) ,India , ,Not Presenting[12]
Mr. Anoop Nayak ,nayak@caos.iisc.ernet.in ,(None) ,India , ,Not Presenting[8]
Mr. Shrikant Pargaonkar ,shrikantmp@gmail.com ,(None) ,India , ,Not Presenting[4]
Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[2]
Dr. Dariusz Baranowski ,darek.baranowski@gmail.com ,(None) ,Poland ,Warsaw ,Not Presenting[16]
Dr. Rob Hall ,robert.hall@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. Brian King ,b.king@noc.ac.uk ,(None) ,India , ,Not Presenting[5]
Dr. Elizabeth Kent ,eck@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[5]
Dr. Nicholas Klingaman ,n.p.klingaman@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[20]
Dr. Simon Peatman ,s.peatman@reading.ac.uk ,(NCAS Research Scientist) ,United Kingdom ,Reading ,Not Presenting[21]
Dr. P. Amol ,prakashamol@gmail.com ,(None) ,India , ,Not Presenting[22]
Dr. C. P. Neema ,cpneema@gmail.com ,(None) ,India , ,Not Presenting[4]
Mr. Chandanlal Parida ,chandanlal.parida@gmail.com ,(None) ,India , ,Not Presenting[24]
Dr. Aneesh Lotliker ,aneesh@incois.gov.in ,(Scientist-D) ,India ,Hyderabad ,Not Presenting[25]
Mr. Ashok Kankonkar ,ashok@nio.org ,(None) ,India , ,Not Presenting[26]
Mr. D. Gracias ,desmond@nio.org ,(None) ,India , ,Not Presenting[27]
Mr. S. Vernekar ,sid.vernekar@gmail.com ,(None) ,India , ,Not Presenting[26]
Mr. Gowthaman Valluvan ,vgowtham@niot.res.in ,(None) ,India , ,Not Presenting[29]
Mr. Dinesh Kothandaraman ,dinesh@incois.gov.in ,(None) ,India , ,Not Presenting[30]
Mr. A. D'Souza ,adsouza@nio.org ,(None) ,India , ,Not Presenting[26]
1 - Indian Institute of Science 2 - University of East Anglia 3 - National Institute of Oceanography, Goa 4 - Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore, India 5 - National Oceanography Centre, Southampton, UK 6 - School of Marine Sciences, Cochin University of Science and Technology, Kochi, India 7 - Indian Institute of Science 8 - Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore, India 9 - University of East Anglia 10 - University of East Anglia 11 - Indian Space Research Organization (ISRO), National Remote Sensing

Centre (NRSC) Hyderabad, India. 12 - ESSO-National Centre for Antarctic and Ocean Research, Goa, India. 13 - Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore, India 14 - Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore, India 15 - University of East Anglia 16 - Institute of Geophysics, Faculty of Physics, University of Warsaw, Warsaw, Poland 17 - University of East Anglia 18 - National Oceanography Centre, Southampton, UK 19 - National Oceanography Centre, Southampton, UK 20 - National Centre for Atmospheric Science, Climate and Department of Meteorology, University of Reading, UK 21 - NCAS Climate, University of Reading 22 - CSIR-National Institute of Oceanography Regional Centre, Visakhapatnam, India 23 - Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore, India 24 - Berhampur University, Odisha, India 25 - Indian National Centre for Ocean Infromation Services (INCOIS) 26 - CSIR-National Institute of Oceanography, Goa, India 27 - CSIR-National Institute of Oceanography, Goa, India 28 - CSIR-National Institute of Oceanography, Goa, India 29 - ESSO-National Institute of Ocean Technology, Chennai, India 30 - ESSO-Indian National Centre for Ocean Information Services, Hyderabad, India. 31 - CSIR-National Institute of Oceanography, Goa, India

Weather systems that form over the Bay of Bengal (BoB) and then move over land contribute significantly to the rainfall received over India, Bangladesh and Myanmar. Air-sea interaction over the BoB plays a central role in nurturing such systems, owing to its ability to sustain a high SST through the season. A hitherto unexplored region important to the spatial patterns of the monsoon rainfall is the southern BoB where the features of the ocean and the overlying atmosphere are unique in many respects. BoBBLE was designed
to obtain high quality in situ data sets of the ocean, air-sea interface and atmosphere during the summer monsoon in the southern BoB. This presentation will provide an overview of the BoBBLE field campaign conducted on board *RV Sindhu Sadhana*, during June-July, 2016 and preliminary results thus obtained*. The southern BoB is marked by the intense monsoon current that flows into the BoB, flanked by the Sri Lanka Dome to its west and a high salinity core underneath. CTD profiles, data from 5 gliders, 2 ADCPs and 7 Argo floats have yielded a time-series of a zonal section of physical and bio-geochemical variables within the summer monsoon period. The time-series observations at 8°N, 89°E have captured two events of upper layer freshening and barrier layer formation interleaved by an episode of mixed layer deepening. The duration of observations encompassed a weak phase of the monsoon and a period of transition to an active phase. Data sets from an automated weather system, eddy covariance measurements and radiosondes have provided a detailed view of the associated development in air-sea fluxes. These observations are being complemented by stand-alone ocean model and coupled model experiments, with the aim of improving the forecast of the summer monsoon.
* Six other accompanying submissions will cover details of various results.

Observed Agulhas Current sensitivity to interannual climate forcings

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Additional Information : None

Dr. Shane Elipot ,selipot@rsmas.miami.edu ,(Associate Scientist) ,United States ,Miami ,Not Presenting[1]
Prof. Lisa Beal ,lbeal@rsmas.miami.edu ,(Professor of Ocean Sciences) ,United States ,Miami ,Not Presenting[1]
1 - Rosenstiel School of Marine and Atmospheric Science at the University of Miami 2 - Rosenstiel School of Marine and Atmospheric Science at the University of Miami

We study the interannual variability of the Agulhas jet transport near 34S from 1993 to 2016, as captured by a proxy time series derived from in situ measurements and satellite altimeter data. We find that 40 percent of the interannual variance of the Agulhas Current Jet transport can be significantly and linearly related to atmospheric patterns of the Southern Hemisphere, as obtained from reanalyses products. The Agulhas transport is increased southward for a wind stress pattern that, when averaged over the Indian Ocean, shows positive zonal wind stress anomalies between 45S and 65S, and negative anomalies between the Equator and 15S, therefore corresponding to intensified Trade Winds and Westerlies. Meridional and zonal wind stress anomalies result in increased positive wind stress curl between 35S and 52S, potentially providing a mechanism for the spin up the of the subtropical Indian gyre, and an intensified Agulhas current. The interannual atmospheric pattern driving stronger Agulhas jet transport can be decomposed into empirical modes, the first of which corresponds to the Madden-Julian Oscillation that leads to positive zonal wind stress anomalies over the South Indian subtropical gyre on interannual time scales. The second mode corresponds to the Antarctic Oscillation, or Southern Annular Mode, that leads to south-shifted Westerlies and positive curl anomalies on the southern edge of the subtropical gyre. Our findings potentially provide a framework for understanding the Agulhas' response to long-term climate change.

Characterization of Air-sea fluxes over the Bay of Bengal during the southwest monsoon

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Additional Information : None

Dr. Alejandra Sanchez-Franks ,alsf@noc.ac.uk ,(None) ,United Kingdom ,Southampton ,Not Presenting[1]
Dr. Elizabeth Kent ,eck@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Dr. Simon Peatman ,s.peatman@reading.ac.uk ,(NCAS Research Scientist) ,United Kingdom ,Reading ,Not Presenting[3]
Prof. Adrian Matthews ,a.j.matthews@uea.ac.uk ,(Professor of Meteorology) ,United Kingdom ,Norwich ,Not Presenting[4]
Dr. Ben Webber ,B.Webber@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]
Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[6]
Dr. Nicholas Klingaman ,n.p.klingaman@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]
Dr. Brian King ,bak@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[8]
Dr. V. Vijith ,vijithvnair@gmail.com ,(Assistant Professor) ,India ,Kochi ,Not Presenting[9]
Dr. Jenson George ,jensonvgeorge@gmail.com ,(Post Doctoral Fellow) ,India ,Bangalore ,Not Presenting[6]
Miss. V Thushara ,thushara@caos.iisc.ernet.in ,(None) ,India , ,Not Presenting[11]
1 - National Oceanography Centre, Southampton, UK 2 - National Oceanography Centre, Southampton, UK 3 - NCAS Climate, University of Reading 4 - University of East Anglia 5 - University of East Anglia 6 - Indian Institute of Science 7 - National Centre for Atmospheric Science, Climate and Department of Meteorology, University of Reading, UK 8 - National Oceanography Centre 9 - School of Marine Sciences, Cochin University of Science and Technology, Kochi, India 10 - Indian Institute of Science 11 - Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore, India

Meteorological variables and surface flux variables from five reanalysis products are compared and evaluated against in-situ data from the RAMA moored array. The reanalysis products, ERA-Interim (ERA-I), TropFlux, MERRA2, JRA-55 and CFSR are specifically assessed for their characterisation of air-sea fluxes during the southwest monsoon season (JJAS) in the Bay of Bengal. Results show that TropFlux and (to a slightly lesser extent) ERA-I perform best, with the highest correlations and smallest biases when compared to the observed meteorological parameters and the associated fluxes from the RAMA array. In contrast, MERRA2, CFSR and JRA-55 have lower correlations and much higher biases when compared to the observed data. In general, however, all products struggle to capture shortwave radiation flux (SWR) and latent heat flux (LHF), with non-negligible biases ranging from -6 W/m2 to 75 W/m2. Further analysis of the flux variables showed SWR and LHF to be the largest drivers of the observed net heat flux variability, thus highlighting the importance of the results from the reanalysis product comparison to the RAMA buoy. It was also found that mean fields were consistent with the findings at the buoy location, indicating confidence in the representation of variability across the basin. Finally, the representation of the intraseasonal variability was investigated through the boreal summer intraseasonal oscillation and it was shown that TropFlux and ERA-I perform best at capturing intraseasonal climate variability during the southwest monsoon season.

Ocean surface warm layers: development and spatio-temporal variability in the Bay of Bengal during the 2016 summer monsoon

Abstract ID : 788

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Additional Information : None

Dr. Dariusz Baranowski ,darek.baranowski@gmail.com ,(None) ,Poland ,Warsaw ,Presenting[1]
Prof. Adrian Matthews ,a.j.matthews@uea.ac.uk ,(Professor of Meteorology) ,United Kingdom ,Norwich ,Not Presenting[2]
Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[3]
Dr. Rob Hall ,robert.hall@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[2]
Dr. Bastien Queste ,b.queste@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. Alejandra Sanchez-Franks ,alsf@noc.ac.uk ,(None) ,United Kingdom ,Southampton ,Not Presenting[7]
1 - Institute of Geophysics, Faculty of Physics, University of Warsaw, Warsaw, Poland 2 - University of East Anglia 3 - Indian Institute of Science 4 - University of East Anglia 5 - University of East Anglia 6 - University of East Anglia 7 - National Oceanography Centre, Southampton, UK

Interactions between the atmosphere and the ocean play an important role in the development and evolution of the summer monsoon in the Bay of Bengal (BoB). Convective cloud systems that form over the BoB's warm waters bring rainfall to the Indian subcontinent during the summer monsoon season. The amount of energy available for development of the convective systems is highly dependent on the sea surface temperature (SST).
Surface warm layers in the ocean are relatively thin (~5m) and short-lived (~8h), and often develop at the ocean surface during the daytime through solar heating and increased SST. Persistent neglect of this layer results in underestimation of the net energy flux from the ocean to the atmosphere, which may lead to biases in monsoon precipitation patterns. Although it plays an important role throughout many stages of convective development, diurnal warm layers are rarely directly measured and their spatial and temporal variability and dependence on the environmental conditions is poorly understood.
During the Bay of Bengal Boundary Layer Experiment (BoBBLE) 5 gliders were deployed to measure upper ocean properties at high resolution across the BoB in July 2016. This dataset provides a unique insight into warm layer development, evolution and decay as well as its spatial and temporal variability and dependence on varying environmental conditions. Time series from the 5 individual platforms show clear variability of warm layer characteristics. In this presentation, dependence on atmospheric (surface wind speed, solar insolation and precipitation) and oceanic (stratification and currents) conditions on warm layer evolution will be addressed based on observations from those platforms.

High Spatial Resolution Imageries for Climate change impact studies at inhabited Islands of Lakshadweep - India

Abstract ID : 859

Conflict Declaration : There is no conflict of interest of anyway in the content and study related to the abstract submitted herewith.
Content Motivation : This study is carried out in the islands located in the submarine ridge, central Indian Ocean.
Additional Information : This abstract is a part of the ongoing interdisciplinary research network project entitled "Vulnerability Assessment and Development of Adaptation Strategies for Climate Change Impact with Special Reference to Coasts and Island Ecosystems of India (VACCIN)" funded by Ministry of Science and Technology, Govt. of India.

Dr. J Sundaresan Pillai ,csirvaccin2015@gmail.com ,(Head Climate Change Informatics) ,India ,New Delhi ,Not Presenting[1]
Mr. Arghadyuti Banerjee ,arghadyutibanerjee@gmail.com ,(None) ,India , ,Not Presenting[1]
Mr. Mutum Ibomcha Singh ,mutum.singh1@gmail.com ,(None) ,India , ,Not Presenting[1]
1 - CSIR-NISCAIR 2 - CSIR-NISCAIR 3 - CSIR-NISCAIR

Climate change will affect communities and their livelihood all over the world. Small islands will have the worst scenario due to climate change impact. Lakshadweep archipelagos located in Arabian Sea are very small flat islands with a few meters above mean sea level. These Islands are volcanic coral islands and is the metamorphic form of volcanic islands. It consists total 36 Islands, 12 are atolls and ten are inhabited. The inhabited Islands are Bitra, Chetlat, Klitan, Kadmat, Amini, Agatti, Androth, Kavaratti, Kalpeni and Minicoy. Lakshadweep islands have an exclusive economic zone of 4,00,000 sq.km and territorial waters of 20,000 sq.km. Land, landscape characteristics, sea level rise and spatial challenge of the ten inhabited islands were examined with satellite imageries of high spatial resolution (50 cm) , geospatial survey and ground truth verification. Digital Terrain Model (DTM) were generated for all the ten inhabited islands from ground control points surveyed with DGPS and Total station. Appropriate interval of contours were generated from DTM. A pair of temporary bench mark were established for each island using Differential Global Position System. Electronic Total Station were used for traversing method of survey along with DGPS. Specific software were applied to make corrections on the data received due to atmospheric disturbances, weak signals from satellite and incorrect signals due to ground disturbances. Thematic maps viz. shoreline, coast line, settlement, road network, water resources for all the ten inhabited Islands were prepared. The regions of inundation hence the worst affected thematic regimes were identified. The spatial challenge for planning in the limited land available in all the islands were examined under various scenarios of climate change and strategies for spatial planning were developed for less vulnerable ecosystem of these very small islands.

Special features of air-sea interaction over the North Indian Ocean during boreal summer

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Conflict Declaration : None
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Additional Information : None

Prof. Ganapati Bhat ,bhat@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[1]
1 - Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore, India

For most inhabitants of Southeast Asia, monsoon is a season of bountiful rainfall. Water vapor supply comes from across the equatorial Indian Ocean, the Arabian Sea and the Bay of Bengal. The highest rates of evaporation over tropical oceans during July-August months are observed between 10°S and 20°S in the Indian Ocean sector north of the Mascarene high, and strong evaporation also occurs over the central Arabian Sea and southern Bay of Bengal. While, high surface winds are partly responsible for this (evaporation rate is proportional to the surface wind speed), special nature of air-sea interactions ensure that air in the atmospheric boundary layer does not get saturated despite huge amount of vapor being added to it all along its several thousand kilometer trajectory before it ascends and rains over India. Several ship cruises have been conducted between 1998 and 2016 over the North Indian Ocean to understand air-sea interactions during the summer monsoon season. This presentation analyses *in situ* observations made during these ship cruises including the BoBBLE cruise, and explains the underlying physical processes. The study shows that both oceanic and atmospheric processes contribute to this, but the unique geographic location of the Arabian Sea and the Bay of Bengal is equally crucial.

Estimation of terms of temperature equation using in situ observations alone during BoBBLE (Bay of Bengal Boundary Layer Experiment)

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Additional Information : None

Dr. V. Vijith ,vijithvnair@gmail.com ,(Assistant Professor) ,India ,Kochi ,Presenting[1]
Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[2]
Dr. Ben Webber ,B.Webber@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
Prof. Adrian Matthews ,a.j.matthews@uea.ac.uk ,(Professor of Meteorology) ,United Kingdom ,Norwich ,Not Presenting[3]
Dr. Jenson George ,jensonvgeorge@gmail.com ,(Post Doctoral Fellow) ,India ,Bangalore ,Not Presenting[2]
Dr. K Vijaykumar ,kvkumar@nio.org ,(None) ,India , ,Not Presenting[6]
Miss. V Thushara ,thushara@caos.iisc.ernet.in ,(None) ,India , ,Not Presenting[7]
Dr. P. Amol ,prakashamol@gmail.com ,(None) ,India , ,Not Presenting[8]
Dr. Aneesh Lotliker ,aneesh@incois.gov.in ,(Scientist-D) ,India ,Hyderabad ,Not Presenting[9]
1 - School of Marine Sciences, Cochin University of Science and Technology, Kochi, India 2 - Indian Institute of Science 3 - University of East Anglia 4 - University of East Anglia 5 - Indian Institute of Science 6 - National Institute of Oceanography, Goa 7 - Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore, India 8 - CSIR-National Institute of Oceanography Regional Centre, Visakhapatnam, India 9 - Indian National Centre for Ocean Infromation Services (INCOIS)

The determination of terms of the temperature equation for the ocean using in situ measurements alone is an earnestly desired task in oceanography, but none exists to the best of our knowledge, owing to the challenges involved, particularly with regard to measuring horizontal gradients of temperature. Typically, in situ time series observations at a single (ship) location are combined with satellite data sets, in order to obtain horizontal gradients in space. An "operation advection" (OA) strategy was employed during BoBBLE (Bay of Bengal Boundary Layer Experiment) to obtain all the terms of the temperature equation from the southern Bay of Bengal, in the midst of the summer monsoon. At a time series location (8°N, 89°E), shipboard CTD profiling was carried out for a period of 10 days at roughly 3-hourly intervals. In addition to the ship, two gliders were simultaneously deployed, one along-stream and the other down-stream, in order to obtain horizontal spatial gradients with respect to the ship-board observations. This method was complemented by daily north-south and east-west uCTD sections, each along a roughly 10 km long transect. Velocities were estimated using two ship-board ADCPs, surface fluxes using both eddy covariance measurements and bulk estimates, and the penetrating component of radiation using an underwater radiometer. Vertical mixing rates were obtained using a turbulence profiler and horizontal mixing using a uCTD - ADCP combination. The analysis presented here quantifies processes that contributed to the evolution of SST during a weak phase in the summer monsoon. Our preliminary comparison of terms of the temperature equation suggests that horizontal advection contributes significantly to the rate of change of temperature. Moreover, we have demonstrated that using state-of-the art instrumentation, it is possible to obtain high quality quantitative estimates of processes determining evolution of SST during the summer monsoon, based on in situ measurements.

A SHALLOW SEAMOUNTS ECOSYSTEM PROJECT IN THE SOUTH WEST INDIAN OCEAN

Abstract ID : 922

Conflict Declaration : None
Content Motivation : Need to strengthen the ecosystem-related perspective in the current IIOE-2 programme
Additional Information : None

Dr. Francis Marsac ,francis.marsac@ird.fr ,(Director, ICEMASA) ,France ,Sete ,Presenting[1]
Miss. Pavanee Annasawmy ,pannasawmy@yahoo.com ,(None) ,Mauritius , ,Not Presenting[2]
Dr. Jean-Francois Ternon ,jean-francois.ternon@ird.fr ,(None) ,France , ,Not Presenting[1]
Mr. Zo Rasoloarijao ,zorasoloarijao@gmail.com ,(None) ,Madagascar , ,Not Presenting[4]
Dr. Michael Roberts ,Mike.Roberts@nmmu.ac.za ,(None) ,South Africa , ,Not Presenting[5]
Dr. Jenny Huggett ,jenny.huggett@gmail.com ,(Marine Scientist) ,South Africa ,Cape Town ,Not Presenting[6]
Mrs. Margaux Noyon ,margauxnoyon@gmail.com ,(None) ,South Africa , ,Not Presenting[7]
Dr. Delphine Thibault ,delphine.thibault@univ-amu.fr ,(None) ,France , ,Not Presenting[8]
1 - IRD 2 - IRD PhD student 3 - IRD 4 - UCT PhD student 5 - Nelson Mandela Metropolitan Unviersity 6 - Department of Environmental Affairs 7 - Nelson Mandela Metropolitan Univ. 8 - Aix-Marseille Univ.

Seamounts are topographic features located at the crossroads of conflicting interests, with fishing on one hand, and biodiversity conservation on the other. Rising from abyssal depths and sometimes reaching the euphotic zone, they act as obstacles within the deep, intermediate and surface circulation. Physical perturbations affect the distribution of biogeochemical components (e.g. uplifting of essential nutrients) in the water column, with consequences for trophic pathways, at least at a local scale. The understanding of physical processes and their ecological responses is thus a critical scientific question to address in the perspective of spatial management of seamount ecosystems. In this talk, we present the rationale, expected deliverables and preliminary results of a project that started in September 2016. It is based on dedicated research cruises carried out over 3 shallow seamounts distributed from tropical to subtropical latitudes in the Southwest Indian Ocean: La Perouse (19°40'S, 54°E, depth 55m), MAD-Ridge (27°25'S, 46°15'E, depth 240m) and Walters Shoal (33°10'S, 43°50'E, depth 25m). Measurements of physical parameters, nutrients, chlorophyll pigments, microplankton, zooplankton and micronekton were conducted using a multi-parameter CTD, sampling bottles, plankton nets of various mesh sizes, multifrequency acoustics and a midwater trawl, following standard protocols allowing comparative analysis. The surveys are complemented with observations made in 1993-94 at another shallow seamount located at the equator (Coco de Mer, 0°26'N, 56°E, depth 191m) which is the most productive seamount worldwide for tuna fishing. Preliminary results on hydrological features at the seamounts, micro- and mesozooplankton biovolume and composition, acoustic-derived estimates of micronekton abundance and fisheries production are presented. We emphasize the merits of this ecosystem approach in advancing knowledge within WIOURI, a flagship IIOE-2 research initiative.

Web Based Applications and Infrastructure for the Second International Indian Ocean Expedition (IIOE-2)

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Content Motivation : None
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Mr. Kiran Kumar N ,kirankumar@incois.gov.in ,(Scientist-In-Charge, Web Based Services) ,India ,Hyderabad ,Presenting[1]
Mr. Vighneshwar S. P ,vighneshwar@incois.gov.in ,(None) ,India , ,Not Presenting[1]
Mr. Ramanjaneyulu J ,ram.j@incois.gov.in ,(None) ,India , ,Not Presenting[1]
Mrs. Sushmitha L ,sushmitha.l@incois.gov.in ,(None) ,India , ,Not Presenting[1]
Mr. Satyanarayana B. V ,bvs@incois.gov.in ,(None) ,India , ,Not Presenting[1]
Dr. Rajan Sivaramakrishnan ,rajan.s@incois.gov.in ,(None) ,India , ,Not Presenting[1]
Dr. Nick D'Adamo ,N.D'Adamo@bom.gov.au ,(None) ,Australia ,None ,Not Presenting[7]
Dr. S.S.C. Shenoi ,shenoi@incois.gov.in ,(None) ,India , ,Not Presenting[1]
Mrs. Louise Wicks ,louise.wicks@bom.gov.au ,(None) ,Australia , ,Not Presenting[7]
1 - Indian National Centre for Ocean Information Services (INCOIS), Hyderabad-500 090, Telangana, India 2 - Indian National Centre for Ocean Information Services (INCOIS), Hyderabad-500 090, Telangana, India 3 - Indian National Centre for Ocean Information Services (INCOIS), Hyderabad-500 090, Telangana, India 4 - Indian National Centre for Ocean Information Services (INCOIS), Hyderabad-500 090, Telangana, India 5 - Indian National Centre for Ocean Information Services (INCOIS), Hyderabad-500 090, Telangana, India 6 - Indian National Centre for Ocean Information Services (INCOIS), Hyderabad-500 090, Telangana, India 7 - UNESCO Intergovernmental Oceanographic Commission (IOC) Perth Programme Office and Australian Joint Project Office (JPO) Node for IIOE-2, c/o Bureau of Meteorology, Perth, Australia 8 - Indian National Centre for Ocean Information Services (INCOIS), Hyderabad-500 090, Telangana, India 9 - UNESCO Intergovernmental Oceanographic Commission (IOC) Perth Programme Office and Australian Joint Project Office (JPO) Node for IIOE-2, c/o Bureau of Meteorology, Perth, Australia

The Second International Indian Ocean Expedition (IIOE-2) is the first large-scale, internationally-supported effort in 50 years to study the Indian Ocean comprehensively with the state-of-the-art scientific tools now available. IIOE-2 will investigate the status and dynamics of the Indian Ocean's biodiversity, biogeochemistry, ocean-atmospheric coupling, and geology - from the full depth of its basins to its coastal regions. A large number of scientists from many of the leading research institutions of the world are already involved in, or are planning their involvement in this cooperative endeavor, structured around a comprehensive Science Plan (Hood et al. 2015). Given the scale of IIOE-2 and the number of stakeholders engaged in it, it was essential that the IIOE-2 had a website that was prominent and could support and help manage the breadth of activities being undertaken. These were the major factors addressed successfully in the website's development, led by specialists at INCOIS (http://www.iioe-2.incois.gov.in).
The web-based application for IIOE-2 provides a user-friendly environment for the presentation of the various activities under IIOE-2 and their progress in a lucid manner. The responsive layout of the website makes it accessible through a wide range of web browsers and devices, including mobiles and tablets. In this presentation, we discuss the architectural framework and look-up mechanism of the infrastructure that has been designed to serve the users, as well as the additional functionalities, enhancements and user-friendly interface to showcase the IIOE-2 activities. We also focus on future planned initiatives for the website which will facilitate capacity building in the Indian Ocean region through an application of the observational data and research outputs that will be made available

through the webpages. Capacity development is a fundamental objective of IIOE-2 and in making information and data available through the IIOE-2 website, scientists that may not have the capacity nor funds to undertake a research project, can still utilise the outputs of others for their own objectives.

Reference: Hood, R.R. et al, 2015. Science Plan of the Second International Indian Ocean Expedition (IIOE-2): A Basin-Wide Research Program. Scientific Committee on Oceanic Research, Newark, Delaware, USA.

Sub-surface oxygen maxima in the equatorial Indian Ocean

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Content Motivation : None
Additional Information : None

Dr. Satya Prakash ,satyap@incois.gov.in ,(Scientist 'D') ,India ,Hyderabad ,Presenting[1]
Dr. Jenson George ,jensonvgeorge@gmail.com ,(Post Doctoral Fellow) ,India ,Bangalore ,Not Presenting[2]
Dr. Aneesh Lotliker ,aneesh@incois.gov.in ,(Scientist-D) ,India ,Hyderabad ,Not Presenting[3]
Dr. Amit Sarkar ,amit@ncaor.gov.in ,(None) ,India , ,Not Presenting[4]
Dr. Rajdeep Roy ,rajdeeproy2003@yahoo.com ,(None) ,India , ,Not Presenting[5]
Dr. Ravidas Naik ,ravi@ncaor.gov.in ,(None) ,India , ,Not Presenting[4]
Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[2]
1 - None 2 - Indian Institute of Science 3 - Indian National Centre for Ocean Infromation Services (INCOIS) 4 - NCAOR, Goa, India 5 - Indian Space Research Organization (ISRO), National Remote Sensing Centre (NRSC) Hyderabad, India. 6 - NCAOR, Goa, India 7 - Indian Institute of Science

The Arabian Sea hosts one of the most pronounced oxygen minimum zones of the world's oceans. Moreover, despite being a relatively smaller basin, it contributes significantly to the global denitrification. Various recent reports suggest that the dissolved oxygen concentration in oceanic water has decreased by more than 2% over a past few decades and this loss could reach upto seven percent by the end of this century. The data from the Indian Ocean region is limited in time and space to infer any secular long term trend. The data collected during the first IIOE-2 expedition in the tropical Indian Ocean along 67°E transect during December 2015, however, shows presence of high oxygen water at 300-400 m water depth. The high oxygen water corresponds to less saline water at the same depth and it extends upto 8°N. The Argo-oxygen data from the equatorial region also shows perennial presence of low-salinity-oxygen-rich water at that depth. Since the concentration of dissolved oxygen (DO) in the oceanic water is an important proxy for any large scale change in the thermohaline circulation and/or sub-surface biogeochemical cycling, our results have greater implications as it suggests a new pathway of oxygen recharge in the Arabian Sea below the thermocline depth.

Second International Indian Ocean Expedition – overview of endorsed science projects and cruises

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Additional Information : None

Dr. Nick D'Adamo ,N.D'Adamo@bom.gov.au ,(None) ,Australia ,None ,Not Presenting[1]
Dr. Rajan Sivaramakrishnan ,rajan.s@incois.gov.in ,(None) ,India , ,Not Presenting[2]
Mrs. Louise Wicks ,louise.wicks@bom.gov.au ,(None) ,Australia , ,Not Presenting[1]
1 - UNESCO Intergovernmental Oceanographic Commission (IOC) Perth Programme Office and Australian Joint Project Office (JPO) Node for IIOE-2, c/o Bureau of Meteorology, Perth, Australia 2 - Indian National Centre for Ocean Information Services (INCOIS), Hyderabad-500 090, Telangana, India 3 - UNESCO Intergovernmental Oceanographic Commission (IOC) Perth Programme Office and Australian Joint Project Office (JPO) Node for IIOE-2, c/o Bureau of Meteorology, Perth, Australia

The Second International Indian Ocean Expedition (IIOE-2: 2015-20) was launched in Goa, India, on 4 December 2015. It is guided by an international Steering Committee chaired by the IIOE-2's founding co-sponsors: UNESCO Intergovernmental Oceanographic Commission (IOC); Scientific Committee on Oceanic Research (SCOR); and Indian Ocean Global Ocean Observing System (IOGOOS) Regional Alliance. The science objectives are framed by a Science Plan (Hood *et al*, 2015) developed under the auspices of SCOR, and being effected under the IIOE-2 Implementation Strategy (www.iioe-2.incois.gov.in). These documents have relevancy to the Indian Ocean rim and island nation constituents across scientific and institutional levels. Many of these nations are represented on the IIOE-2 Steering Committee.
The IIOE-2 is five decades on from the first coordinated basin-wide investigation of the Indian Ocean undertaken during 1959-65 under SCOR and IOC. It consists of sub- to basin-wide surveys and associated research pursuits, cutting across coupled oceanic/climatic characterisation, including physical and biogeochemical oceanography, modelling and knowledge transfer through capacity development, in order to foster a lasting legacy that spans across scientifically developed to less developed communities.
The IIOE-2 focusses its science pursuits via six over-arching science themes: (i) Human impacts; (ii) Boundary current dynamics, upwelling variability and ecosystem impacts; (iii) Monsoon variability and ecosystem response; (iv) Circulation, climate variability and change; (v) Extreme events and their impacts on ecosystems and human populations; and (vi) Unique geological, physical, biogeochemical and ecological features of the Indian Ocean. The way in which specific research questions are being addressed in IIOE-2 includes via collaborative multi-institutional and multi-national efforts.
This talk will overview the history leading to IIOE-2 and highlight the broad scientific objectives, multi-disciplinary approach and associated opportunities for science and capacity development, including for early career scientists. It will provide a summary of the growing list of IIOE-2 endorsed research initiatives, including process studies and complementary research cruises (completed and prospective).

Observations of a mixing event in southern Bay of Bengal during summer monsoon

Abstract ID : 1086

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Dr. Jenson George ,jensonvgeorge@gmail.com ,(Post Doctoral Fellow) ,India ,Bangalore ,Presenting[1]
Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[1]
Dr. V. Vijith ,vijithvnair@gmail.com ,(Assistant Professor) ,India ,Kochi ,Not Presenting[3]
Miss. V Thushara ,thushara@caos.iisc.ernet.in ,(None) ,India , ,Not Presenting[4]
Dr. P. Amol ,prakashamol@gmail.com ,(None) ,India , ,Not Presenting[5]
Dr. K Vijaykumar ,kvkumar@nio.org ,(None) ,India , ,Not Presenting[6]
1 - Indian Institute of Science 2 - Indian Institute of Science 3 - School of Marine Sciences, Cochin University of Science and Technology, Kochi, India 4 - Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore, India 5 - CSIR-National Institute of Oceanography Regional Centre, Visakhapatnam, India 6 - National Institute of Oceanography, Goa

Bay of Bengal (BoB) has strong upper layer stratification owing to fresh water influx from both precipitation and terrestrial run off. To maintain the salinity of BoB, export of this fresh water and mixing with higher salinity water from Arabian Sea is necessary. During the BoBBLE (Bay of Bengal boundary layer experiment) campaign in Southern BoB, time series observations were carried out at 8^0N 89^0E from 4^{th} July to 15^{th} July 2016 using a loosely tethered micro-structure profiler (VMP 250). The time series data captured a mixing event which lasted for 4 days. Prior to the event, the upper layer was characterized by relatively fresh surface layer and a 30- 35m thick barrier layer. As the winds strengthened from 1 - 10 m/s, the barrier layer eroded, stratification became weaker and mixed layer depth deepened from ~20m to ~70m. In addition, the mixing event eroded the 34.5 isohaline at 60m depth and surface salinity increased by about 1psu. The turbulent kinetic energy (TKE) dissipation rate inferred from the micro-scale shear data showed high values (> 10^{-7} W/Kg) in the upper 60 m during this event. It was found that the winds alone were not responsible for causing the mixing event but by a change in the background stratification. Close proximity of the summer monsoon current to the time series location indicates possible modification of the stratification either by advection or by lateral mixing of high saline water from Arabian Sea to the measurement location.

Seaglider observations of a phytoplankton bloom within the Sri Lanka Dome during BoBBLE

Abstract ID : 1104

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Miss. V Thushara ,thushara@caos.iisc.ernet.in ,(None) ,India , ,Not Presenting[1]
Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[2]
Prof. Adrian Matthews ,a.j.matthews@uea.ac.uk ,(Professor of Meteorology) ,United Kingdom ,Norwich ,Not Presenting[3]
Dr. Ben Webber ,B.Webber@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
1 - Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore, India 2 - Indian Institute of Science 3 - University of East Anglia 4 - University of East Anglia

The Bay of Bengal (BoB) is considered to be a region of low biological productivity, limited by light and nutrients owing to the competing effects of freshwater and wind mixing. Nevertheless, satellite and in situ observations reveal the presence of prominent regional blooms, especially in the southern BoB during the summer monsoon. Seaglider observations during the Bay of Bengal Boundary Layer Experiment (BoBBLE) in the southern BoB during June - July 2016 were able to capture the evolution of a chlorophyll bloom associated with the Sri Lanka Dome (SLD) -- a cyclonic gyre located to the east of Sri Lanka, driven by open ocean Ekman pumping. Upper ocean processes controlling the biological productivity in the region of the SLD were examined using the high-resolution observations of physical and biological parameters measured by a glider over a period of about two weeks, along with satellite derived estimates of ocean color and sea level anomalies (SLA). The observed chlorophyll bloom, with magnitudes higher than 1 mg m^{-3}, was found to be associated with negative SLA, upsloping of isotherms, cooler temperature and higher salinity. Vertical profiles of temperature and salinity from the glider suggest the presence of strong upwelling. The bloom intensified with the strengthening of the dome and decayed with its weakening. These observations reveal the role of open ocean Ekman pumping associated with the monsoonal forcings in maintaining the biological productivity of the southern bay. Thus, high-resolution measurements from gliders can make a significant contribution to understanding the biogeochemistry of the BoB, implying the need for expanding these observations in future.

The dynamics of the Southwest Monsoon Current in the Bay of Bengal

Abstract ID : 1111

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Ben Webber ,B.Webber@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Prof. Adrian Matthews ,a.j.matthews@uea.ac.uk ,(Professor of Meteorology) ,United Kingdom ,Norwich ,Not Presenting[1]
Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[3]
Dr. Jenson George ,jensonvgeorge@gmail.com ,(Post Doctoral Fellow) ,India ,Bangalore ,Not Presenting[3]
Dr. Rob Hall ,robert.hall@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[1]
Dr. Elizabeth Kent ,eck@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]
Dr. Brian King ,bak@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[8]
Dr. Bastien Queste ,b.queste@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Dr. Alejandra Sanchez-Franks ,alsf@noc.ac.uk ,(None) ,United Kingdom ,Southampton ,Not Presenting[7]
Miss. V Thushara ,thushara@caos.iisc.ernet.in ,(None) ,India , ,Not Presenting[11]
Dr. V. Vijith ,vijithvnair@gmail.com ,(Assistant Professor) ,India ,Kochi ,Not Presenting[12]
1 - University of East Anglia 2 - University of East Anglia 3 - Indian Institute of Science 4 - Indian Institute of Science 5 - University of East Anglia 6 - University of East Anglia 7 - National Oceanography Centre, Southampton, UK 8 - National Oceanography Centre 9 - University of East Anglia 10 - National Oceanography Centre, Southampton, UK 11 - Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore, India 12 - School of Marine Sciences, Cochin University of Science and Technology, Kochi, India

The Indian monsoon provides 80% of the annual rainfall total for over a billion people, and prediction of its variability is crucial to support Indian agriculture. Variability in sea surface temperature and salinity over the Bay of Bengal (BoB) influence the monsoon rainfall by altering the fluxes of heat and moisture on which storm systems feed as they propagate northwestwards over northern India. A key feature in the summertime BoB is the Southwest Monsoon Current (SMC), a relatively shallow (<500 m) but fast (~1 m s-1) current which transports warm salty water into the BoB from the Arabian Sea, thus influencing the spatial pattern of surface temperature and salinity.

Here we present results from an array of Seagliders deployed during the Bay of Bengal Boundary Layer Experiment (BoBBLE) project in June-July 2016, combined with ship observations and a high-resolution numerical ocean model simulation for the same time period. These Seagliders were aligned along 8°N, between 85 and 90°E, and spanned the core of the SMC. For the first time we were able to quantify the high-frequency variability of this current, and relate this to surface forcing and the impact of ocean Rossby waves radiating from the eastern boundary of the BoB. As the Sri Lanka Dome weakens and moves westwards, the peak northwards flow of the SMC also shifts westwards and weakens, from 0.7 m s-1 around 87.5°E to 0.5 m s-1 at 86.5°E. This trend is evident down to at least 400 m depth.

The SMC transports a core of high-salinity and relatively high-oxygen water northeastwards. The high-resolution glider data shows that this water mass interleaves with fresher and more oxygen-depleted water from the northern BoB, at times exhibiting very strong variability at time scales < 1 day

and vertical scales of 10 m or less. The strong vertical mixing generated by this variability at the edge of the SMC will modify surface salinity and barrier layer formation, thus influencing air-sea interaction and monsoon rainfall.

Key Biogeochemical and Ecological Problems in the Indian Ocean

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Dr. Raleigh Hood ,rhood@umces.edu ,(Scientist) ,United States ,Cambridge ,Not Presenting[1]
Dr. Jenny Huggett ,jenny.huggett@gmail.com ,(Marine Scientist) ,South Africa ,Cape Town ,Presenting[2]
Dr. Nick D'Adamo ,nick.dadamo@bom.gov.au ,(None) ,Australia ,None ,Not Presenting[3]
1 - University of Maryland 2 - Department of Environmental Affairs 3 - UNESCO IOC Perth Programme Office

Although there has been considerable recent research focus in the Indian Ocean by the atmospheric science and physical oceanographic research communities, the biogeochemical and ecological research communities have lagged behind. This is in spite of the fact that there are many pressing biogeochemical and ecosystem-oriented research questions that need to be addressed in the Indian Ocean. First order descriptive studies still need to be undertaken along with process studies aimed at expanding basic mechanistic understanding. In this presentation several key biogeochemical and ecological research questions are highlighted that need to be addressed in the Indian Ocean. These include questions related to the role of Fe limitation versus grazing control of primary production in the western Arabian Sea and throughout the tropical and subtropical Indian Ocean; the biogeochemical, ecological and human impacts of expanding hypoxic and anoxic zones in the northern Indian Ocean; and the role of nitrogen fixation in the Indian Ocean nitrogen cycle. They also include questions related to the biogeochemical and ecological impacts of acidification; the biogeochemical and ecological impacts of the Indonesian Throughflow in the Indian Ocean; and the importance of mesoscale eddies in the southern hemisphere of the Indian Ocean. Finally, there is a need to better understand the physical, chemical and biological impacts of ridges and topographic highs in the Indian Ocean; and the biogeochemical and ecological impacts of upwelling in the Indian Ocean - from physics to fish. Efforts are now being undertaken, as part of the 2nd International Indian Ocean Expedition (IIOE-2), to motivate studies to address these questions, spanning a stakeholder community from the very highest of competencies to aspiring fundamental and applied scientists, including through the IIOE-2's Early Career Scientists Network.

Mean equatorial upwelling induced by intraseasonal Mixed Rossby-Gravity waves in the Indian Ocean

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Dr. Yukio Masumoto ,masumoto@eps.s.u-tokyo.ac.jp ,(Professor) ,Japan ,Tokyo ,Presenting[1]
Dr. Tomomichi Ogata ,ogata.tomomichi.ga@u.tsukuba.ac.jp ,(None) ,Japan , ,Presenting[2]
Dr. Motoki Nagura ,nagura@jamstec.go.jp ,(None) ,Japan , ,Not Presenting[3]
1 - University of Tokyo 2 - Tsukuba University 3 - JAMSTEC

A possible formation mechanism of mean subsurface upwelling along the equator in the Indian Ocean is investigated using a series of hierarchical setting of ocean general circulation model (OGCM) integrations and analytical considerations. In an eddy-resolving OGCM with realistic forcing, mean vertical velocity in the tropical Indian Ocean shows rather strong upwelling, with its maximum on the equator in subsurface layer below the thermocline. Heat budget analysis exhibits that horizontal and vertical heat advection due to currents and temperature deviations from the mean balances with vertical advection due to mean equatorial upwelling. Horizontal heat convergence is mostly associated with intraseasonal variability with a period from 3- to 91-day, while contribution from longer period (> 91 days) are small. Sensitivity experiments with a coarse-resolution OGCM further demonstrate that such mean equatorial upwelling cannot be reproduced by seasonal forcing only. Adding the intraseasonal wind forcing, especially meridional wind variability with a period of 15 days, generates significant mean subsurface upwelling on the equator. Further experiments with idealized settings confirm the importance of intraseasonal mixed Rossby-gravity (MRG) waves to generate mean upwelling, which appears along the energy "beam" of the MRG wave. An analytical solution of the MRG indicates that wave-induced temperature advection caused by the MRG waves with upward (downward) phase propagation results in warming (cooling) on the equator. This wave-induced warming (cooling) is shown to balance with the mean equatorial upwelling (downwelling), which is consistent with simulated characteristics in the OGCM experiments.

Identifying pathways between the South Indian Ocean and Leeuwin Current System

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Dr. Helen Phillips ,h.e.phillips@utas.edu.au ,(Senior Research Fellow) ,Australia ,Hobart ,Not Presenting[1]
Dr. Ryo Furue ,furue@hawaii.edu ,(None) ,Japan , ,Not Presenting[2]
Mr. Kevin Guerreiro ,guerreiro.kevin@gmail.com ,(None) ,France , ,Not Presenting[3]
Prof. Jay McCreary ,jay@hawaii.edu ,(None) ,United States , ,Not Presenting[4]
Prof. Nathan Bindoff ,n.bindoff@utas.edu.au ,(None) ,Australia , ,Not Presenting[5]
1 - University of Tasmania - IMAS 2 - APL/JAMSTEC 3 - LEGOS, Université de Toulouse, CNES, CNRS, IRD, UPS 4 - IPRC, University of Hawaii 5 - Institute for Marine & Antarctic Studies, University of Tasmania

The Leeuwin Current System (LCS) along the coast of Western Australia consists of the southward-flowing Leeuwin Current (LC), the northward-flowing Leeuwin Undercurrent (LUC), and neighboring flows in the South Indian Ocean (SIO). The LC and LUC are remarkable in that they flow opposite to the directions of the boundary currents along most eastern-ocean boundaries in the Atlantic and Pacific Oceans. The SIO zonal current is noteworthy because it flows against the predictions of wind-driven theory.
We use geostrophic currents obtained from a highly-resolved (1/8°) hydrographic climatology (CSIRO Atlas of Regional Seas, CARS) to describe the spatial structure and annual variability of the LC, LUC, and SIO zonal currents. We estimate their transports, and identify connections between them. Although the three-dimensional structure and seasonality of the LCS have been suggested by previous observational and modeling studies, we believe our analysis is the first quantitative description of them. Furthermore, the seasonality of the LUC is described for the first time.
Our analysis establishes that there is a large overturning circulation in the zonal-vertical plane with an eastward flow in the upper 200 m into the LC, downwelling from the LC into the LUC, and a westward flow out of the LUC in the lower layer (200-900 m). This contradicts some of the previous theories (including ours) that the LC should accelerate southward because it keeps absorbing the mass from the near-surface eastward flow. Our results suggest that this downwelling is key to the not-yet-well-understood dynamics of the LCS, especially that of the LUC. We expect our results will provide guidelines that lead to the development of more complete theories.

Mesoscale activity in the Comoros Basin

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Additional Information : None

Dr. Charine Collins ,charinecollins@gmail.com ,(Post-Doctoral Research Fellow) ,South Africa ,Cape Town ,Not Presenting[1]
Dr. Juliet Hermes ,juliet@saeon.ac.za ,(None) ,South Africa ,None ,Not Presenting[2]
Prof. Chris Reason ,chris.reason@uct.ac.za ,(None) ,South Africa , ,Not Presenting[3]
Dr. Raymond Roman ,raymond.roman@uct.ac.za ,(None) ,South Africa , ,Not Presenting[3]
1 - South African Environmental Observation Network 2 - SAEON 3 - University of Cape Town 4 - University of Cape Town

Limited knowledge exists about the dynamics in the Comoros Basin situated to the NW of Madagascar, potentially an important region of mesoscale variability and source of biological material into the Agulhas system. In this study we analyse, high-resolution model and satellite altimetry data to show that anticyclonic eddies are generated at the northern tip of Madagascar, contradicting the long-held notion of a single, quasi-stationary anticyclonic cell. An automated eddy tracking scheme, applied to satellite altimetry data and a high-resolution model showed that the mesoscale activity in the Comoros Basin is dominated by anticyclonic eddies but consists of cyclonic eddies as well. Anticyclonic eddies are primarily generated west of the northern tip of Madagascar due to barotropic instabilities associated with the North East Madagascar Current (NEMC). Cyclonic eddies in the basin are mainly formed along the northwest coast of Madagascar due to strong baroclinic instability. The anticyclonic eddies have an average lifespan of ~3 months and remain in the Comoros Basin for about 1.5 months before propagating into the Mozambique Channel. Initially, the anticyclones, with translation speeds of 6-8km d^{-1}, follow the trajectory of the NEMC before turning south upon reaching the coast of Africa. The cyclonic eddies, with a similar lifespan, have lower translation speeds (2.5-.3.5 km.d^{-1}) and are retained in the basin almost indefinitely. Hydrographic data collected in the Comoros Basin in 2009 revealed that all the main water masses characterising the South West Indian Ocean are present in the basin, even those previously thought absent. The hydrographic data also show evidence of a cyclonic eddy along the northwest coast of Madagascar with surface velocities of 0.1-1m/s. To investigate the transport of water masses and potential biological particles, lagrangian particle tracking was applied to the model and showed that ~50% of particles released in the NEMC are entrained in the anticyclonic eddies and transported into the Mozambique Channel while the rest is advected into the East African Coastal Current.

Subsurface radiant flux during summer monsoon in the southern Bay of Bengal

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Dr. Aneesh Lotliker ,aneesh@incois.gov.in ,(Scientist-D) ,India ,Hyderabad ,Not Presenting[1]
Mr. Chandanlal Parida ,chandanlal.parida@gmail.com ,(None) ,India , ,Not Presenting[2]
Mr. Alakes Samanta ,samanta.a@incois.gov.in ,(None) ,India , ,Not Presenting[3]
Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[4]
1 - Indian National Centre for Ocean Infromation Services (INCOIS) 2 - Berhampur University, Odisha, India 3 - INCOIS, Hyderabad 4 - Indian Institute of Science

The upper ocean radiative transfer of visible spectrum has significant potential for local heating and thus has implications for thermal and dynamical processes as well as for ocean-atmosphere interactions. A 10 w-m^{-2} change in the quantity of solar radiation absorbed within a 10m layer can result in a temperature change of more than 0.68^{0}C month^{-1}. The Bay of Bengal plays a critical role in Indian monsoon and to study the air-sea fluxes in this region, the Bay of Bengal Boundary Layer Experiment (BoBBLE) a was conducted during summer monsoon of 2016. In oligotrophic waters, subsurface propagation of radiation is largely controlled by the presence of light attenuating substances such as chlorophyll in addition to water molecule itself. In the present study, subsurface light field was measured using a radiometer and chlorophyll was estimated using a fluorometer. In addition, the attenuation coefficient of photosynthetically available radiation (PAR, k_{PAR}) was generated from satellite data and validated using the in situ optical data. The filed observation showed that the water was optically clear with an average attenuation coefficient of downwelling irradiance at 490 nm (k_d490) of 0.056 m^{-1} and k_{PAR} 0.067 m^{-1}. The satellite derived k_{PAR} closely matched with the modelled, with an average value of 0.06 m^{-1}. The chlorophyll concentration did not contribute significantly to attenuation of light as the surface values were very low (0.3 to 0.4 mg-m^{-3}) and the deep chlorophyll maxima (DCM) was at depth between 40-50m where the radiant flux was less than 10% of the surface value. However, it was observed that 20-30% of the surface radiant flux penetrated below the mixed layer.

Meridional variability of subsurface light field along IIOE-2 transect using satellite dat

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Dr. Aneesh Lotliker ,aneesh@incois.gov.in ,(Scientist-D) ,India ,Hyderabad ,Presenting[1]
Dr. Nagur Cherukuru ,Nagur.Cherukuru@csiro.au ,(None) ,Australia , ,Not Presenting[2]
Mr. Alakes Samanta ,samanta.a@incois.gov.in ,(None) ,India , ,Not Presenting[3]
Dr. Satya Prakash ,satyap@incois.gov.in ,(Scientist 'D') ,India ,Hyderabad ,Not Presenting[4]
Dr. Rajdeep Roy ,rajdeeproy2003@yahoo.com ,(None) ,India , ,Not Presenting[5]
Dr. Amit Sarkar ,amit@ncaor.gov.in ,(None) ,India , ,Not Presenting[6]
Dr. Ravidas Naik ,ravi@ncaor.gov.in ,(None) ,India , ,Not Presenting[6]
Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[8]
1 - Indian National Centre for Ocean Infromation Services (INCOIS) 2 - CSIRO, Canberra, ACT, Australia 3 - INCOIS, Hyderabad 4 - None 5 - Indian Space Research Organization (ISRO), National Remote Sensing Centre (NRSC) Hyderabad, India. 6 - NCAOR, Goa, India 7 - NCAOR, Goa, India 8 - Indian Institute of Science

The subsurface radiative transfer has large implication in-terms of energy reservoir within the water column. It also has impact on the ocean thermodynamics from local to regional scale. Thus to account for the energy budget in the upper ocean, it is require to understand the spatial and temporal variability in underwater solar radiative transfer. The vertical attenuation coefficient of photosynthetically available radiation (k_{PAR}) defines the subsurface light field, which exhibits linear relationship with downwelling diffuse attenuation coefficient at 490 nm (k_d490). The ocean colour remote sensing has the ability to estimate k_d490 at synoptic scale. In the present study, two models were evaluated to estimate k_{PAR} from satellite (MODIS-Aqua) derived k_d490. Subsequently spatio-temporal variability of k_{PAR} was described using satellite data at monthly climatological scale. At the beginning, k_d490 and k_{PAR} estimated from satellite data (MODIS-Aqua) was validated with *in situ* data measured during first scientific cruise of second Internal Indian Ocean Expedition (IIOE-2).and found in good agreement. The satellite estimated k_{PAR} varied from 0.035 to 0.065 m^{-1} depicting the water to be oligotrophic and optically clear where the euphotic depth reached up to 80 m. Meridional distribution of k_{PAR} was analyzed along the cruise transect at monthly climatological scale using satellite data. There was no significant variability observed at intra annual scale. However, significant variability was observed at spatial scale. The maximum k_{PAR} was observed at 5^0N that decreased towards equator and increased further at 10^0S. Beyond this, k_d490 decreased to a minimum at 20^0N. In oligotrophic water, attenuation of light is more sensitive to chlorophyll (chl) aprt from water molecule itself. Therefore, we also analyzed the vertical profiles of *in situ* chl. The surface chl was very low of the order less than 0.1 mg-m^{-3}. The deep chl maxima (DCM) was observed at depth 60-70m till 2^0S beyond which DCM swallowed till 50m. The average light level at DCM was 11% of the surface.

Results from the First Expedition of IIOE-2

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Additional Information : None

Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Presenting[1]
Dr. Jenson George ,jensonvgeorge@gmail.com ,(Post Doctoral Fellow) ,India ,Bangalore ,Not Presenting[1]
Dr. V. Vijith ,vijithvnair@gmail.com ,(Assistant Professor) ,India ,Kochi ,Not Presenting[3]
Dr. P. Amol ,prakashamol@gmail.com ,(None) ,India , ,Not Presenting[4]
Dr. Satya Prakash ,satyap@incois.gov.in ,(Scientist 'D') ,India ,Hyderabad ,Not Presenting[5]
Dr. S.S.C. Shenoi ,shenoi@incois.gov.in ,(None) ,India , ,Not Presenting[6]
1 - Indian Institute of Science 2 - Indian Institute of Science 3 - School of Marine Sciences, Cochin University of Science and Technology, Kochi, India 4 - CSIR-National Institute of Oceanography Regional Centre, Visakhapatnam, India 5 - None 6 - Indian National Centre for Ocean Information Services (INCOIS), Hyderabad-500 090, Telangana, India

The first expedition of IIOE-2, on board ORV Sagar Nidhi, sailed from Goa on 04 December 2015, made observations along 67°E from 12°N upto 5°S and reached at Port Luis, Mauritius on 22 December 2015. The major objectives of this multi-disciplinary as well as multi-national observational expedition was: (a) to understand the structure of water masses in the western Indian Ocean along 67°E and possibly assess the difference in their characteristics with respect to the measurements made during IIOE and (b) to understand the physical-chemical-biological characteristics in the equatorial Indian Ocean and their inter-relationships. The major observational objectives were to map the hydrography in the upper 1000m where the Red Sea, Persian Gulf and Arabian Sea High Salinity water are known to be present and collect water samples to determine chemical, biological and optical parameters. The cross-equatorial observations were made when the westerly winds and the eastward Wyrtki jets were strong. Ship-board ADCP profiles showed a 1 m/s strong eastward jet that was about 4 degrees wide but confined to a depth of just 75m. The mixed layer was deep at the equator, shallowing towards either side. The CTD profiles provided a latitudinal view of the water masses in the western Indian Ocean. Arabian Sea High Salinity Water (ASHSW) and Persian Gulf Water (PGW) water was present at almost all latitudes but Red Sea Water (RSW) was confined to the north of the equator. Between 12°N and 5°S, the ASHSW lost its salinity by abut 1.5, PGW by about 0.7 and RSW by about 0.5. The RSW was found to mix with Australiasian Mode Water (AAMW) near the equator. The Indian Central Water was found to increase the oxygen concentration in the central Arabian Sea. Comparison with historical data sets suggest that variability in the structure of water masses are highly non-uniform across the section along which observations were made.

Monsoonal influence on the development of the Island Mass Effect in the Northern Indian Ocean

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Ms. Danielle Su ,danielle.su@research.uwa.edu.au ,(PhD Candidate) ,Australia ,Crawley ,Not Presenting[1]
Dr. Sarath Wijeratne ,sarath.wijeratne@uwa.edu.au ,(None) ,Australia , ,Not Presenting[1]
Prof. Charitha Pattiaratchi ,chari.pattiaratchi@uwa.edu.au ,(None) ,Australia , ,Not Presenting[3]
1 - UWA 2 - UWA 3 - The University of Western Australia

The islands of Sri Lanka and the Maldives occupy a unique location due to their position at the crossroads of water exchange between the Arabian Sea and the Bay of Bengal in the Northern Indian Ocean (NIO). This puts the islands in direct contact with the eastward flowing Southwest monsoon current during the Southwest monsoon (SWM) period from June to October and the westward flow from the Northeast monsoon current during the Northeast monsoon (NEM) from December to April. The flow-topography interaction of these islands with the monsoonal currents enhances primary productivity in the lee of the islands as a result of the Island Mass Effect (IME). Under these conditions, nutrients are upwelled into the photic zone, leading to elevated chlorophyll blooms. This creates near-island 'hotspots' of phytoplankton biomass throughout the upper water column, increasing ocean productivity locally.
To date, evidence of the IME phenomena has been documented via satellite ocean colour imagery along the Maldivian coastlines and the southern coast of Sri Lanka. It revealed a prominent chlorophyll bloom along the Maldivian western coastline during the NEM and a counterpart recirculation feature along the eastern coastline that extends as a plume from the Maldives to southern India and then on to Sri Lanka during the SWM. Along with numerical simulations, it has been shown that upwelling along the southern coast of Sri Lanka is prevalent throughout the year, despite the variation in wind strength and direction between the different monsoon periods.
There is increasing recognition that the IME is an ecosystem generator crucial to modulating ocean productivity, yet much remains unknown about the prevalence and drivers of this phenomenon and how it will respond to potential changes in the Indian Monsoon.Thus, an integrated approach using satellite imagery and a numerical model derived from the Regional Ocean Model System has been performed to investigate the role of the monsoon on the variability of the IME in the NIO as well as the generation mechanisms for the three-dimensional flow structure of the IME around Sri Lanka and the Maldives.

An IIOE-2 Capacity Building Initiative - The Indian Ocean Early Career Scientist Network

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Additional Information : None

Ms. Danielle Su ,danielle.su@research.uwa.edu.au ,(PhD Candidate) ,Australia ,Crawley ,Not Presenting[1]
Dr. Arvind Singh ,av.arvind@gmail.com ,(None) ,India , ,Not Presenting[2]
Dr. Benjamin Kurten ,benjamin.kurten@kaust.edu.sa ,(None) ,Saudi Arabia , ,Not Presenting[3]
Dr. Riaan Cedras ,rcedras@uwc.ac.za ,(None) ,South Africa , ,Not Presenting[4]
Dr. Gildas Todinanahary ,gildas.todinanahary@ihsm.mg ,(None) ,Madagascar , ,Not Presenting[5]
Dr. Eric Raes ,eric.raes@awi.de ,(None) ,Germany , ,Not Presenting[6]
Dr. Michelle Fernandes ,michellefds19@gmail.com ,(None) ,India , ,Not Presenting[7]
Dr. Nimit Kumar ,nimitkumar.j@incois.gov.in ,(None) ,India , ,Not Presenting[8]
Dr. Edward Senkondo ,eddoseny@gmail.com ,(None) ,Tanzania , ,Not Presenting[9]
1 - UWA 2 - Physical Research Laboratory 3 - King Abdullah University of Science and Technology 4 - University of Western Cape 5 - Université de Toliara 6 - Alfred Wegener Institute Helmhotlz Centre for Polar and Marine Research 7 - National Institute of Oceanography 8 - Indian National Center for Ocean Information Services 9 - Tanzania Fisheries Research Institute

The Indian Ocean Early Career Scientist Network (ECSN) is an ongoing initiative of the Second International Indian Ocean Expedition (IIOE-2) that addresses the goal of creating international and interdisciplinary capacity building for research conducted in the Indian Ocean (IO).
The ECSN was developed during an early career scientist workshop at the first IIOE-2 symposium held at the National Institute of Oceanography (Goa, India) in December 2015. During this workshop, early career scientists from around the world participated in discussions about important research topics for the IIOE-2 and proposed strategies for stimulating research expertise and capacity in the region. Since then, this diverse group of scientists have self-organized into the ECSN to continue the development of research priorities for each of the IIOE-2 Science Themes.
The objectives of the ECSN are to communicate research priorities from early career scientists to the scientific leadership of the IIOE-2, as well as to provide a platform for facilitating interdisciplinary and regional research collaborations. To date, their activities have focused on active recruitment of new members, promoting new collaborations, publishing articles on IIOE-2 research priorities and recommendations to international peer-reviewed scientific journals.
Another motivation for this initiative was to be the first regional network for early career scientists engaged in research specific to the IO. The concept of establishing a regional network for early careers scientists is to promote project goals in specific regions and collectively contribute to a better understanding of oceanic processes in the IO.
Although the ECSN is still in its early stages, it is well-positioned to become an organization to train future generations of marine scientists to shape research in the IO region. The legacy of the IIOE-2 will be determined by not just how much it advances our understanding of the IO, but also for laying the groundwork for maintaining and establishing new capacity building programs and collaborations in the region. The IIOE-2 is an exciting time of opportunity for marine science throughout the IO, especially for early career scientists. This presentation will provide an overview of the current achievements of the ECSN and future directions for the network.

Role of sub-surface intensified eddies in the southern Indian Ocean

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Mr. Fehmi Dilmahamod ,fehmi.dilmahamod@gmail.com ,(PhD Student) ,South Africa ,Cape Town ,Presenting[1]
Mr. Neil Malan ,neilcmalan@gmail.com ,(PhD Candidate) ,South Africa ,Cape Town ,Not Presenting[1]
Dr. Borja Aguiar Gonzalez ,borja.aguiar.gonzalez@gmail.com ,(None) ,Netherlands , ,Not Presenting[3]
Mr. Will de Ruijter ,willenelsderuijter@gmail.com ,(None) ,Netherlands , ,Not Presenting[4]
Dr. Juliet Hermes ,juliet@saeon.ac.za ,(None) ,South Africa ,None ,Not Presenting[5]
1 - University of Cape Town 2 - University of Cape Town 3 - 2NIOZ Royal Netherlands Institute for Sea Research, Department of Ocean Systems Sciences and Utrecht University 4 - Utrecht University 5 - SAEON

A unique feature of the Indian Ocean is the zonal sub-surface maximum of eddy-available potential energy at around 150m deep, from Australia up to Madagascar. This energy is a resultant of sub-surface intensified eddies (Intra-thermocline eddies; ITEs), known to be ubiquitous in the world ocean and present in the Indian Ocean's basin. Having a horizontal extent of nearly the same size of internal Rossby radius of deformation, these eddies are coherent structures keeping the water characteristics of their area of formation. Their generation and propagation properties are still to be defined. Altimetry and Argo databases are used in combination with a high-resolution model to investigate these sub-surface intensified eddies. Using both an eddy detection scheme, a mean eddy analysis with a focus on the eddy characteristics is carried out. Separating Argo-based temperature and salinity profiles from surface-intensified and sub-surface intensified eddies allow us to distinguish between the large amounts of heat and salt transport between these 2 eddy-types and their specific role in the temperature and salinity budgets in the Indian Ocean. The formation area and pathways can also be perceived from this method. Characterizing these ITEs are fundamental as they impact the three-dimensional tracers' distribution for the Indian Ocean.

JM1 - Observing Our Planet From Space (IAMAS, IAGA, IAPSO)

Prospects of the earth observation with modern satellite sensors

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Prof. Teruyuki Nakajima ,terry-nkj@nifty.com ,(Director) ,Japan ,Tsukuba ,Not Presenting[1]
Dr. Riko Oki ,oki.riko@jaxa.jp ,(None) ,Japan ,None ,Not Presenting[1]
Dr. Misako Kachi ,kachi.misako@jaxa.jp ,(None) ,Japan ,None ,Not Presenting[1]
Dr. Takuji Kubota ,kubota.takuji@jaxa.jp ,(None) ,Japan ,None ,Not Presenting[1]
Dr. Hiroshi Murakami ,murakami.hiroshi.eo@jaxa.jp ,(None) ,Japan ,None ,Not Presenting[1]
Dr. Masahiro Hori ,hori.masahiro@jaxa.jp ,(None) ,Japan ,None ,Not Presenting[1]
Dr. Makiko Hashimoto ,hashimoto.makiko@jaxa.jp ,(None) ,Japan ,None ,Not Presenting[1]
Dr. Akihiko Kuze ,kuze.akihiko@jaxa.jp ,(Associate Senior Researcher) ,Japan ,Tsukuba ,Not Presenting[1]
Dr. Takeo Tadono ,tadono.takeo@jaxa.jp ,(None) ,Japan ,None ,Not Presenting[1]
Dr. Kei Shiomi ,shiomi.kei@jaxa.jp ,(None) ,Japan ,None ,Not Presenting[1]
Dr. Hideaki Takenaka ,takenaka.hideaki@jaxa.jp ,(None) ,Japan ,None ,Not Presenting[1]
Dr. Maki Kikuchi ,kikuchi.maki@jaxa.jp ,(None) ,Japan ,None ,Not Presenting[1]
1 - Japan Aerospace Exploration Agency 2 - Japan Aerospace Exploration Agency 3 - Japan Aerospace Exploration Agency 4 - Japan Aerospace Exploration Agency 5 - Japan Aerospace Exploration Agency 6 - Japan Aerospace Exploration Agency 7 - Japan Aerospace Exploration Agency 8 - Japan Aerospace Exploration Agency 9 - Japan Aerospace Exploration Agency 10 - Japan Aerospace Exploration Agency 11 - Japan Aerospace Exploration Agency 12 - Japan Aerospace Exploration Agency

There is a large progress of the earth's satellite sensing in the last three decades. Recent important aspects are new technologies of passive and active sensing, multi-sensor analysis, combined analysis with use of numerical weather/climate models, and more consciousness of applications to social problems. We like to introduce various highlights in these points from our recent activities of using various modern satellite sensors, such as GPM, GCOM-W, GOSAT, HIMAWARI-8, and future plans to use GCOM-C, EarthCARE, and others. Useful high level results are multi-sensor data sets of precipitation (GSMaP), SST, atmospheric greenhouse gases, aerosols, radiation budget using active and passive sensors, and others. Discussions are new development of algorithms and data assimilation methods for these satellite-retrieved geophysical parameters, and also future directions to be pursued in the next generation.

The SPARC Water Vapour Assessment (WAVAS) activity, phase II: Goals, methods, and status

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Content Motivation : None
Additional Information : None

Dr. Gabriele Stiller ,gabriele.stiller@kit.edu ,(Senior Scientist/Group Head) ,Germany ,Karlsruhe ,Not Presenting[1]
1 - Karlsruhe Institute of Technology

The first SPARC Water Vapour Assessment was published in 2000 (SPARC report no. 2) and dealt at that time with only a handful of satellite data sets. Since the beginning of the 21st century, a large number of satellite instruments observing the upper troposphere and stratosphere have been launched, and thus it was time to start another quality assessment of the water vapour data records they have provided. Within WAVAS-II we have assessed more than 40 different water vapour records from 15 satellite instruments. Profile comparisons were made to ground truth instruments like frost point hygrometers and microwave radiometers, and between co-located measurements of the satellites. Time series were analysed for drifts and their representativeness of shorter-term variability (seasonal cycle, QBO effects). A special focus was on the humidity of the upper troposphere, an area where large variability makes any assessment challenging. Isotopologues of water vapour have been inter-compared as well. In this talk an overview of the different methods will be given, and first results of the comparisons will be presented.

Continuation of multi-angular polarized observation of the Earth's reflectance from space with DPC (directional polarized camera) on board GF-5

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Additional Information : None

Prof. Zhengqiang Li ,lizq@radi.ac.cn ,(Research director) ,China ,Beijing ,Presenting[1]
Prof. Jin Hong ,hongjin@aiofm.ac.cn ,(None) ,China , ,Not Presenting[2]
Dr. Li Li ,lili3@radi.ac.cn ,(None) ,China , ,Not Presenting[2]
Dr. Binghuan Meng ,bhmeng@aiofm.ac.cn ,(None) ,China , ,Not Presenting[2]
Prof. Xiaobing Sun ,xbsun@aiofm.ac.cn ,(None) ,China , ,Not Presenting[2]
Prof. Yanli Qiao ,ylqiao@aiofm.ac.cn ,(None) ,China , ,Not Presenting[2]
1 - Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences 2 - Chinese Academy of Sciences 3 - Chinese Academy of Sciences 4 - Chinese Academy of Sciences 5 - Chinese Academy of Sciences 6 - Chinese Academy of Sciences

A directional polarized camera (DPC) with heritage of a series of POLDER (POLarization and Directionality of the Earth's Reflectances) sensors from 1996 to 2013, will be lunched to space on board Chinese GF-5 satellite in 2017. Together with other 5 sensors onboard the same platform for measuring trace gases and surface properties, the DPC sensor dedicate to continue the multi-angular polarized observation of earth's reflectance of POLDER sensors, contributing to the advanced remote sensing of atmospheric aerosols and clouds. The first laboratory characterization of space-borne DPC sensor is presented, with an introduction of the improved spatial resolution and calibration performance. The intercomparison of sky radiance and polarization measurements with a ground-based polarized sun/sky-radiometer is also reported, as a test of instrumental overall performance.

Blended sea level anomaly fields with enhanced coastal coverage along the U.S. West Coast

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Additional Information : None

Mr. Craig Risien ,crisien@coas.oregonstate.edu ,(Senior Faculty Research Assistant) ,United States ,Corvallis ,Not Presenting[1]
Prof. P. Ted Strub ,tstrub@coas.oregonstate.edu ,(Professor, Emeritus) ,United States ,Corvallis ,Not Presenting[1]
1 - Oregon State University 2 - Oregon State University

Over the past 24 years satellite altimeter measurements have significantly improved our understanding of upper ocean processes, including large scale ocean circulation and mesoscale variability. In coastal regions, however, land contamination, imprecise tidal corrections and incorrect removal of atmospheric effects limit the use of altimeter-derived data products. In an effort to improve coastal sea level anomaly (SLA) estimates we present a new 'blended' data set that combines gridded daily fields derived from altimeter data with coastal tide gauge data. Within approximately 55-70 km of the coast, the altimeter data are removed and replaced by a linear interpolation between the tide gauge and remaining offshore altimeter data. To create a common reference height for altimeter and tide gauge data, a 20-year mean (1993-2012) is subtracted from each time series (from each tide gauge and altimeter grid point) before combining the data sets to form a blended mean sea level anomaly (SLA) data set. Daily, 0.25° latitude × 0.25° longitude gridded, mean fields are produced for the period 1 January 1993 - 31 October 2016 along the U.S. West Coast (32-48.5°N and 135-115°W). The primary validation of these fields compares geostrophic velocities calculated from the sea level height anomalies with velocities measured at four moorings covering the north-south range of the data set. We find that these new blended fields, which have been used in studies looking at the hydrography, and plankton and krill distributions off Oregon, as well as baseline ecological studies of marine protected areas along the Northern California Coast, improve the alongshore (meridional) component of the currents, indicating an improvement in the cross-shelf gradient of the mean SLA data set. In addition to presenting the above methods and results, we will present preliminary results from a study that applies the aforementioned methods to the 250 km section of South African coastline between Cape Columbine and Danger Point for the 10-year period 2001 - 2010.

Towards Unified Reporting of Errors (TUNER)

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Additional Information : None

Dr. Thomas von Clarmann ,thomas.clarmann@kit.edu ,(Head of research group) ,Germany ,Karlsruhe ,Presenting[1]
Dr. Nathaniel Livesey ,nathaniel.j.livesey@jpl.nasa.gov ,(None) ,United States , ,Not Presenting[2]
Prof. Doug Degenstein ,doug.degenstein@usask.ca ,(None) ,Canada , ,Not Presenting[3]
1 - KIT/IMK 2 - Jet Propulsion Laboratory, California Institute of Technology 3 - University of Saskatchewan, Institute of Space and Atmospheric Studies

Towards Unified Error Reporting (TUNER) has been selected as an emerging SPARC activity. Its goal is to make error estimates of existing satellite observations of atmospheric temperature and constituent profiles intercomparable. Error estimates of measurements of atmospheric state variables are essential to judge whether differences between estimates of the atmospheric state can be explained or if they hint at unknown problems. While many recipes exist to calculate the error budget of an observation, the data user is faced with the problem that errors reported by various instrument groups are rarely consistent. In this talk, the following problems will be tackled: (a) which error components should be included in the error budget; (b) how should the content of prior information in the retrievals be dealt with; (c) how can retrievals be characterized which were not produced via an optimal-estimation-like formalism and thus do not provide the usual diagnostics; (d) how can error estimates which were generated using different approaches be made comparable, and (e) what is to be considered when comparing with direct (non-remote) measurements. An action plan towards unified error reporting will be suggested.

An understanding The Earth System derived from Earth Observations

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Additional Information : None

Mr. Graeme Stephens ,graeme.stephens@jpl.nasa.gov ,(None) , , ,Not Presenting[1]
1 - None

How much will the Earth warm in the coming decades? How will the Earth's hydrological cycle and major storm systems change in response to the projected warming? These questions are timely and societally important to address. They also represent basic science challenges confronting our understanding of the evolving Earth System. Addressing these questions involves understanding of the processes that couple water cycle and energy producing the critical feedbacks that govern the response of the Earth system to a global warming. This talk will highlight how Earth observations of the past few decades have contributed to fundamental aspects of Earth system science.

Long-term Remote Sensing of Hydrometeor Size over the Amazon Basin

Abstract ID : 516

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Additional Information : None

Prof. Alex Correia ,acorreia@if.usp.br ,(Professor) ,Brazil ,Sao Paulo ,Presenting[1]
Ms. Marina Mendonça ,ma.monteiro.m@gmail.com ,(None) ,Brazil , ,Not Presenting[1]
Dr. Elisa Sena ,elisatsena@gmail.com ,(None) ,Brazil , ,Not Presenting[1]
1 - University of Sao Paulo 2 - University of Sao Paulo 3 - University of Sao Paulo

Clouds have a deep impact over climate, either by affecting Earth's radiative balance or by changing the hydrological cycle. Despite this pivotal role in climate there are still fundamental issues that need to be better understood in the dynamics of cloud formation and development. At the microscopic scale, we still need to investigate how cloud water droplets and ice particles interact with aerosols, surface properties, and meteorological parameters. Here we present results from a 15-year study on cloud microphysical properties in the Amazon Basin.
The top of atmosphere upwelling radiance field measured by geostationary satellites, from 2000 to 2014, was assessed over the Amazon Basin, in visible (0.64 μm, VIS), near infrared (3.9 μm, NIR), and thermal infrared (11 μm, TIR) wavelengths. A VIS vs. TIR threshold-based cloud mask was applied to identify cloudy pixels in individual images. The TIR flux measurements allowed determining the brightness temperature of cloudy pixels. NIR flux measurements were compared to precomputed look-up tables to estimate the effective radius of hydrometeors in liquid, mixed-phase, and ice clouds. Physical properties of liquid droplets were computed using a Mie scattering radiative code. Ice cloud scattering properties were calculated assuming a general habit mixture model for ice particles. Columnar aerosol information was obtained from Aerosol Robotic Network (AERONET) level 2.0 data. The results were analyzed according to season, time, atmospheric content of water vapor, ozone, and aerosols.
Typical hourly profiles of cloud temperature vs. effective radius (T-reff diagrams) show how cloud droplets or ice particles grow as a function of time. Seasonal differences in cloud T-reff profiles show that during the wet season the average effective radius of warm ($T>0°C$) water clouds was about 7.2 μm, decreasing to about 5.1 μm during the dry season, when thick smoke plumes from anthropic biomass burning activities are frequent in the region. Ice and mixed-phase clouds also show marked seasonal contrasts in their vertical distribution, and frequency of occurrence. These results open the path to a new scope of information, adding a temporal dimension to studies of cloud microphysics and its impact on climate.

Contributions of Aquarius and SMAP satellites to studies of ocean salinity and its linkages with climate variability and water cycle

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Additional Information : None

Dr. Tong Lee ,tlee@jpl.nasa.gov ,(Principal Scientist) ,United States ,Pasadena, California ,Not Presenting[1]
1 - NASA JPL

Sea surface salinity (SSS) measurements from NASA's Aquarius and Soil Moisture Active Passive (SMAP) missions are significantly contributing to our understanding of ocean circulation and the linkages with climate variability and water cycle. This presentation will provide an overview of recent accomplishments using Aquarius and SMAP SSS measurements to study salinity processes in the ocean, their roles in ocean circulation, the relationships with climate variability from intraseasonal to interannual time scales, and the linkages with the atmospheric and terrestrial elements of the water cycle (e.g., precipitation, continental runoff) from synoptic to interannual time scales. The accuracy/uncertainty characteristics of the SSS measurements will be discussed. Future challenges and the ongoing technological development to address these challenges will be described. The synergy of these measurements with other satellite and in-situ observations to address Earth System science will be highlighted.

A new approach for obtaining sea ice parameters over the polar regions from low frequency passive microwave measurements

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Conflict Declaration : None
Content Motivation : None
Additional Information : School of Earth and Env Sci. Seoul National Univ. Seoul, 151-747 Korea

Prof. B.J. Sohn ,sohn@snu.ac.kr ,(None) ,South Africa ,None ,Not Presenting[1]
1 - SNU

Horizontally and vertically polarized emissivities at 6.9 GHz, and associated physical sea ice temperature have been retrieved from 6.9 GHz brightness temperature measurements using the so-called "combined Fresnel equation", which combines two Fresnel polarized reflectivity equations into one. Comparison of the pixel-based sea ice temperature with in-situ buoy measurement indicates a correlation coefficient of about 0.99 and a mean bias of 0.83 K, demonstrating an excellent agreement, and the same degree of accuracy can expected in the obtained surface emissivity. Based on the assumption that the retrieved sea ice temperature at 6.9 GHz is similar to ones retrieved at 10.7, 18.7 GHz, spectrally dependent surface emissivities are obtained, from which first-year sea ice can be discriminated from multiyear sea ice. It was shown that emissivity gradient between 10.7 and 18.7 GHz for the first year ice is found to be opposite to that for multi-year sea ice, enabling to separate first-year ice from multi-year old ice. Comparison against first-year and multi-year information obtained from CRELL buoy data demonstrated that the separation method is solid, and long-term data about fresh ice distribution can be used for examining the climate change signal over the Arctic, when combined with sea ice temperature information.

Inferring source regions and transport pathways of iron in the Southern Ocean from satellite chlorophyll data

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Additional Information : None

Dr. Robert Graham ,robert.graham@npolar.no ,(Postdoc) ,Norway ,Tromso ,Presenting[1]
Dr. Agatha de Boer ,agatha.deboer@geo.su.se ,(None) ,Sweden ,None ,Not Presenting[2]
Dr. Karen Kohfeld ,kohfeld@sfu.ca ,(None) ,Canada , ,Not Presenting[3]
Dr. Erik van Sebille ,e.van-sebille@imperial.ac.uk ,(None) ,Netherlands , ,Not Presenting[4]
Dr. Christian Schlosser ,cschlosser@geomar.de ,(None) ,Germany , ,Not Presenting[5]
1 - Norwegian Polar Institute 2 - Stockholm University 3 - SFU 4 - Institute for Marine and Atmospheric Research, Utrecht University, Netherlands 5 - GEOMAR

Primary productivity is limited by the availability of iron over large areas of the global ocean. Changes in the supply of iron to these regions could have major impacts on primary productivity and the carbon cycle. However, source regions and supply mechanisms of iron to the global oceans remain poorly constrained. Shelf sediments are considered one of the largest sources of dissolved iron to the global ocean, and a large shelf sediment iron flux is prescribed in many biogeochemical models over all areas of bathymetry shallower than 1000 m. Here, we infer the likely location of shelf sediment iron sources in the Southern Ocean, by identifying where satellite chlorophyll concentrations are enhanced over shallow bathymetry (<1000 m). We further compare chlorophyll concentrations with the position of ocean fronts, to assess the relative role of horizontal advection and upwelling for supplying iron to the ocean surface. We show that mean annual chlorophyll concentrations are not visibly enhanced over areas of shallow bathymetry that are located more than 500 km from a coastline. Mean annual chlorophyll concentrations >2 mg m^{-3} are only found within 50 km of a continental or island coastline. These results suggest that sedimentary iron sources only exist on continental and island shelves. Large sedimentary iron fluxes do not seem present on seamounts and submerged plateaus. Large chlorophyll blooms develop where the western boundary currents detach from the continental shelves, and turn eastward into the Sub-Antarctic Zone. Chlorophyll concentrations are enhanced along contours of sea surface height extending off the continental shelves, as shown by the trajectories of virtual water parcels in satellite altimetry data. These analyses support the hypothesis that bioavailable iron from continental shelves is entrained into western boundary currents, and advected into the Sub-Antarctic Zone along the Dynamical Subtropical Front. Our results indicate that upwelling at fronts in the open ocean is unlikely to deliver iron to the ocean surface from deep sources. Finally, we hypothesise how a reduction in sea level may have altered the distribution of shelf sediment iron sources in the Southern Ocean and increased export production over the Sub-Antarctic Zone during glacial intervals.

IONOGLOW: new perspectives for tsunami detection from space

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Additional Information : None

Dr. Giovanni Occhipinti ,ninto@ipgp.fr ,(Associate Professor) ,France ,Paris ,Presenting[1]
Prof. Mioara MANDEA ,mioara.mandea@cnes.fr ,(Innovation, Application and Science Directorate) ,France ,Paris ,Not Presenting[2]
Dr. Eric Pequignot ,Eric.Pequignot@cnes.fr ,(None) ,France , ,Not Presenting[3]
Dr. Elvira Astafyeva ,astafyeva@ipgp.fr ,(None) ,France , ,Not Presenting[1]
Dr. Philippe Lognonné ,lognonne@ipgp.fr ,(None) ,France , ,Not Presenting[1]
Dr. Hélène Hébert ,helene.hebert@cea.fr ,(None) ,France , ,Not Presenting[6]
Dr. Lucie Rolland ,Lucie.ROLLAND@geoazur.unice.fr ,(None) ,France , ,Not Presenting[7]
Dr. Anthony Sladen ,sladen@geoazur.unice.fr ,(None) ,France , ,Not Presenting[7]
Prof. Jonathan Makela ,jmakela@illinois.edu ,(None) ,United States , ,Not Presenting[9]
Dr. Pierdavide Coïsson ,coisson@ipgp.fr ,(Associate Physicist) ,France ,Chambon la forêt ,Not Presenting[10]
1 - Institut de Physique du Globe 2 - CNES - Centre National d'Etudes Spatiales 3 - CNES 4 - Institut de Physique du Globe 5 - Institut de Physique du Globe 6 - CEA 7 - GeoAzur 8 - GeoAzur 9 - University of Illinois 10 - Institut de Physique du Globe de Paris

The tsunamigenic Tohoku earthquake (2011) strongly affirms, again, after the Sumatra event (2004), the necessity to open new paradigms in oceanic monitoring. Detection of ionospheric anomalies following the Sumatra earthquake event (*e.g.*, Occhipinti et al. 2006, 2010) demonstrated that ionosphere is sensitive to earthquake and tsunami propagation: ground and oceanic vertical displacement induces acoustic-gravity waves propagating within the neutral atmosphere and detectable in the ionosphere. Observations supported by modelling proved that tsunamigenic ionospheric anomalies are deterministic and reproducible by numerical modeling via the ocean/neutral-atmosphere/ionosphere coupling mechanism (Occhipinti et al., 2008). To prove that the tsunami signature in the ionosphere is routinely detected we show here perturbations of total electron content (TEC) measured by GPS and following tsunamigenic earthquakes from 2004 to 2011 (Rolland, Occhipinti et al. 2010, Occhipinti et al., 2013), nominally, Sumatra (26 December, 2004 and 12 September, 2007), Chile (14 November, 2007), Samoa (29 September, 2009) and the recent Tohoku-Oki (11 Mars, 2011). Based on the observations close to the epicenter, mainly performed by GPS networks located in Sumatra, Chile and Japan, we highlight the TEC perturbation observed within the first hour after the seismic rupture. This perturbation contains informations about the ground displacement, as well as the consequent sea surface displacement resulting in the tsunami. In addition to GPS/TEC observations close to the epicenter and measured by GEONET network, new exciting measurements in the far-field were performed by Airglow measurement in Hawaii: those measurements show the propagation of the IGWs induced by the Tohoku tsunami in the Pacific Ocean (Occhipinti et al., 2011). This revolutionary imaging technique is today supported by two new observations of moderate tsunamis: Queen Charlotte (M: 7.7, 27 October, 2013) and Chile (M: 8.2, 16 September 2015).
In this talk we present all this new tsunami observations in the ionosphere and we discuss, under the light of modelling, the potential role of ionospheric sounding in the oceanic monitoring and future tsunami warning system, based on the potential idea to put an Airglow camera on a satellite.
The review presented in this talk is published as Occhipinti (2015) available @ www.ipgp.fr/~ninto

Satellite-measured daily-to-seasonal variations of low-cloud fraction over the South Indian Ocean

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Dr. Hisashi Nakamura ,hisashi@atmos.rcast.u-tokyo.ac.jp ,(Professor) ,Japan ,Tokyo ,Not Presenting[1]
1 - University of Tokyo

Variations of low-cloud fraction over the South Indian Ocean on daily to seasonal timescales and their relationship with meteorological and maritime conditions are investigated, on the basis of daytime satellite data of low-level clouds with no overlapping with mid- and high-level clouds. In the subtropics, mean summertime low-cloud fraction maximizes off the western coast of Australia, while unlike in other ocean basins, it is distributed more zonally across the basin in winter. Over the midlatitude and subpolar oceans, low-cloud fraction is particularly large throughout the year, with a sharp meridional decline across a midlatitude oceanic front. The cloudiness distribution is overall correspondent with estimated inversion strength that depends on sea-surface temperature (SST) and subsidence associated with the subtropical anticyclone. However, the wintertime enhancement of the subtropical cloudiness across the basin better corresponds with that of the southeasterly Trades that induce cold advection and upward surface sensible heat flux (SHF) to favor shallow convection. Sensitivity of daily variations in low-cloud fraction to surface thermal advection shows distinct regionality. Enhanced cold advection over the subtropical ocean tends to increase cloudiness, while high cloudiness over the midlatitude/subpolar oceans is maintained also under enhanced warm advection that induces downward SHF to facilitate fog and stratus. The sharp SST decline across the oceanic front augments surface thermal advection directly and also indirectly by anchoring a stormtrack core and thereby intensifying cross-frontal wind fluctuations. Low-cloud fraction is most influential not only in determining to the seasonal distribution of albedo but also to its daily variations.

What TANSO-FTS onboard GOSAT has measured for 8 years with its high spectral resolution, wide spectral range, and agile pointing capability?

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Dr. Akihiko Kuze ,kuze.akihiko@jaxa.jp ,(Associate Senior Researcher) ,Japan ,Tsukuba ,Presenting[1]
Ms. Fumie Kataoka ,kataoka.fumie@restec.or.jp ,(None) ,Japan , ,Not Presenting[2]
Dr. Hiroshi Suto ,suto.hiroshi@jaxa.jp ,(None) ,Japan , ,Presenting[3]
Dr. Kei Shiomi ,shiomi.kei@jaxa.jp ,(None) ,Japan ,None ,Presenting[1]
Dr. Nobuhiro Kikuchi ,kikuchi.nobuhiro@jaxa.jp ,(None) ,Japan , ,Not Presenting[3]
Dr. Makiko Hashimoto ,hashimoto.makiko@jaxa.jp ,(None) ,Japan ,None ,Not Presenting[1]
1 - Japan Aerospace Exploration Agency 2 - RESTEC 3 - JAXA 4 - Japan Aerospace Exploration Agency 5 - JAXA 6 - Japan Aerospace Exploration Agency

The Greenhouse gases Observing SATellite (GOSAT) is the first satellite program designed to accurately and precisely monitor carbon dioxide (CO_2) and methane (CH_4) from space.?It was launched in January 2009 and Thermal And Near infrared Sensor for carbon Observation Fourier-Transform Spectrometer (TANSO-FTS) has been acquiring high-resolution spectra. Monthly onboard and annual vicarious calibrations can produce the same quality radiance spectra of the full GOSAT time series for decade long greenhouse gases (GHG) monitoring from space.
With the FTS multiplex advantage, the single spectrometer with a common field of view can simultaneously cover both two linear polarization of the solar scattered light in the short wave infrared (SWIR) band and thermal emission from the earth's surface and atmosphere in the thermal infrared (TIR) band. By combing SWIR and TIR, at least two layer of CO_2 and CH_4 can be retrieved and polarization information improved detectivity of aerosol, which is one of the largest error sources.
In addition to GHG, from high resolution spectra, solar induced plant fluorescence has been measured firstly from space from and the solar lines data base has been updated.
Using the GOSAT target observation capability with an agile pointing, we have demonstrated optimization of spatiotemporal sampling patterns. In addition to global distribution, GOSAT has detected enhanced GHG associated with (1) extremely high emissions from point source such as a gas leak, livestock, landfill, coal mining and oil field, (2) a widespread megacity, and (3) seasonal variations in the eight-year data set.

Eddy detection in satellite-derived fields: achievements and challenges

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Additional Information : None

Dr. Svetlana Karimova ,svetlana.karimova@ulg.ac.be ,(Postdoctoral researcher) ,Belgium ,Liege ,Not Presenting[1]
1 - University of Liege

Coherent vortical structures, or eddies, of different spatial scales are essential elements of developed oceanic turbulence. Being responsible for local extrema in the field of surface currents and having relatively long lifetimes, these structures play a crucial role in horizontal and vertical water transport, which in its turn determines to a great extent the dynamics of biochemical parameters.
Satellite remote sensing provides a variety of data sources for reconstructing surface circulation of marine basins and for detecting eddies of different spatial scales. Thus, in thermal infrared imagery eddies (mostly mesoscale) can be seen due to thermal contrasts between the adjacent water particles. Visible-range satellite imagery can manifest both submesoscale and mesoscale circulation elements, provided that there are organic or inorganic suspended particles in surface water. Organic films on the water surface and strong wave-current interactions also visualize vortical, mostly submesoscale, structures while being imaged by synthetic aperture radar (SAR). Finally, locations of vortical structures can be extracted indirectly using the fields of sea level anomaly (SLA) and/or surface geostrophic currents.
Multiple techniques have been proposed for extracting information on the presence of vortical structures and their characteristics from different scalar and vector remotely-derived fields. Among them, there are methods based on front detection, ellipse/circle fitting, analysis of vector/streamline geometry, extraction of closed contours, wavelet analysis, observing lagrangian coherent structures, etc. In this presentation, an overview of such techniques along with an analysis of their potentials and limitations is provided. As a research material, a dataset of more than 30.000 eddy manifestations detected in different types of satellite imagery (thermal infrared, visible-range, SAR) in a number of marine basins (namely, the Baltic, Black, Caspian, Mediterranean, North, and Red Seas) is being used. Such obtained database of eddy manifestations is applied for testing other, less direct, techniques of eddy detection in satellite-derived fields.
This research was supported by the University of Liege and the EU in the context of the FP7-PEOPLE-COFUND-BeIPD project. The study has been conducted using E.U. Copernicus Marine Service Information.

Observing Air Quality from Geostationary Constellation

Abstract ID : 1073

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Additional Information : None

Prof. Jhoon Kim ,jkim2@yonsei.ac.kr ,(None) , , ,Presenting[1]
Dr. Jay Al-Saadi ,j.a.al-saadi@nasa.gov ,(None) ,United States , ,Not Presenting[2]
Dr. Ben Veihelmann ,ben.veihelmann@esa.int ,(None) ,Netherlands , ,Not Presenting[3]
Dr. Kelly Chance ,kchance@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[4]
Dr. Xiong Liu ,xliu@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[5]
Prof. M.H. Ahn ,terryahn65@ewha.ac.kr ,(None) ,South Korea , ,Not Presenting[6]
1 - Yonsei University 2 - NASA LaRC 3 - ESA ESTEC 4 - Harvard Smithonian Center for Astrophysics
5 - Harvard-Smithsonian Center for Astrophysics, Cambridge 6 - Ewha Womans University

Monitoring air quality is very important in understanding the globalization of air pollution, climate change, and assessing the public health impacts of air pollution. Satellite remote sensing has played a significant role in providing a global picture of air quality, filling the gaps of ground-based networks. With the recent developments of spec-trometers in UV-visible wavelengths with sub-nm spectral resolution and of retrieval algorithms, we now can gener-ate estimates of the column amounts of atmospheric O_3, NO_2, SO_2, HCHO, CHOCHO and other constituents in the troposphere. To date, all the UV-visible satellite missions to monitor trace gas concentrations in the atmosphere have been in low Earth orbits (LEOs), usually allowing one observation per day. With the advent of new UV-visible instruments on geosta-tionary Earth orbit (GEO) platforms, the diurnal variation of these components can be captured. By the early 2020s, the geostationary belt is expected to be occupied by three UV-visible spectrometers: The NASA Tropospheric Emissions: Monitoring of Pollution (TEMPO) over North America, the Copernicus Sentinel-4 ultraviolet visible near infrared spectrometer (developed by ESA) over Europe, and the KARI Geostationary Environment Monitoring Spectrometer (GEMS) over Asia, with the Tropospheric Monitoring Instrument (TROPOMI) and Ozone Mapping Profiler Suite (OMPS) flying underneath in LEO. Recognized by the Committee on Earth Observation Satellites (CEOS) Atmospheric Composition Virtual Constella-tion (AC-VC), the geostationary constel-lation of UV-visible spectrometers will enlighten us on the global distribution of ozone, aerosol, and their precursors. To integrate the dataset for global measure-ments, consistent data quality is very important, thus inter-calibration among the three different UV-visible satellite instruments and the standardiza-tion and harmonization of data products and data quality are now under discussion. Together with geostationary meteorological satellite programs, these three missions will contribute to monitoring global air quality, long range transport, and top-down emission sources.

Assessing the impact of the anthropocene on atmospheric composition using remote sensing from aircraft and space based instrumentation.

Abstract ID : 1141

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Additional Information : None

Mr. John P. Burrows ,burrows@iup.physik.uni-bremen.de ,(None) ,Germany ,None ,Not Presenting[1]
1 - Institute of Environmental Physics, University of Bremen

Between the Neolithic revolution and the industrial revolution the population grew from several millions to 1 billion by exploiting wind and solar power, biomass burning and some coal burning to produce energy. Since the industrial revolution the earth has grown to ~7.5 Billion and at the same time the standard of living has increased dramatically. This has been possible through the exploitation of fossil fuels as an energy source. There has been an acceleration of the release of both short lived climate pollutants and long lived greenhouse gases. Pollution in the atmosphere now spans all scales from the local to the global. Air quality, stratospheric ozone and climate change are all being influenced by anthropogenic activity and the earth has entered a new geological epoch the Anthropocene.
The SCIAMACHY (Scanning Imaging Absorption spectrometer for Atmospheric CHartographY) project, which began in the 1980s, aimed to yield the amounts and distribution of atmospheric constituents: trace gases, aerosols and clouds from space based passive remote sensing in the solar spectral range. As a result of this initiative the following instruments have been developed and launched on satellite platforms into sun synchronous low earth orbit: GOME (Global Ozone Monitoring Experiment - ESA ERS-2 1995-2011), SCIAMACHY (ESA Envisat 2002 to 2012) GOME_2 (EUMTSAT Metop A 2006 to present, Metop B 2012 to present). In addition the spin off OMI (Ozone Monitoring Instrument - NASA AURA 2004 to present) was developed by NSO. GOME GOME-2 and OMI make measurements of the back scattered electromagnetic upwelling at the top of the atmosphere in nadir. SCIAMACHY makes alternate limb and nadir measurements. Appropriate mathematical inversion of the measurements of these instruments yields information about the total stratospheric and tropospheric column amounts and distributions of the following gases, which are either short lived climate pollutants or greenhouse gases: O3, NO2, H2O, HCHO, CHO.CHO, BrO, IO, CO, CH4 and CO2. This presentation will provide an update on the analysis at the University of Bremen of the time series provided by these instruments and related instruments developed for aircraft.

Magnetic Remote Sensing of Ocean Heat and Transport

Abstract ID : 1152

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Robert Tyler ,robert.h.tyler@nasa.gov ,(None) ,United States ,Greenbelt ,Not Presenting[1]
1 - UMD/NASA-GSFC

Understanding and predicting climate and sea level change requires monitoring the amount of heat stored in the ocean. A primary concern is that the extent of global warming may currently be masked by unaccounted heat increases in the ocean. Despite the recognized importance, adequate monitoring of ocean heat content (as well as heat transport) has remained elusive using established in situ and remote observational methods.

Here we demonstrate that monitoring of ocean heat content and transport may potentially be performed by satellite magnetometers by exploiting a phenomenon whereby ocean flow generates weak magnetic-field fluctuations that reach far outside of the ocean, even passing through sea ice. These magnetic fluctuations are modulated by the ocean's electrical conductance (i.e. depth-integrated electrical conductivity) which we show to be linearly related to depth-integrated ocean temperature and thereby depth-integrated heat content. Inversion of magnetic data using the electromagnetic induction equation and appropriate methodology might then provide a means of remotely monitoring ocean heat content. Demonstration of this opportunity is made timely by the global magnetic survey underway by the recently launched ESA Swarm constellation of satellites that provides for the first time two-component gradiometric remote measurements of the magnetic field.

Our research actively underway so far specifically shows (a) a strong linear relationship between conductance and heat content; (b) a proof in concept that a highly accurate description of conductance can be recovered from synthetic (i.e. numerically modeled) ocean tidal (M2) magnetic data as would be observable remotely; (c) an M2 tidal magnetic field extracted from observations that agrees well with the synthetic prediction; and (d) that despite this agreement conductance obtained by inverting the observed M2 magnetic data can show disproportionate differences that are sensitive to the inversion method currently used (a factor of the well-known ill-posedness in inverse problems) such that observational noise and/or modeling errors presently limit the practical reliability of results. Indeed, practical monitoring of temporal changes will likely require even higher accuracy, though there are also some mitigating factors when needing to determine only differences. Addressing this challenge are the improved observational data being collected by Swarm, and improvements in data processing, modeling, and inversion methodologies.

Carbon Monoxide Transport across the Pacific as Seen from the MOPITT Instrument

Abstract ID : 1316

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. James Drummond ,james.drummond@dal.ca ,(Professor of Physics) ,Canada ,Halifax ,Not Presenting[1]
Dr. Florian Nichitiu ,nichitiu@atmosp.physics.utoronto.ca ,(None) ,Canada , ,Not Presenting[2]
Dr. Jiansheng Zou ,jzou@atmosp.physics.utoronto.ca ,(None) ,Canada , ,Not Presenting[2]
1 - Dalhousie University 2 - University of Toronto 3 - University of Toronto

Carbon monoxide (CO) is a pollutant gas with a major source in uncontrolled combustion and similar processes all of which have both a natural and anthropogenic component. Since it has a moderate lifetime of about a month in the atmosphere, it can be transported over great distances especially if lofted into the mid and upper troposphere.
Since 2000 the Measurements Of Pollution In The Troposphere (MOPITT) instrument has been measuring CO over the entire globe, and these long-term dense measurements permit us to see the evolution of CO at the continental and global scale. Using this dataset we can follow the transport of CO across the oceans, in this case the Pacific ocean, and we find a number of distinct phenomena both regular and intermittent, contribute to this stream. For example, in 2016 there was considerable transport of CO from Northern Russia into Northern Canada including the Canadian Arctic leading to detection of CO anomalies as far North as Eureka (80N). These intrusions appear to be at least comparable to CO sources within Canada at the time and so are significant contributors to the CO burden above the country.
MOPITT was built in Canada by COMDEV of Cambridge, ON and the instrument and operations are funded by the Canadian Space Agency. The instrument is carried on the NASA Terra satellite.

Development of geophysical products from the new generation of Korean geostationary meteorological satellite Geo-KOMPSAT-2A

Abstract ID : 1349

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Mr. Sung-Rae Chung ,csr@korea.kr ,(Senior Researcher) ,South Korea ,Jincheon ,Not Presenting[1]
Prof. Dong-Bin Shin ,dbshin@yonsei.ac.kr ,(None) ,South Korea , ,Not Presenting[2]
Dr. Seon-Kyun Baek ,frogsun@korea.kr ,(None) ,South Korea , ,Not Presenting[1]
Dr. Gyung-Soo Han ,kyung-soo.han@pknu.ac.kr ,(None) ,South Korea , ,Not Presenting[4]
Prof. Myoung-Hwan Ahn ,terryahn65@gmail.com ,(None) ,South Korea ,Seoul ,Not Presenting[5]
Prof. Won-Chan Jung ,wcjung@etri.re.kr ,(None) ,South Korea , ,Not Presenting[6]
1 - Korea Meteorological Administration 2 - Yonsei University 3 - Korea Meteorological Administration 4 - Pukyong National University 5 - Ewha Womans U. 6 - Electronics and Telecommunications Research Institute

Korea Meteorological Administration (KMA) has developed second geostationary meteorological satellite, Geo-KOMPSAT-2A (GK-2A) since 2013. It is scheduled for a launch in May 2018. GK-2A will have a new generation of geostationary imager, Advanced Meteorological Imager (AMI) like Himawari-8/9 and GOES-R satellites. GK-2A/AMI will provide huge observational data through 16 channels with high spatial and temporal resolution to observe the Earth's weather, climate and environment. In order to implement these applications, KMA is developing fifty-two geophysical products in cooperation with Korean Electronics and Telecommunications Research Institute (ETRI) and domestic academia. These geophysical products are categorized as scene analysis/surface information, cloud/rainfall, radiation/aerosol and atmosphere/aviation information according to their characteristics and applications. We are now in the provisional validation stage of the products to evaluate their performances and utilizations for satellite data users as well as in-depth review the science and concepts for the products. In this paper, the status of the development of GK-2A's geophysical products and related activities are presented.

Early phase achievement of Chinese carbon dioxide observation satellite (TanSat) Mission

Abstract ID : 1355

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. Yi Liu ,liuyi@mail.iap.ac.cn ,(Scientist) ,China ,Beijing ,Presenting[1]
Prof. Naimeng Lu ,lunm@cma.gov.cn ,(None) ,China , ,Presenting[2]
Mr. Daren Lu ,ludr@mail.iap.ac.cn ,(None) , , ,Presenting[3]
1 - Institute of Atmospheric Physics, Chinese Acedemy of Sciences 2 - National Satellite Meteorological Center 3 - None

As the large developing and GHG emission country, China is seeking the sustainable development and trying to reduce the GHG emission. The ministry of science and technology of the People's republic of China had sponsored the Chinese carbon dioxide observation satellite (TanSat) mission 6 years ago. After successfully launched on December 22 in Jiuquan Satellite Launch Center, TanSat is going into initial experimental phase from January to April, the Carbon Dioxide Spectrometer (CDS) and Cloud and Aerosol Polarization Imager (CAPI) are conducted a series of on-orbit calibrations. The initial calibration and observations experiments have demonstrated satisfied results in spectra data of O_2A band, CO_2 weak and CO_2 strong bands. More detailed experiments on the calibration, different observation modes and retrieval testing will be projected.

According to the scientific application plan of TanSat observation and the open data policy, the calibrated Level 1 data and validated Lever 2 data will be released to the domestic and international scientific researchers. The TanSat observations will contribute to the CO_2 monitoring and CO_2 emission reduction over regional and global scales.

Monitoring storm surges in the Adriatic Sea using satellite altimetry

Abstract ID : 1418

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Stefano Vignudelli ,vignudelli@pi.ibf.cnr.it ,(Researcher) ,Italy ,pisa ,Not Presenting[1]
1 - CNR

The Adriatic Sea, including the area around Venice, is an important laboratory for validating and applying coastal altimetry products. The area is frequently affected by storm surges because of its geographical position and geometry. Storm surges are usually generated by strong winds from the south-east that are directed along the main axis of the basin. The resulting surge signal is maximum in the northwestern part of the basin, especially at the city of Venice and its surrounding lagoon where is it called "Acqua Alta" (high water). With the significant impact that every surge event has on the city, and the huge investments (7 billion Euros) put into the MOSE flood protection barrier system due for completion in 2016, accurate forecasting of the timing and level of surges is more important than ever. Satellite radar altimetry is designed to measure heights at sea (along-track only, but on a truly global mesh of ground tracks, i.e. also in zones with no tide gauges around). It provides the 'true' water level measured by an observer at the coast (i.e. what the storm surge community calls "total water level envelope", TWLE). Until a few years ago, satellite radar altimetry was not exploited for storm surge research, let alone in the Adriatic Sea. In this poster we illustrate the dedicated reprocessing of satellite radar altimetry carried out in the Adriatic Sea. Data analysis and comparisons with tide gauges show that more data can be recovered not only closer to the coast, but also over the open part of the North Adriatic Basin. Moreover, the estimated errors for the reprocessed data (of the order of 10cm for the high-rate data, which can then be significantly reduced with along-track averaging) qualify the altimeter-derived TWLEs for verification of and assimilation in surge models.

The interpretation of gravity and magnetic data and the value of long wavelength information

Abstract ID : 1438

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. Susan J. Webb ,susan.webb@wits.ac.za ,(None) ,South Africa ,Johannesburg ,Not Presenting[1]
1 - University of the Witwatersrand

The exploration geophysics community is usually interested in short-wavelength (10s to 100s m) anomalies in the search for resources. However, the investigation of large scale crustal features of economic importance, such as the Bushveld Complex, has benefitted from the consideration of the long wavelength gravity signal. In the case of the Bushveld Complex, the inclusion of crustal flexure resulted in a dramatically different interpretation of the geometry from previously published interpretations that ignored this long wavelength component. This reinterpretation has opened up a vast area of the Bushveld Complex for exploration. Another example of the importance of the long wavelength gravity signal is the consideration of the effect of composition versus temperature in the seismically fast keel beneath the Kaapvaal Craton and the interpretation of the resulting gravity field. The presence of the keel is an important marker for the Archaen craton and its potential to host diamondiferous kimberlites.

Regional airborne magnetic data are usually collected in large blocks and stitched together, obscuring wavelengths on the order of the survey block. At a larger scale, these datasets are often disrupted by large gaps, variable collection parameters, and dates of collection. While gaps can be filled with satellite magnetic data this is imperfect as some wavelengths are likely still missing. The wavelengths of 400 km down to 20 km are of interest for large scale crustal features. Examples include investigations of the Bushveld Complex, which extends ~350 km laterally, the Witwatersrand Basin with an extent of ~300 km and the Vredefort impact structure of at least 80 km. All of these features were flown in a patchwork of surveys that were merged into gridded datasets but they host strongly magnetic components that have long wavelength magnetic anomalies that can contribute to their interpretation.

Integrating Spaceborne and Ground Data to Study Air Quality: Background and Urban-influenced

Abstract ID : 1464

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Anne Thompson ,anne.m.thompson@Nasa.gov ,(Senior Scientist) ,United States ,Greenbelt ,Not Presenting[1]
Dr. Ryan Stauffer ,ryan.m.stauffer@Nasa.gov ,(None) ,United States , ,Presenting[2]
Dr. Bryan Duncan ,bryan.n.duncan@nasa.gov ,(None) ,United States , ,Not Presenting[1]
Ms. Jacquelyn Witte ,jacquelyn.witte@nasa.gov ,(None) ,United States , ,Not Presenting[1]
Dr. Lok Lamsal ,lok.lamsal@nasa.gov ,(None) ,United States , ,Not Presenting[1]
1 - NASA 2 - NASA/Goddard 3 - NASA 4 - NASA 5 - NASA

Satellite data are indispensable for studying global trends because of coverage. When it comes to tropospheric ozone and precursors (for example, CO, NO_x) current technology shows promise but also some limitations. Examples will be shown, principally from the OMI satellite (2005->), that include changes in NO_2, and from ground-based measurements (sondes, spectrometers).

JM2 - Climate Variability And Change On All Scales (IAMAS, IAPSO)

The climate shift of interannual variability of winter precipitation over China

Abstract ID : 130

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. XiaoJing Jia ,jiaxiaojing@zju.edu.cn ,(Professor) ,China ,HangZhou ,Not Presenting[1]
1 - ZheJiang University

The interdecadal change of the leading mode of the mean winter precipitation over China has been investigated using observational data for the period from 1960 to 2012. The leading empirical orthogonal function (EOF) mode (EOF1) of the winter precipitation over China displays a mono-sign pattern over southeastern China, accounting for 49.7% of the total variance in the precipitation. Both the El Niño-Southern Oscillation (ENSO) and the East Asian winter monsoon (EAWM) can impact EOF1. A positive (negative) EOF1 is accompanied by warm (cold) ENSO events and weak (strong) EAWM, and the latters can cause anomalous southerlies (northerlies) along the coast of southeastern China, accompanied by the transportation of water vapor from the Bay of Bengal and the South China Sea favoring a wet (dry) winter over southeastern China.
An abrupt transition of the EOF1 is observed around the mid-1980s. Therefore, the data are divided into two subperiods, i.e., 1960 to 1987 (P1) and 1988 to 2009 (P2). Significant differences in the large scale atmospheric circulation and sea surface temperature (SST) anomalies associated with EOF1 during these two subperiods are observed. EOF1 is closely related to the mid- to high-latitude atmospheric circulation in P1, while its relationship to the tropics obviously increases during P2. The partial regression analysis results show that the interdecadal change of EOF1 is caused by both the interdecadal changes of the EAWM and ENSO around the mid-1980s. In P1, the lower-level anomalous southerlies along the coastal southeastern China accompanied by water vapor transportation that causes above-average precipitation are related to an anti-cyclonic system centered over the mid-latitude western North Pacific associated with EAWM. In P2, the influence of the EAWM is weaker, and the southerly anomaly over the coastal southeastern China is mainly caused by the anticyclone over Philippines, which is related to the ENSO.

Community-based Climate Adaptation: Alaska Native Communities Design a Relocation Process to Protect Their Human Rights

Abstract ID : 182

Conflict Declaration : None
Content Motivation : This abstract is part of the UNEP IAMAS session M16: Resilience: the science of adapting to climate change
Additional Information : Alaska has warmed twice as fast as the global average over the past half a century, and temperatures are projected to rise by 1-3C by 2030 and by 3-6.5C by 2100. Accelerated warming in the Arctic has tremendous implications for the world as a whole, and not least Alaska. Less sea ice covers the Arctic Ocean today than at any time in recent geological history, and landmasses are also affected by rising temperatures. Permanently frozen subsoil, or permafrost, keeps land intact and habitable along the state's north-west coast, but it is melting. This has led to increased erosion rates and flooding, which damage or destroy infrastructure and threaten the livelihoods and well-being of people residing throughout state. Alaska Natives are among the first to decide that the relocation of whole communities is the only long-term adaptation strategy to protect them from the impacts of climate change.

Dr. Robin Bronen ,robin.bronen@akijp.org ,(Executive Director) ,United States ,Anchorage ,Not Presenting[1]
1 - Alaska Institute for Justice

The displacement and relocation of millions of people will be one of the greatest adaptation challenges for the people forced to leave their homes and the government institutions responsible for implementing adaptation strategies. Extreme weather events coupled with sea level rise and erosion is causing coastal and riverine areas where people live and maintain livelihoods to permanently disappear. Adaptation to these environmental changes, including the permanent relocation of millions of people, requires new governance tools. In the U.S, local governments, often with state-level and national-level support, will be primarily responsible for protecting residents from climate-change impacts and implementing policies needed to protect their welfare. Government agencies have a variety of tools to facilitate protection in place and managed coastal retreat, but have very limited tools to facilitate a community-wide relocation. In addition, no institutional mechanism currently exists to determine whether and when preventive relocation needs to occur in order to protect people from climate change impacts. Based on research involving 15 Alaska Native communities threatened by climate-induced environmental impacts, this paper proposes the design and implementation of an adaptive governance framework to respond to the need to relocate populations. In this context, adaptive governance means the ability of institutions to dynamically respond to climate change impacts. A component of this adaptive governance framework is a social-ecological monitoring and assessment tool, which can facilitate collaborative knowledge production by community residents and governance institutions to guide sustainable adaptation strategies and determine whether and when relocation needs to occur. This paper will discuss the work being done by 15 Alaska Native communities to design and implement a community-led relocation process, which includes the development of this monitoring and assessment tool in collaboration with state and federal government agencies.

Non-stationarity in Southern Hemisphere climate variability associated with the seasonal breakdown of the stratospheric polar vortex.

Abstract ID : 223

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Mr. Nick Byrne ,n.byrne@pgr.reading.ac.uk ,(PhD Student) ,United Kingdom ,Reading ,Not Presenting[1]
Prof. Alan Plumb ,plumb@mit.edu ,(None) ,United States , ,Not Presenting[2]
Dr. Tim Woollings ,Tim.Woollings@physics.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
Prof. Theodore G. Shepherd ,theodore.shepherd@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]
1 - None 2 - MIT 3 - University of Oxford 4 - University of Reading

Statistical models of climate generally regard climate variability as anomalies about a climatological seasonal cycle, which are treated as a stationary stochastic process plus a long-term seasonally dependent trend. However, the climate system has deterministic aspects apart from the climatological seasonal cycle and long-term trends, and the assumption of stationary statistics is only an approximation. The variability of the Southern Hemisphere zonal-mean circulation in the period encompassing late spring and summer is an important climate phenomenon and has been the subject of numerous studies. In this talk we will show, using re-analysis data, that this variability is rendered highly non-stationary by the organizing influence of the seasonal breakdown of the stratospheric polar vortex, which breaks time symmetry. It will be argued that the zonal-mean tropospheric circulation variability during this period is best viewed as interannual variability in the transition between the springtime and summertime regimes induced by variability in the vortex breakdown. In particular, the apparent long-term poleward jet shift during the early-summer season can be more simply understood as a delay in the equatorward shift associated with this regime transition. The implications of such a perspective for various open questions will also be discussed.

Stratospheric Response to the 11-year Solar Cycle: Breaking Planetary Waves, Internal Reflection and Resonance

Abstract ID : 228

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Hua Lu ,hlu@bas.ac.uk ,(None) ,United Kingdom ,Cambridge ,Not Presenting[1]
Prof. Lesley Gray ,gray@atm.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Dr. Thomas Bracegirdle ,tjbra@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
Dr. Ian White ,ian.white@mail.huji.ac.il ,(Postdoctoral Researcher) ,Israel ,Jerusalem ,Not Presenting[4]
1 - British Antarctive Survey 2 - NCAS-Climate, Department of Atmospheric Physics, Oxford University 3 - British Antarctic Survey 4 - Hebrew University of Jerusalem

Breaking planetary waves (BPWs) precondition the winter stratosphere and play a crucial role in the development of the stratospheric polar vortex. Regions with enhanced BPWs act as barriers or reflecting surfaces to subsequent wave propagation. Nonlinear reflection from the region of BPWs and resonant growth of reflected waves can alter the net wave forcing on the polar vortex. Reanalysis data sets are used here to evaluate an 11-year solar cycle modulation of BPWs, nonlinear reflection and resonant growth of the reflected waves during northern winter. The study shows that BPWs are enhanced in the middle and upper stratosphere during high solar activity winters. Enhanced dissipation of planetary-scale Rossby waves with zonal wavenumber 1 (wave-1) occurs in the polar upper stratosphere and the stratospheric surf zone at 35-45°N, 7-20 hPa. These wave-1 anomalies are accompanied by enhanced downward or poleward reflection of planetary waves with zonal wavenumber 2/3 from the regions with enhanced BPWs. Consistent with the enhanced BPWs, significantly enhanced poleward focusing of transient planetary waves is detected in late winter. Resonance growth of the reflected wave-2/3 also contributes to enhanced late winter wave-driving. These processes involving preconditioning BPWs and 'internal-mode' resonance differ distinctly from the commonly invoked mechanism involving the poleward and downward propagation of zonal mean wind anomalies. They are also able to explain the observed reversal of the solar cycle wind anomalies between early winter when the polar vortex is found to be stronger during high solar activity years, and late winter when the polar vortex is weaker.

What determines the evolution of global mean sea surface temperature?

Abstract ID : 395

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Rui Ponte ,rponte@aer.com ,(None) ,United States ,Lexington, MA 02421-3126 ,Not Presenting[1]
Dr. Christopher Piecuch ,cpiecuch@aer.com ,(None) ,United States , ,Not Presenting[1]
1 - AER 2 - AER

Global mean sea surface temperature (GMSST) is a variable of primary interest in studies of climate variability and change. The temporal evolution of GMSST can be influenced by heat transfer across the air-sea interface (**H**) and by mixing (**M**) and advection (**A**) processes internal to the ocean. Determining these different factors can provide insight on the nature of air-sea interactions and the processes controlling the variability in GMSST, but such calculations from data alone are prone to substantial uncertainties. Here we derive a closed GMSST budget for the period 1993-2015 based on a recent global state estimate, which is an exact solution of a general circulation model constrained to most extant ocean observations through advanced optimization methods. The estimated average temperature of the top (10-m thick) layer in the model is a good fit of the observed GMSST at monthly and longer time scales. For the seasonal time scale, GMSST is mostly determined by relatively small imbalances between **H** and **M**, with weaker contributions from **A**. While both **H** and **M** are dominated by roughly out-of-phase annual cycles, there is a clear semi-annual peak in GMSST, approximately coinciding with times of peak **H** and **M**. For nonseasonal GMSST variability, while **H** and **M** still tend to have opposite phase and balance each other to leading order, **A** becomes more important, particularly at the longest (decadal) time scales. The behavior of **H**, **M** and **A** will be further explored in terms of their various underlying mechanisms (e.g., turbulent and radiative heat fluxes, advection of mean temperature by variable currents or vice versa), with an eye towards understanding the relevant forcing and the active role of ocean processes in setting the evolution of GMSST.

Tracking the delayed response of the northern winter stratosphere to ENSO using multi reanalyses and model simulations

Abstract ID : 588

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Rongcai Ren ,rrc@lasg.iap.ac.cn ,(Prof.) ,China ,Beijing ,Presenting[1]
Prof. Guoxiong Wu ,gxwu@lasg.iap.ac.cn ,(Professor) ,China ,Beijing ,Presenting[2]
Mr. Ming Cai ,mcai@fsu.edu ,(None) ,United States , ,Presenting[3]
Mr. Jian Rao ,raojian@nuist.edu.cn ,(None) ,China , ,Not Presenting[4]
Ms. ChunYi Xiang ,xiangchunyi@gmail.com ,(None) ,China , ,Not Presenting[5]
1 - LASG, Institute of Atmospheric Physics 2 - LASG, Institute of Atmospheric Physics, CAS 3 - FSU
4 - NUIST, Chian 5 - CMA

The concurrent effects of the El Niño-Southern Oscillation (ENSO) on the northern winter stratosphere have been widely recognized; however, the delayed effects of ENSO in the next winter after mature ENSO have yet to be confirmed in multi reanalyses and model simulations. This study uses three reanalysis datasets, a long-term fully coupled model simulation, and a high-top general circulation model to examine ENSO's delayed effects in the stratosphere. The warm-minus-cold composite analyses consistently showed that, except those quick-decaying quasi-biennial (QB) ENSO events that reverse signs during July−August−September (JAS) in their decay years, ENSO events particularly those quasi-quadrennial (QQ) that persist through JAS, always have a significant effect on the extratropical stratosphere in both the concurrent winter and the next winter following mature ENSO. During the concurrent winter, the QQ ENSO-induced Pacific−North American (PNA) pattern corresponds to an anomalous wavenumber-1 from the upper troposphere to the stratosphere, which acts to intensify/weaken the climatological wave pattern during warm/cold ENSO. Associated with the zonally quasi-homogeneous tropical forcing in spring of the QQ ENSO decay years, there appear persistent and zonally quasi-homogeneous temperature anomalies in the midlatitudes from the upper troposphere to the lower stratosphere until summer. With the reduction in ENSO forcing and the PNA responses in the following winter, an anomalous wavenumber-2 prevails in the extratropics. Although the anomalous wave flux divergence in the upper stratospheric layer is still dominated by wavenumber-1, it is mainly caused by wavenumber-2 in the lower stratosphere. However, the wavenumber-2 activity in the next winter is always underestimated in the model simulations, and wavenumber-1 activity dominates in both winters.

Evolution of the Atlantic Multidecadal Variability in a model with an improved North Atlantic Current

Abstract ID : 648

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Annika Drews ,adrews@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[1]
Prof. Richard J. Greatbatch ,rgreatbatch@geomar.de ,(None) ,Germany , ,Not Presenting[1]
1 - GEOMAR Helmholtz Centre for Ocean Research Kiel 2 - GEOMAR Helmholtz Centre for Ocean Research Kiel

The dynamics and temporal evolution of the Atlantic Multidecadal Variability (AMV) is investigated in a coupled climate model. The model contains a correction to the North Atlantic flow field to improve the path of the North Atlantic Current, thereby alleviating the surface cold bias, a common problem with climate models, and offering a unique opportunity to study the AMV in a model. Changes in greenhouse gas forcing or aerosol loading are not considered. A striking feature of our results is the contrast between the western and eastern sides of the subpolar gyre in the model. On the western side, heat supply from the ocean plays a major role, with most of this heat being given up to the atmosphere in the warm phase, largely symmetrically about the time of the AMV maximum. By contrast, on the eastern side, the ocean gains heat from the atmosphere, with relatively little role for ocean heat supply in the years before the AMV maximum. Thereafter, the balance changes with heat now being removed from
the eastern side by the ocean leading to a reducing ocean heat content, behavior we associate with the establishment of an intergyre gyre at the time of the AMV maximum. In the warm phase, melting sea-ice leads to a freshening of surface waters northeast of Greenland which travel southward into the Irminger and Labrador Sea, shutting down convection and terminating the AMV warm phase.

The role of convection above Indonesia for the influence of the Indian Ocean on ENSO

Abstract ID : 664

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Ms. Claudia Wieners ,c.e.wieners@uu.nl ,(None) ,Netherlands ,Utrecht ,Presenting[1]
Prof. Henk Dijkstra ,h.a.dijkstra@uu.nl ,(None) ,Netherlands , ,Not Presenting[1]
Prof. Will de Ruijter ,w.p.m.deruijter@uu.nl ,(None) ,Netherlands , ,Not Presenting[1]
1 - Utrecht University 2 - Utrecht University 3 - Utrecht University

In recent years it has been discussed whether a cool West Indian Ocean (WIO) or negative Indian Ocean Dipole (IOD) in boreal autumn favours El Niño at a lead time of 15 months. Observations suggests that a cool WIO or negative IOD might be accompanied by easterlies over the West Pacific (WPO), though it is hard to disentangle influences of the Indian Ocean and ENSO.
Such easterlies can enhance the West Pacific Warm Water Volume, thus favouring El Niño development from the following boreal spring onward.

However, the Gill response to a cool WIO forcing would lead to westerly winds over the WPO. We hypothesise that a cool WIO leads to low-level air convergence and enhanced convectional heating over the Maritime Continent (MC), which in turn amplifies the wind convergence such as to cause easterly winds over the WPO. This hypothesis is tested by adding a simplified Indian Ocean and a simple convective feedback over the MC to a Zebiak-Cane model. We confirm that for a sufficiently (but not unreasonably!) strong convection feedback a cool WIO (or negative IOD) indeed leads to easterlies over the WPO. The wind response Indian Ocean Basinwide cooling (negative IOB) is still westerly, with the direct Gill response dominating over convection. Positive IOB events typically occur a few months after El Niño (observed lagged correlations are about +0.85) and cause easterlies over the Pacific, facilitating the switch to La Niña. Hence IOB variability dampens the ENSO mode and reduces its period. The IOD, on the other hand, tends to be positive a few months prior to El Niño and trigger westerlies favouring ENSO development.

The IOD is less ENSO-dependent (correlation of +0.6), so its influence on ENSO does not occur as systematically on certain phases of the ENSO cycle. Hence the net effect of the IO on the spectral properties of ENSO is dominated by IOB variability while the IOD is a more promising ENSO predictor, offering information on future ENSO development that is independent of the current state of ENSO.
CESM (CGCM) simulations are consistent with these results but exaggerate East Indian Ocean influence.

Projecting Future Tropical Cyclone Activity in the WNP Using High-Resolution AGCMs

Abstract ID : 779

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Huang-Hsiung Hsu ,hhhsu@gate.sinica.edu.tw ,(Research Fellow Research Center for Environmental Changes) ,Taiwan ,Taipei ,Not Presenting[1]
Dr. Chia-Ying Tu ,cytu@gate.sinica.edu.tw ,(None) ,Taiwan , ,Not Presenting[1]
Dr. Ping-Gin Chiu ,tony.blc@gmail.com ,(None) ,Taiwan , ,Not Presenting[1]
1 - Academia Sinica 2 - Academia Sinica 3 - Academia Sinica

GFDL high-resolution (23-km) AGCM HiRAM was used for AMIP-type time-slice simulations for the present (1979-2008) and the end of century (2074-2100). HiRAM well simulates mean climatology, Asian Monsoon seasonal evolution, and frontal activity. Strength of simulated extreme precipitation is compatible with TRMM precipitation. The ensemble-mean SST increase projected by CMIP5 CGCMs under RCP8.5 was superimposed on the present SST to force the end-of-century simulation. Tropical cyclone activity in the western North Pacific is projected to be significantly weakened at the end of the 21st century. This result was reproduced by using MRI-AGCM of 20-km resolution and in the time-slice experiments forced by different projected SST patterns. This projected change is triggered by the contraction of convection toward the tropics and the corresponding anomalous subsidence poleward of the equatorial convection belt. Strongest response occurs in the western North Pacific and results in significantly weakened convection and westward extension of the subtropical anticyclone in the western North Pacific. Relative contribution of SST changes in various basins to the changes in the WNP is assessed. Hypothesis is proposed to explain why the response to the global warming in the western North Pacific is stronger than those in other regions.

Alleviating Tropical Atlantic Sector Biases in the Kiel Climate Model: Implications for Interannual Variability and Seasonal Predictability

Abstract ID : 789

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Content Motivation : None
Additional Information : None

Prof. Mojib Latif ,mlatif@geomar.de ,(Professor) ,Germany ,Kiel ,Not Presenting[1]
1 - GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel

We have investigated the quality of simulating tropical Atlantic (TA) climatology and interannual variability in integrations of the Kiel Climate Model (KCM) with varying atmosphere model resolution, ranging horizontally from T42 to T255 and vertically from L31 to L62. The horizontal ocean model resolution is kept fixed at 2° with an enhanced meridional resolution of 0.5° in the equatorial region. A reasonable simulation of TA climatology and interannual variability including its seasonal phase locking can only be achieved at sufficiently high horizontal *and* vertical atmospheric resolution. Two major reasons for the marked improvements at high atmosphere model resolution can be identified. First, the western equatorial Atlantic westerly surface wind bias in spring can be largely eliminated by a better representation of meridional and vertical zonal momentum transport. The enhanced atmospheric circulation along the equator in turn greatly improves the thermal structure in the upper equatorial Atlantic with a much reduced warm sea surface temperature (SST) bias in the east. Second, the coastline in the southeastern TA and steep orography associated with the Andes are much better resolved, which leads to stronger alongshore winds and in turn a much reduced warm SST bias in the Benguela upwelling region.
The strongly diminished wind and SST biases in the TA allows for a more realistic latitudinal position of the Intertropical Convergence Zone (ITCZ). The resulting stronger cross-equatorial winds, in conjunction with a shallower thermocline, enable a rapid cold tongue development in the eastern TA in boreal spring. We discuss the implications of the better interannual variability for seasonal predictability in the KCM.

Three dimensional meridional circulation in mass-weighted isentropic time mean

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Additional Information : None

Prof. Toshiki Iwasaki ,Iwasaki@wind.gp.tohoku.ac.jp ,(Professor) ,Japan ,Sendai ,Presenting[1]
Mr. Yuki Kanno ,kanno@dc.tohoku.ac.jp ,(None) ,Japan , ,Not Presenting[1]
1 - Tohoku University 2 - Tohoku University

We develop a diagnositic scheme of mass-weighted isentropic time mean (T-MIM) of meridional circulation to see the 3-D structure of the stratospheric Brewer-Dobson (B-D) circulation and extratropical tropospheric direct (ETD) circulations. Mass-weighted isentropic zonal mean (Z-MIM) is an extension of Transformed Eulerian Mean (TEM) to finite-amplitude expression and exact treatment of lower-boundary conditions. Z-MIM allows us to diagnose the B-D circulations and ETD circulations. The low-level equatorward flow of ETD circulations indicates zonal mean of polar cold air outbreaks (Iwasaki et al., JAS, 2014). We notice that the time-averaged mass-weighted isentropic time mean of Z-MIM is equivalent to zonally-averaged mass-weighted isentropic zonal mean of T-MIM.
The 3-D T-MIM meridional velocity can be decomposed into the sum of simple isentropic time mean (TM, without mass weight) and "Bolus velocity" (Rhines, 1982). The Bolus velocity is called as the transient wave-induced mass transport, which is the time-averaged eddy correction of mass-weight and velocity. This concept was developed in Ocean dynamics.
The 3-D structure of T-MIM meridional velocity is very similar to TM meridional velocity. However, the time-averaged mass-weighted isentropic zonal mean of TM shows indirect circulations in extratropical stratosphere and troposphere of winter hemispheres, except for very weak meridional circulation NH troposphere. Although the Bolus velocity has much smaller 3-D variability than the TM meridional velocity, the time-averaged mass-weighted isentropic zonal mean of Bolus velocity greatly contributes to 2-D B-D circulation and ETD circulations in the extratropics. In particular, both of low-level equatorward flows and upper-level poleward flows distinctly appear around the storm tracks over the northern Pacific and Atlantic oceans in NH winter, whereas those appear in the whole longitude around 40S-60S. Those results indicate that the Bolus velocity due to baloclinic instability waves mainly contributes to 2-D direct circulations and form the longitudinal and geographical distribution. An exception is the NH troposphere, where the stationary ultra-long waves may contribute to the direct circulation in the Z-MIM and offset the indirect circulation in the conventional Eurelian-means.

Trends of clouds inferred from long-term trends in precipitation extremes.

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Additional Information : None

Prof. Shaw Chen Liu ,shawliu@gate.sinica.edu.tw ,(None) , , ,Not Presenting[1]
1 - None

Clouds are critically important in the climate system due to their impact on radiation budget and precipitation. Changes in cloud cover are hard to infer due to the lack of long term cloud data. An attempt is made in this study to investigate changes in cloud cover using the relationship between precipitation extremes and clouds. Heavy precipitation is associated with high clouds, while light precipitation occurs mostly with low clouds. The Global Precipitation and Climatology Project (GPCP) precipitation data is used to relate changes in heavy and light precipitation with changes in high and low cloud cover, respectively, from the Visible and Infrared Scanner (VIRS) data of the Tropical Rainfall Measuring Mission (TRMM) available for the period 1998-2012. Results show that there is an increase of about 4.91 ± 2.07% in high cloud cover over land in (20°-60°N), which is comparable to the NOAA HIRS trends of about 6.98 ± 3.53% increase per decade. We also find decreases of about 3.72 ± 1.69% and 3.19 ± 1.48% per decade in low cloud cover over tropcal oceans and the northern midlatitude land region, respectively, which match well with decreases of about 3.12 ± 1.68% and 5.31 ± 2.22% reported by NOAA HIRS data over the respective regions. We relate changes in cloud cover to the increase in global temperature quantitatively using inter-monthly difference technique and derive a decrease of about 11.87 ± 6.83% in low cloud cover globally (70S-70N) for each degree Kelvin (K) increase in global mean temperature.

The global importance of reducing tropical SST errors in climate models

Abstract ID : 977

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Additional Information : None

Dr. Prashant Sardeshmukh ,prashant.d.sardeshmukh@noaa.gov ,(None) ,United States , ,Presenting[1]
Dr. Sang-Ik Shin ,sangik.shin@noaa.gov ,(None) ,United States , ,Not Presenting[2]
Dr. Gilbert Compo ,Gilbert.P.Compo@noaa.gov ,(None) ,United States , ,Not Presenting[2]
Ms. Chesley McColl ,Chesley.McColl@noaa.gov ,(None) ,United States , ,Not Presenting[2]
1 - University of Colorado/CIRES and NOAA/ESRL/PSD 2 - CIRES/University of Colorado and PSD/ESRL/NOAA 3 - CIRES/University of Colorado and PSD/ESRL/NOAA 4 - CIRES/University of Colorado and PSD/ESRL/NOAA

Tropical sea surface temperatures (SSTs) impact the mean climate and climate variability worldwide through the Hadley and Walker circulations and forced planetary Rossby waves. Model misrepresentations of the changing magnitudes and patterns of tropical SSTs thus have important consequences. The sensitivities of the remote teleconnections to SST errors at different tropical locations may be estimated from the global responses to prescribed localized SST anomalies in atmospheric models. Such investigations yield in effect a "Fuzzy Green's Function" of the global atmospheric response to tropical SST forcing, and have been conducted by prescribing 42 regularly spaced localized tropical SST patches as anomalous boundary conditions in the NCAR and ECHAM5 models. The dominant EOF patterns of the 42 responses, and the relative magnitudes with which they are generated by the individual patches, determine the dominant pairs of response and forcing (formally, the left and right singular vectors of the Green's function operator). The dominant SST patterns are properly interpreted as the patterns of tropical SST errors or SST changes to which remote climates are most sensitive. The dominant SST sensitivity pattern is found to have a very different structure from that of the dominant ENSO pattern of observed SST variability, and has the largest magnitude but opposite signs in the western and eastern portions of the Indo-Pacific warm pool. It is therefore particularly important for climate models to represent SSTs accurately in this region, which they currently do not. More generally, the CMIP5 models underestimate the magnitude and misrepresent the spatial variation of 20th century tropical SST changes, and hence the magnitude of long-term changes in the mean atmospheric circulation and variability (and associated weather extremes) in most regions of the globe. By underestimating the changes in the SST gradients, the models exaggerate the relatively robust regional thermodynamic responses to GHG forcing over the equally important circulation responses that are less robust and spuriously weak in the models.

Surface Current in “Hotspot” Serves as a New and Effective Precursor for El Niño Prediction

Abstract ID : 1045

Conflict Declaration : None
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Additional Information : None

Dr. Jianing Wang ,wjn@qdio.ac.cn ,(Associate Professor) ,China ,Qingdao ,Not Presenting[1]
1 - Institute of Oceanology, Chinese Academy of Sciences

The El Niño and Southern Oscillation (ENSO) is the most prominent sources of inter-annual climate variability. Related to the seasonal phase-locking, ENSO's prediction across the low-persistence barrier in the boreal spring remains a challenge. Here we identify regions where surface current variability influences the short-lead time predictions of the July Niño 3.4 index by applying a regression analysis. A highly influential region, related to the distribution of wind-stress curl and sea surface temperature, is located near the dateline and the southern edge of the South Equatorial Current. During El Niño years, a westward current anomaly in the identified high-influence region favours the accumulation of warm water in the western Pacific. The opposite occurs during La Niña years. This process is seen to serve as the "goal shot" for ENSO development, which provides an effective precursor for the prediction of the July Niño 3.4 index with a lead time of 2-4 months. The prediction skill based on surface current precursor beats that based on the warm water volume and persistence in the subsequent months after July. In particular, prediction based on surface current precursor shows skill in all years, while predictions based on other precursors show reduced skill after 2002.

Reverse decadal shifts of summer rainfall in southern China

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Additional Information : None

Dr. Jilong Chen ,cjl@mail.iap.ac.cn ,(Associate Professor) ,China ,Beijing ,Not Presenting[1]
1 - INSTITUTE OF ATMOSPHERIC PHYSICS, CHINESE ACADEMY OF SCIENCES

The present study documents two reverse shifts of summer rainfall in southern China under global warming, and explores the plausible reasons for these two shifts. Southern China summer rainfall had a sudden increase around 1992/1993 but experienced an abrupt decrease around 2002/2003. Coherent changes in atmospheric circulation are investigated. The changes in lower-level wind around 1992/1993 feature two anomalous anticyclones: one over the SCS-subtropical WNP, and the other over north China-Mongolia. The outflows from the two anomalous anticyclones converge over southern China, leading to anomalous moisture convergence, enhanced ascent, and increased rainfall. The development of the northern anticyclone is related to an increase in the preliminary Tibetan Plateau snow cover while the southern anticyclone is related to an increase in sea surface temperature (SST) in the equatorial Indian Ocean. The changes in lower-level wind around 2002/2003 exhibit a southeast-northwest oriented dipole pattern: an anomalous cyclone over northern China-Mongolia, and an anomalous anticyclone over southeastern China-subtropical WNP. Simultaneously, an anomalous anticyclone dominates the upper troposphere over southern China. Other than the climatic effect of Tibetan Plateau, SST warming over tropical Indian and central Pacific oceans plays an important role in the development of the lower-level anticyclone leading to anomalous moisture divergence and decreased rainfall in southern China around 2002/2003.

Are we near the limit of tropical SST predictability?

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Additional Information : None

Dr. Matt Newman ,matt.newman@noaa.gov ,(Senior Research Scientist) ,United States ,Boulder ,Presenting[1]
Dr. Prashant Sardeshmukh ,prashant.d.sardeshmukh@noaa.gov ,(None) ,United States , ,Not Presenting[1]
1 - University of Colorado/CIRES and NOAA/ESRL/PSD 2 - University of Colorado/CIRES and NOAA/ESRL/PSD

The predictability of seasonal anomalies worldwide rests largely on the predictability of tropical sea surface temperature (SST) anomalies. Despite extensive model development, however, the tropical SST forecast skill of the operational North American Multi-Model Ensemble (NMME) prediction system, which combines forecasts from eight coupled atmosphere-ocean models, remains close both regionally and temporally to that of a vastly simpler Linear Inverse Model (LIM) derived from the observed covariances of SST, sea surface height, and wind fields. This suggests that the predictable SST dynamics are essentially linear. The NMME and LIM skills also closely track and are only slightly lower than the regionally and temporally varying potential skill estimated using the LIM's forecast signal-to-noise ratios in a perfect model framework, which suggests that the scope for further skill improvement may be small, except in the western tropical Pacific where the NMME skill is currently much lower than the LIM skill.

Impact of recent El Niño in the Lowveld, South Africa – an indication of anthropogenic climate forcing?

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Additional Information : None

Dr. Johan Malherbe ,jmalherbe@csir.co.za ,(Senior Researcher) ,South Africa ,Pretoria ,Presenting[1]
Dr. Francois Engelbrecht ,FEngelbrecht@csir.co.za ,(None) ,South Africa , ,Not Presenting[2]
Dr. Izak Smit ,izak.smit@sanparks.org ,(None) ,South Africa , ,Not Presenting[3]
1 - CSIR 2 - CSIR/NRE 3 - SANParks

Heat and drought during the 2015/16 summer over the Lowveld of South Africa reinforced the significance of extreme events through impacts noted on large herbivore populations. Analysis of temperature data reveals an unprecedented number of heat-wave days characterizing and exacerbating the drought event. Moreover, the extreme temperatures in the area are associated with a generally upward trend in extreme temperatures in the observed temperature time series.
We consider the regional temperature trends since 1960, and specifically in extremes, with respect to global temperature trend. Moreover, we describe the synoptic patterns with which extreme events in the region are associated and how these relate to ENSO. The 2015/16 summer specifically is evaluated in terms of the synoptic patterns with which extreme maximum temperatures were associated. We subsequently employ the Conformal Cubic Atmospheric Model to downscale ERA Reanalysis data for the period 1979 to 2016 to obtain an 8-km resolution dataset for the region. Regional anomalies of various modelled atmospheric fields at the higher spatial resolution are used to understand the meso-scale drivers of extreme temperatures under specific synoptic patterns.
To investigate the possible contribution of anthropogenic climate forcing to the extremes noted in recent years, the CCAM downscaling ERA Reanalysis data for 1979 - 2016 is compared to a corresponding high-resolution AMIP-style CCAM downscaling with pre-industrial anthropogenic forcing and consistent SSTs.We provide evidence that the extreme temperature events and associated circulation patterns of the 2015/16 summer fall outside the realm of pre-industrial climate over the region.

Processes Underlying the Pacific Decadal Oscillation and their Potential Changes in a Warmer World

Abstract ID : 1174

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Additional Information : None

Mr. Michael Alexander ,Michael.Alexander@noaa.gov ,(Meteorologist) ,United States ,Boulder ,Not Presenting[1]
Dr. Matt Newman ,matt.newman@noaa.gov ,(Senior Research Scientist) ,United States ,Boulder ,Not Presenting[2]
Dr. Clara Deser ,cdeser@ucar.edu ,(None) ,United States , ,Not Presenting[3]
Mr. Adam Phillips ,asphilli@ucar.edu ,(None) ,United States , ,Not Presenting[3]
1 - NOAA/Earth System Research Laboratory 2 - University of Colorado/CIRES and NOAA/ESRL/PSD 3 - National Center for Atmospheric Research 4 - National Center for Atmospheric Research

Climate variability on interannual-to-multidecadal time scales tends to be organized into large-scale spatial patterns that span entire ocean basins and often show global connectivity. Patterns of sea surface temperature (SST) variability on these timescales result from a combination of atmospheric and oceanic processes. These SST anomaly patterns may be due to: i) intrinsic modes of atmospheric variability that imprint themselves upon the SST field via surface energy fluxes and Ekman transport; ii) coupled ocean-atmosphere interactions, such as the El Niño-Southern Oscillation (ENSO) phenomenon in the tropical Indo-Pacific with extensions to higher latitudes; and iii) intrinsic oceanic modes. These three broad types of climate patterns may respond very differently in a warming climate.

In this talk, we examine how these broad concepts apply to the Pacific Decadal Oscillation, which is influenced by all three processes described above, specifically random fluctuations in the Aleutian Low, teleconnections associated with ENSO, "the atmospheric bridge" and coupled extratropical air-sea interaction including low frequency changes modulated by oceanic Rossby waves. We explore how these processes may change due to an increase in greenhouse gasses.

Impact of Arctic sea ice decline on recently observed climate change: a coordinated multi-model study

Abstract ID : 1182

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Content Motivation : None
Additional Information : None

Prof. Noel Keenlyside ,noel.keenlyside@uib.no ,(None) ,Norway ,None ,Not Presenting[1]
Dr. Fumiaki Ogawa ,Fumiaki.Ogawa@gfi.uib.no ,(None) ,Norway , ,Not Presenting[2]
Dr. Yongqi Gao ,yongqi.gao@nersc.no ,(None) ,Norway , ,Not Presenting[3]
Dr. Torben Koenigk ,Torben.Koenigk@smhi.se ,(None) ,Sweden , ,Not Presenting[4]
Dr. Shuting Yang ,shuting@dmi.dk ,(None) ,Denmark , ,Not Presenting[5]
Dr. Lingling Suo ,linglings@nersc.no ,(None) ,Norway , ,Not Presenting[6]
Dr. Tao Wang ,wangtao@mail.iap.ac.cn ,(None) ,China , ,Not Presenting[7]
Dr. Guilaume Gastineau ,ggalod@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[8]
Dr. Tetsu Nakamura ,nakamura.tetsu@ees.hokudai.ac.jp ,(None) ,Japan , ,Not Presenting[9]
Dr. Ho Nam Cheung ,Ho.Cheung@uib.no ,(None) ,Norway , ,Not Presenting[2]
1 - Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research 2 - Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research 3 - Nansen Environmental and Remote Sensing Center and Bjerknes Centre for Climate Research 4 - Swedish Meteorological and Hydrological Institute 5 - Danish Meteorological Institute 6 - Nansen Environmental and Remote Sensing research Center 7 - Institute of Atmospheric Physics, Chinese Academy of Sciences 8 - Sorbonne Universités/UPMC/CNRS/IRD 9 - Hokkaido University 10 - Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research

To what extent the recent sea-ice decline influenced Northern Hemisphere climate trends remains an open question. To address this we perform two atmospheric general circulation model experiments: In both experiments observed daily sea ice cover variations are prescribed for the period 1982 to present, while for SST, one experiment uses observed daily variations and the other the observed climatology. The experiment is performed by six different state-of-the-art AGCMs. Our results show that the observed wintertime temperature trend near the surface is poorly reproduced. The impact of SIC variation seems to be confined near the surface, while SST variation seems a key for temperature trend above. This suggests a necessity to consider the atmospheric poleward energy transport associated with SST variation to understand the observed arctic amplification. The simulations fail to reproduce the observed changes in the Siberian High and Eurasian wintertime cooling. Northern hemisphere surface and zonal mean tropospheric temperature trends are better reproduced in boreal autumn, but the impact of sea ice decline remains limited to the lower troposphere. Overall, our results indicate a limited impact of sea ice decline on Northern Hemisphere climate change during the recent decades.

The large shift to a more positive NAO between the 1960s and 1990s; to what extent do CMIP5 models reproduce congruent shifts in NAO variability and broader characteristics of the North Atlantic westerly jet?

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Content Motivation : None
Additional Information : None

Dr. Thomas Bracegirdle ,tjbra@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Dr. Hua Lu ,hlu@bas.ac.uk ,(None) ,United Kingdom ,Cambridge ,Not Presenting[2]
1 - British Antarctic Survey 2 - British Antarctive Survey

During the 20th century and the start of the 21st century there have been large multi-decadal shifts in the polarity of NAO indices, for example the large positive shift from the 1960s through to the 1990s. At the same time there have been multi-decadal shifts in shorter-term NAO variability (≤ inter-annual time scales) whereby a more positive (negative) NAO is associated with decreased (increased) variability. A key question is the extent to which these multi-decadal shifts in NAO index and its variability are linked.

Here we investigate instances of large 30-year positive NAO trends in the CMIP5 historical simulations to determine the extent to which congruent decreases in variability occur. The analysis is extended beyond the NAO to analyse diagnostics of congruent 30-year trends in the North Atlantic eddy-driven westerly jet and the role that this may play in shorter-term variability of the NAO. It is found that there is a statistically significant relationship between 30-year trends in the mean and variability of the NAO that agree in sign with the observation record. However, the relationship is rather weak with only a small amount of variance explained. A slightly stronger relationship is found between 30-year trends in jet strength and variability in jet position whereby a stronger jet exhibits less latitudinal variability. Implications of these results for our understanding of the observational record and potential links to ocean variability will be discussed.

The Characteristics and Drivers of Regionally-Extensive Droughts over Southern Africa

Abstract ID : 1333

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Mr. Babatunde Abiodun ,babiodun@csag.uct.ac.za ,(Senior Lecturer) ,South Africa ,Cape Town ,Presenting[1]
Mr. Eva Ujeneza ,ujeneva@gmail.com ,(None) ,South Africa , ,Presenting[2]
Mr. Arlindo Meque ,arlindo.meque@gmail.com ,(None) ,South Africa , ,Presenting[2]
1 - CSAG, UCT 2 - University of Cape Town 3 - University of Cape Town

Drought remains a threat to various socio-economic activities in southern Africa. Most studies on Southern African droughts usually quantify the droughts based on precipitation only (e.g. the Standardised Precipitation Index, SPI), thereby neglecting the important roles of evapotranspiration on droughts. Also, they often focus on local-scale droughts with little attention on regionally-extensive droughts (REDs) that cause more devastation. The present study used a climate water balance approach (i.e. Standardized Precipitation Evapotranspiration Index, SPEI) in quantifying the droughts and employed two techniques in characterizing REDs over southern Africa. The first technique identified the dominant drought modes while the second technique identified the major drought patterns over the region. The results of first technique showed that about 50% southern African droughts can be represented with four major drought modes. The results of the second approach revealed that southern African drought patterns can be generally classified into three groups: "All-dry" pattern, which shows a dry condition over the entire Southern Africa; "All-wet" pattern, which shows a wet condition over the whole region; and "Dipole pattern", which shows both wet and dry conditions over the sub-continent. Each drought pattern can occur in any season, but some drought patterns have preference for seasons. While some droughts patterns persist from a season to season, others easily transit to another drought pattern in the following season. The study reveals that the Southern African droughts are generally shifting from "All-wet" to "All-dry" patterns. It also shows that while "All-dry" drought patterns usually occurs during El-Niño and "All-wet" pattern during the La-Niña events, only few percentage of the Southern African drought patterns are induced solely by ENSO, other drought patterns are caused by complex interactions among the atmospheric teleconnections. The results of the study have application in monitoring and predicting regionally-extensive droughts over Southern Africa.

On the Response of the Aleutian Low to Greenhouse Warming

Abstract ID : 1348

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Bolan Gan ,gbl0203@ouc.edu.cn ,(Scientist) ,China ,Qingdao ,Presenting[1]
Prof. Lixin Wu ,lxwu@ouc.edu.cn ,(None) ,China , ,Not Presenting[2]
Dr. Fan Jia ,jiafan@qdio.ac.cn ,(RESEARCH ASSOCIATE) ,China ,QINGDAO ,Not Presenting[3]
Dr. Shujun Li ,lishujunouc@163.com ,(None) ,China , ,Not Presenting[4]
Prof. Wenju Cai ,Wenju.Cai@csiro.au ,(None) ,China , ,Not Presenting[5]
Dr. Hisashi Nakamura ,hisashi@atmos.rcast.u-tokyo.ac.jp ,(Professor) ,Japan ,Tokyo ,Not Presenting[6]
Mr. Michael Alexander ,Michael.Alexander@noaa.gov ,(Meteorologist) ,United States ,Boulder ,Not Presenting[7]
Dr. Arthur Miller ,ajmiller@ucsd.edu ,(None) ,United States , ,Not Presenting[8]
1 - Ocean University of China/ Qingdao National Laboratory for Marine Science and Technology 2 - Ocean University of China/Qingdao National Laboratory for Marine Science and Technology 3 - Institute of Oceanology, Chinese Academy of Sciences 4 - Ocean University of China 5 - Qingdao National Laboratory for Marine Science and Technology 6 - University of Tokyo 7 - NOAA/Earth System Research Laboratory 8 - Scripps Institution of Oceanography

The Aleutian Low, known as a semi-permanent low-pressure system over the North Pacific, influences formation of pack ice in the Bearing Sea and the temperature extremes in the North Pacific Rim. Changes in its intensity and position substantially affect the North Pacific oceanic gyres and upper-ocean temperature field, which can thereby alter marine biological resources and fish stocks in the Northeast Pacific. However, it remains uncertain how robust the climatological-mean Aleutian Low responds to greenhouse warming and what driving mechanisms are involved. Here past and future changes in the Aleutian Low are investigated by using observation-based sea level pressure (SLP) datasets and CMIP5 multi-models. It is found that the Aleutian Low intensity, measured by the North Pacific Index (NPI), has significantly strengthened during the 20th century, with the observed centennial-trend double the modeled counterpart for the multi-model average of historical simulations, suggesting compound signals of anthropogenic warming and natural variability. As climate warms under the strongest future warming scenario, the climatological-mean Aleutian Low will continue to intensify and expand northward, as manifested in the significant decrease (-1.3 hPa) of multi-model-averaged NPI which is 1.6 times its unforced internal variability and the central area of low-pressure (SLP < 999.0 hPa) expanded about 7 times that in the 20th century. A suite of idealized experiments further demonstrate that the deepening of the Aleutian Low can be driven by an El-Niño-like warming of the tropical Pacific sea surface temperature (SST), with a reduction in the climatological-mean zonal SST gradient, which overshadows the dampening effect of a weakened wintertime land-ocean thermal contrast on the Aleutian Low change in a warmer climate. While the projected deepening of Aleutian Low on multi-model average is robust, individual model portrayals vary primarily in magnitude. Inter-model difference in surface warming amplitude over the Asian continent, which is found to explain about 31% of variance of the NPI changes across models, has a greater contribution than that in the spatial pattern of tropical Pacific SST warming (which explains about 23%) to model uncertainty in the projection of Aleutian Low intensity.

Tropical-Extratropical teleconnections in present and future climate: internal versus forced variability.

Abstract ID : 1388

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Susanna Corti ,s.corti@isac.cnr.it ,(Senior Scientist) ,Italy ,Bologna ,Not Presenting[1]
Dr. Paolo Davini ,p.davini@isac.cnr.it ,(None) ,France , ,Not Presenting[2]
Dr. Jost von Hardenberg ,j.vonhardenberg@isac.cnr.it ,(None) ,Italy , ,Not Presenting[1]
Dr. Irene Mavilia ,i.mavilia@isac.cnr.it ,(None) ,Italy , ,Not Presenting[1]
1 - ISAC-CNR 2 - LMD-ENS & ISAC-CNR 3 - ISAC-CNR 4 - ISAC-CNR

In this study we assess the impact of model resolution and stochastic parameterisations on the simulation of tropical-extratropical teleconnections. We aim to answer to the following questions: (i) How well are the teleconnection patterns "reproduced" in climate simulations? (ii) What is the "degree of reproducibility" of these teleconnection patterns in a set of climatological sister simulations? (iii) What are the factors that might weaken or strengthen a teleconnection pattern (or the regime sensitivity to "decadal oscillations")?
We present results from a large set of climate simulations carried out with the EC-Earth model in the framework of the Climate SPHINX project (Stochastic Physics HIgh resolutioN eXperiments http://www.to.isac.cnr.it/sphinx/). Climate SPHINX includes atmosphere-only simulations grouped into three main blocks: (i) Present-day Atmosphere-only simulations (PDA) forced with observed SSTs (HADiSST2.1.1 dataset), (ii) Future Scenario Atmosphere-only (FSA) forced by synthetic SSTs constructed following Mizuta et al. (2008) methodology; (iii) Past-to-Future coupled simulations.
PDA and FSA have been run at five different horizontal resolutions (from 125 to 16 km) and with the number of ensemble members decreasing with increasing resolution (20 to 2). PFC simulations (6 ensemble members) are run at 80km in the atmosphere and 1 degree in the ocean. For each resolution, half of the ensemble members have the stochastic physics parameterisations activated. The atmosphere-only experiments extend for 30 consecutive years, from 1979 up to 2008 for PDA, while FSA experiments are run from 2039 up to 2068 and the PFC from 1850 up to 2100. Greenhouse gases (GHGs) and ozone concentrations as well as volcanic aerosol are set according to the CMIP5 Historical forcing and the RCP8.5 scenario.

Variability of Western Pacific Equatorial Currents Associated with ENSO

Abstract ID : 1407

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Xiaohui Tang ,tangxiaohui@qdio.ac.cn ,(Assistant Research Scientist) ,China ,Qingdao ,Not Presenting[1]
Mr. Yilong Lyu ,lvyl90@163.com ,(None) ,China , ,Not Presenting[1]
Prof. Fan Wang ,qdwangfan@126.com ,(None) ,China , ,Not Presenting[1]
1 - Institute of Oceanology, Chinese Academy of Sciences 2 - Institute of Oceanology, Chinese Academy of Sciences 3 - Institute of Oceanology, Chinese Academy of Sciences

Direct current measurements by ADCP moorings are used to investigate intraseasonal-to-annual variability of Western Pacific Equatorial Currents during 2015 El Niño and 2016 La Niña. The results show that Equatorial Undercurrent (EUC) around 142°E weakened during 2015 El Niño events, and strengthened during 2016 La Niña. The South Equatorial Current (SEC) and EUC are closely correlated with developing phase of ENSO, leading Nino3 index by 4-6 months. The Equatorial Intermediate Current (EIC) has less relationship with ENSO, but its intraseasonal variability is strongly influence by local and remote atmospheric forcing.
Combined with TAO-TRITON and HYCOM analysis current velocity fields and ERA-Interim 10m wind velocity fields, roles of surface and subsurface Western Pacific Equatorial currents in ENSO cycle are further discussed.

Seasonal and Regional Patterns of Variability and Long-Term Changes in Upper Tropospheric Jets From Reanalyses

Abstract ID : 1423

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Gloria Manney ,manney@nwra.com ,(Senior Research Scientist) ,United States ,Socorro ,Presenting[1]
Dr. Michaela Hegglin ,m.i.hegglin@reading.ac.uk ,(Lecturer in Atmospheric Chemistry) ,United Kingdom ,Reading ,Presenting[2]
1 - NorthWest Research Associates, Inc. 2 - University of Reading

Interannual variability and long-term changes in upper tropospheric jet latitude, altitude, and strength are assessed using the JETPAC (JEt and Tropopause Products for Analysis and Characterization) products derived from reanalysis datasets. These variations are evaluated separately for the subtropical and polar (eddy-driven) jets, and regional and seasonal patterns are assessed. The evaluations are done for five modern reanalyses, MERRA and MERRA-2, ERA-Interim, JRA-55, and NCEP-CFSR, with the level of agreement among reanalyses providing guidance on the regions and seasons experiencing robust changes. We will highlight findings on shifts in the subtropical jets and their seasonal and regional dependencies (including changes over the African continent), along with their implications for tropical widening. We will also discuss changes observed in the polar jets, which are related to storm track variations and which differ substantially by region and season; while the most common and robust changes in the SH polar jet confirm a poleward shift, regions and seasons with robust changes in the NH polar jet typically show an equatorward shift. Our results highlight the importance of accounting for regional and seasonal variations when quantifying long term changes in jet locations, and demonstrate the value of comparing multiple reanalyses in assessing the robustness of those changes.

JM3 - Thunderstorm Coupling To The Upper Atmosphere (IAMAS, IAGA)

On the validity of the global Earth-ionosphere spherical capacitor concept

Abstract ID : 659

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. Christos Haldoupis ,chald@physics.uoc.gr ,(Professor) ,Greece ,Heraklion ,Not Presenting[1]
Prof. Colin Price ,cprice@flash.tau.ac.il ,(Head of Porter School of Environment) ,Israel ,Tel Aviv ,Not Presenting[2]
Prof. Michael Rycroft ,michaelrycroft@btinternet.com ,(None) ,United Kingdom , ,Not Presenting[3]
Dr. Earle Williams ,ekagww@gmail.com ,(None) ,United States , ,Not Presenting[4]
1 - University of Crete 2 - Tel Aviv University 3 - CAESAR Consultancy 4 - Massachusetts Institute of Technology

In the context of the Global Electric Circuit (GEC), the surfaces of the Earth and the lower ionosphere are taken as the conductive shells of a gigantic spherical capacitor, with the neutral atmosphere between acting as an insulator. This idea has been around for a long time, as it was first conceived by Lord Kelvin in 1860 and developed further by Wilson ~100 years ago. In this scheme, and since the conducting Earth has, in the steady state, its surface charged negatively, the concentric shell of the conducting bottomside ionosphere was taken to be equally charged but positively. Although this represents an oversimplified model of a complicated phenomenon, it has been considered helpful in viewing some basic properties of the GEC, and thus it was adopted and used by numerous authors in many works and publications, including review papers, text books, and monographs. In this paper, we examine whether the Earth-ionosphere capacitor model is indeed functional, by comparing its observational properties with those of an ordinary spherical capacitor, as defined in basic electromagnetism. The simple comparisons suggest that the Earth-ionosphere capacitor concept cannot be reconciled with, and hence cannot account for, the observed behaviour of the atmospheric electric field reduction with height, which is well known from numerous measurements. This means that the spherical Earth-ionosphere capacitor model may be incorrect by being too simplistic and thus misleading. The reason for this likely in-correctness is rather simple and straightforward. It is therefore indeed surprising that this important point has often escaped attention in being spelled out and clarified. Finally, it is important to stress that the deficiencies of a simple Earth-ionosphere spherical capacitor do not affect the widely used and fully accepted models of both the DC and AC global electric circuits.

Variability in lightning NOx production rates due to regional U.S. differences in lightning type and polarity

Abstract ID : 934

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Jeff Lapierre ,jefflapierre6@gmail.com ,(Postdoctoral Researcher) ,United States ,Charlottesville ,Not Presenting[1]
1 - None

Lightning is the dominant source of nitrogen oxides (NO_x = NO + NO_2) to the upper troposphere (UT). NO_x is a key driver of chemistry in the UT and accurate and precise estimates of per flash lightning NO_x production rates (LNO_x) are needed to constrain the oxidative capacity in the UT and the global ozone burden; however, LNO_x estimates are highly variable and uncertain. Here, we investigate LNO_x variability in the U.S. due to lighting flash type and polarity. We correlate space-based NO_2 observations and surface lightning data separately in three regions of the U.S., Southeast, South Central, and North Central U.S., which exhibit different lightning characteristics. We find that differences in U.S. regional LNO_x estimates are generally consistent with regional differences in the prevalence and proportion of inter-cloud (IC) and positive and negative cloud-to-ground (+CG and -CG) lightning flashes in each region. We find CG flashes generally produce at least ten times more NO_x than IC flashes. We repeat the analysis, correlating NO_2 observations with current data, rather than flash frequency, determining the same IC, +CG, and -CG LNO_x patterns but deriving lower NO_x yields with reduced variability, suggesting current is a more precise predictor than flash frequency.

JM4 - Future Climate For The African Continent (IAMAS, IAPSO)

The representation of the seasonality of African rainfall in CMIP5 climate models

Abstract ID : 118

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Miss. Caroline Dunning ,c.m.dunning@pgr.reading.ac.uk ,(PhD Student) ,United Kingdom ,None ,Not Presenting[1]
Prof. Richard Allan ,r.p.allan@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
Dr. Emily C.L. Black ,e.c.l.black@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]
1 - University of Reading 2 - University of Reading 3 - University of Reading

Past and future changes in climate are felt not only through changes in mean precipitation, but also through altered seasonality, which is sensitive to changes in atmospheric circulation patterns. In order to use global climate models to interpret recent trends and variability in the seasonality of African precipitation, understand the physical mechanisms and drivers, and robustly evaluate future projections, it is necessary that climate models correctly represent the seasonality of African precipitation. A novel technique for analysing the seasonality, by objectively determining the onset and cessation dates using daily precipitation, is applied to CMIP5 simulations across continental Africa. The representation of the seasonal regime, seasonal rainfall progression and wet season timing is assessed in AMIP and CMIP historical simulations. Spatial patterns of seasonal rainfall progression are well represented in both experiments. Mean onset and cessation dates across AMIP and CMIP historical simulations were within 2 weeks of the observational mean for the majority of regions experiencing an annual rainfall regime. The CMIP historical simulations capture the biannual seasonal regime over the Horn of Africa and Central Africa, but not over the southern coastline of West Africa, whereas the AMIP simulations capture the correct regimes across the continent. The misrepresentation of the seasonal regime over the southern coastline of West Africa is related to errors in the SST seasonal cycle over the Gulf of Guinea, and incorrect SST/ rainfall relationships in the coupled simulations. Future projections of onset, cessation and season length, are produced using a range of scenarios from a selection of global climate models.

Large-scale drivers of variability in the East African short rains

Abstract ID : 330

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Linda Hirons ,l.c.hirons@reading.ac.uk ,(National Centre of Atmospheric Science (NCAS) Research Scientist) ,United Kingdom ,Reading ,Not Presenting[1]
1 - None

The large-scale processes that control African mean climate and variability are examined in the Met Office Unified Model (MetUM) as part of the IMPALA (Improving Model Processes for African Climate) project, within FCFA (Future Climate for Africa). The current analysis focuses on the large-scale drivers of variability in the East African short rains from October to December (OND).
Correlation of observed global sea surface temperature (SST) with OND rainfall over East Africa shows that wetter years are associated with el Niño conditions in the central and eastern Pacific. In observations, wet years are also shown to be associated with the positive phase of the Indian Ocean Dipole (IOD), anomalous eastward displacement of the eastern ridge of the Mascarene High (MH) and strong off-equatorial moisture convergence into East Africa.
The sensitivity of these teleconections to (a) horizontal resolution (~135km versus ~60km) and (b) air-sea coupling (coupled versus atmosphere-only) are investigated in the MetUM. The role of the MH is best captured by the coupled model, however, the atmosphere-only versions of the MetUM better capture the equatorial "dip" in moisture convergence during the positive phase of the IOD. We hypothesize that this bias is due to systematic cold SST biases that develop on the equator in the coupled model. In the MetUM, these drivers are shown to be largely insensitive to the change in horizontal resolution.
It is important to understand these MetUM results in the context of the models own mean state biases over the Indian Ocean. Therefore, the analysis of Indian Ocean biases during OND and the large-scale drivers of the East African short rains has been extended to the CMIP5 ensemble of models in both atmosphere-only (AMIP) and coupled formulations.

biodiversity conservation in an uncertain climatic future

Abstract ID : 491

Conflict Declaration : one of the Co-authors, Richard Washington is co-convening the JM 4 session
Content Motivation : None
Additional Information : one of the Co-authors, Richard Washington is co-convening the JM 4 session

Ms. Boipelo Tshwene-Mauchaza ,boipelo.tshwene-mauchaza@ouce.ox.ac.uk ,(PhD Candidate) ,United Kingdom ,Oxford ,Not Presenting[1]
Prof. Richard Washington ,richard.washington@ouce.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
Prof. Richard Grenyer ,richard.grenyer@ouce.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
1 - None 2 - Oxford University 3 - Oxford University

Climate projection estimates derived from General Circulation Models (GCMs) are used to assess the potential impacts of climate change on ecosystems and humans. However it is generally thought that GCMs, are too coarse in spatial resolution to capture with reliability patterns of important ecological climatic variables. This paper tests the assumption. We commence by comparing downscaled high resolution climate projections of precipitation and surface air temperature (AFRICLIM v3 30" SMHI-RCA4) with the equivalent from ten individual sets of GCMs used in the high resolution climate projections. We focus on two domains, one over broader southern Africa and the other over the narrow Kavango Zambezi Transfrontier Conservation Area. We go on to assess the use of the climate information in the production of bioclimatic projection estimates for species distribution modelling, under current and future 2$^{?}$C and 4$^{?}$C climate scenarios. We analyse and explore uncertainties in changes in future climate simulations from the datasets for two target periods, the mid-century 2085 and the late 21st century, 2100. The paper then evaluates implications that these climate datasets differences have in the relationship between climate and ecology; firstly in predictions of species distribution under changing climate envelopes, and secondly in future conservation and management strategies of species to ensure their long term persistence in protected areas, under climate change. The paper addresses the questions; (i) what are the GCM and Africlim datasets future climate projections and their difference over Southern Africa & KAZA, (ii) what are the predicted future species distributions under the different climate projections? (iii) How much do variations in the future predicted species distribution matter for conservation. Establishing the sensitivity of using coarse resolution versus fine resolution downscaled data to ecological impacts provides a useful way of establishing whether the laborious efforts involved in the downscaling work are indeed justified. In addition, knowledge on how much the variations in future predicted species distribution due to future change matters for conservation, offers potential to improve the robustness of biodiversity impact assessments carried out for purposes of conservation and management planning under a changing climate.

The association between the Angola Low and southern African rainfall in coupled climate models

Abstract ID : 1381

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Mr. Callum Munday ,callum.munday@seh.ox.ac.uk ,(None) ,United Kingdom , ,Presenting[1]
Prof. Richard Washington ,richard.washington@ouce.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]
1 - University of Oxford 2 - Oxford University

The Angola Low is a low-pressure system which straddles the Namibian-Angola border. It is a key element of the circulation during southern African summer, although little is known about its seasonal cycle or its representation in climate models. In the present paper we document for the first time the monthly mean seasonal cycle of the Angola Low as it transitions from a thermal low in austral spring to a tropical low in austral summer. In the core of the summer season (December-February; DJF) we find that the simulated strength of the Angola Low amongst 21 coupled climate models is associated with up to 60% of intermodel variability in rainfall across the subcontinent. The relationship between model Angola Low strength and intermodel rainfall variability is especially strong along a northwest-to-southeast axis aligned from Angola down to the Mozambican Channel. The set of models with deeper Angola Lows simulate increased moisture transport, by up to 50 g kg-1 ms^{-1}, along the axis compared to models with weaker Angola Lows. The anomalous northerly moisture transport in models with a stronger Angola Low increases the rate of low-level moisture convergence across central areas of southern Africa, and reduces the rate of divergent flow across the Mozambican coast. The analysis suggests that a better representation of the Angola Low in climate models may lead to improvements in their simulation of rainfall across the subcontinent.

Analysing tropical-extratropical cloud bands over southern Africa: how far can we trust model representations of climate variability and change?

Abstract ID : 1458

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Rachel James ,rachel.james@eci.ox.ac.uk ,(Research Fellow (University of Oxford) Visiting Researcher (University of Cape Town)) ,South Africa ,Cape Town ,Not Presenting[1]
Dr. Neil Hart ,neil.hart@ouce.ox.ac.uk ,(Postdoctoral Research Assistant) ,United Kingdom ,Oxford ,Not Presenting[1]
Prof. Richard Washington ,richard.washington@ouce.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]
Prof. Chris Reason ,chris.reason@uct.ac.za ,(None) ,South Africa , ,Not Presenting[4]
1 - University of Oxford 2 - University of Oxford 3 - Oxford University 4 - University of Cape Town

If climate model projections are to inform adaptation planning, it is important to understand their behaviour. How well do they simulate regional climate systems, including key processes of variability and change? What are the modelled mechanisms for future change, and do these correspond to changes we might expect in nature? For southern Africa, tropical-extratropical cloud bands, or Tropical-Temperate Cloud Bands (TTCBs), represent an important target for evaluation. TTCBs play an important role in heavy precipitation events, and are influenced by many important drivers of regional climate, including tropical convection, storm tracks, and subtropical highs. By investigating how climate models simulate TTCBs in historical runs, we can begin to evaluate their representation of regional climate variability. This analysis can then inform investigation of future experiments, to examine whether the occurrence of TTCBs is projected to change, and the extent to which this is a credible response.

As part of two FCFA projects (IMPALA and UMFULA), we analyse TTCBs in CMIP5 models and the Met Office Unified Model. The work is based on an automated cloud identification algorithm, which is applied to daily OLR data, flagging contiguous regions of low OLR with sufficient latitudinal extent and a NW-SE orientation. This enables analysis of the frequency, spatial distribution, annual cycle of TTCBs. We also examine precipitation contributed by these events, and the associated regional circulation, including moisture fluxes, pressure gradients, and upper level jets. Comparisons between models, and with satellite and reanalysis data, reveals important differences across these datasets in terms of the number of TTCB events, and seasonal cycle. Many models generate too many TTCB events over the Indian Ocean, where convection is often overestimated. Some models appear to generate TTCBs during winter, which are not found in nature. These differences may partly explain why precipitation is often overestimated over southern Africa, and may call into question projected precipitation changes in some models. After further investigation, we hope this work will shed light on which of the models, if any, have a more realistic simulation of TTCBs, and whether any change in TTCBs and associated rainfall might be expected in future.

JA1 - Space Weather Throughout The Solar System: Bringing Data And Models Together (IAGA, IAMAS)

Information theoretical approach to discovering solar wind drivers of the outer radiation belt

Abstract ID : 70

Conflict Declaration : None
Content Motivation : None
Additional Information : Invited oral presentation

Dr. Simon Wing ,simon.wing@jhuapl.edu ,(None) ,United States ,Laurel ,Not Presenting[1]
Mr Enrico Camporeale ,e.camporeale@cwi.nl ,(None) ,Netherlands , ,Not Presenting[2]
Dr. Jay Johnson ,jrj@andrews.edu ,(None) ,United States ,Michigan ,Not Presenting[3]
Mr Geoffrey Reeves ,geoff@reevesresearch.org ,(None) ,United States , ,Not Presenting[4]
1 - Johns Hopkins University 2 - CWI 3 - Andrews University 4 - Los Alamos National Laboratory

The solar wind-magnetosphere system is nonlinear. The solar wind drivers of geosynchronous electrons with energy range of 1.8-3.5 MeV are investigated using mutual information (MI), conditional mutual information (CMI), and transfer entropy (TE). These information theoretical tools can establish linear and nonlinear relationships as well as information transfer. The information transfer from solar wind velocity (*Vsw*) to geosynchronous MeV electron flux (*Je*) peaks with a lag time (*t*) of 2 days. As previously reported, *Je* is anticorrelated with solar wind density (*nsw*) with a lag of1 day. However, this lag time and anticorrelation can be attributed mainly to the *Je*(*t* + 2 days) correlation with *Vsw*(*t*) and *nsw*(*t* + 1 day) anticorrelation with *Vsw*(*t*). Analyses of solar wind driving of the magnetosphere need to consider the large lag times, up to 3 days, in the (*Vsw*, *nsw*) anticorrelation. Using CMI to remove the effects of *Vsw*, the response of *Je* to *nsw* is 30% smaller and has a lag time < 24 hr, suggesting that the MeV electron loss mechanism due to *nsw* or solar wind dynamic pressure has to start operating in < 24 hr. *nsw* transfers about 36% as much information as *Vsw* (the primary driver) to *Je*. Nonstationarity in the system dynamics are investigated using windowed TE. When the data is ordered according to high or low transfer entropy it is possible to understand details of the triangle distribution that has been identified between *Je*(*t* + 2 days) vs. *Vsw*(*t*).

Carbon Dioxide Trends in the Mesosphere and Lower Thermosphere

Abstract ID : 275

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Liying Qian ,lqian@ucar.edu ,(Project Scientist) ,United States ,Boulder ,Not Presenting[1]
Dr. Wenbin Wang ,wbwang@ucar.edu ,(None) ,United States , ,Not Presenting[1]
Dr. Alan Burns ,aburns@ucar.edu ,(None) ,United States , ,Not Presenting[1]
Dr. Stanley Solomon ,stans@ucar.edu ,(None) ,United States , ,Not Presenting[1]
1 - National Center for Atmospheric Research 2 - National Center for Atmospheric Research 3 - National Center for Atmospheric Research 4 - National Center for Atmospheric Research

We investigated trends of carbon dioxide (CO2) in the upper atmosphere, using data from the Atmosphere Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS) and from the Sounding of the Atmosphere using Broadband Emission Radiometry (SABER). Recent analyses of these measurements had indicated that CO2 above approximately 90 km appeared to be increasing about twice as fast as it was in the lower atmosphere. Models could not reproduce this differential CO2 trend, calculating instead that the proportional CO2 increase is approximately constant with altitude. We found three issues with the methodologies used to derive trends from CO2 profiles: the way that seasonal changes and sampling are accounted for in the analysis, referred to as deseasonalizing; the registration of profiles in pressure versus altitude coordinates; and data quality indicators. Each of these can have significant effects on the derivation of trends. We applied several deseasonalizing procedures, using both pressure and altitude coordinates, also used a time-series fit without deseasonalizing, and applied data quality filters. The derived trends were approximately constant with pressure or altitude, about 5.5% per decade, consistent with lower atmosphere CO2 trends, and consistent with model calculations. We conclude that the difference between the trend of CO2 above the homopause and the trend in the lower atmosphere is not statistically significant.

Space Weather at Mars - Measurements from the Surface of Mars with RAD on the Mars Science Laboratory

Abstract ID : 309

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Donald M. Hassler ,hassler@boulder.swri.edu ,(Science Program Director) ,United States ,Boulder ,Not Presenting[1]
Dr. Robert F. Wimmer-Schweingruber ,wimmer@physik.uni-kiel.de ,(None) ,Germany , ,Not Presenting[2]
1 - Southwest Research Institute 2 - Christian Albrechts University

Future human missions to Mars will be required to provide their own Space Weather monitoring and warning for the simple reason that ~50% of the time Mars is on the other side of the Sun from the Earth, and therefore Earth-based or L1/L5-based assets will not be sufficient to provide timely Solar Particle Event (SPE) prediction and warning.
Therefore, to improve our understanding and take us one step closer to enabling a human Mars to mission, the Radiation Assessment Detector (RAD) on the Mars Science Laboratory (MSL) has been characterizing the radiation environment, both during cruise and on the surface of Mars for the past 5 years. These are the first measurements of the energetic particle radiation environment on the surface of another planet, and can be used to provide useful synoptic Space Weather measurements of the energetic particle environment at a 2nd location in heliosphere (other than near-Earth or L1), and will aid heliospheric modeling over solar cycle.
These observations of SEP fluxes are also contributing to a solar energetic particle (SEP) event database at Mars and the Martian surface, to aid prediction of SPEs, including onset, temporal & size predictions.
This presentation will provide an overview of the RAD measurements of the Space Weather and radiation environment on the surface of Mars, and discuss the importance of providing broad heliospheric coverage for situational awareness of space weather as we plan to send humans out into deep space and to Mars.
RAD is supported by NASA (HEOMD) under JPL subcontract #1273039 to SwRI, and by DLR in Germany under contract with Christian-Albrechts-Universitat (CAU).

Space Weather Prediction Through the Observation and Modeling of Coronal Magnetism

Abstract ID : 317

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Sarah Gibson ,sgibson@ucar.edu ,(Senior Scientist/Section Head) ,United States ,Boulder ,Presenting[1]
Dr. Yuhong Fan ,yfan@ucar.edu ,(None) ,United States , ,Not Presenting[1]
Dr. Edward DeLuca ,edeluca@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[3]
Dr. Steven Tomczyk ,tomczyk@ucar.edu ,(None) ,United States , ,Not Presenting[1]
Dr. Svetlan Tassev ,svetlan.tassev@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[3]
Dr. Giuliana de Toma ,detoma@ucar.edu ,(None) ,United States , ,Not Presenting[6]
Dr. Steven Tomczyk ,tomczyk@ucar.edu ,(None) ,United States , ,Not Presenting[1]
Dr. Kevin Dalmasse ,dalmasse@ucar.edu ,(None) ,United States , ,Not Presenting[8]
Dr. Antonia Savcheva ,asavcheva@cfa.harvard.edu ,(Astrophysicist) ,United States ,Cambridge ,Not Presenting[3]
Dr. Nishu Karna ,nishu.karna@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[3]
Dr. Doug Nychka ,nychka@ucar.edu ,(None) ,United States , ,Not Presenting[11]
Mr. Nathaniel Mathews ,nathaniel.mathews@colorado.edu ,(None) ,United States , ,Not Presenting[12]
Dr. Natasha Flyer ,flyer@ucar.edu ,(None) ,United States , ,Not Presenting[11]
1 - NCAR/HAO 2 - NCAR/HAO 3 - Center for Astrophysics/Harvard University 4 - NCAR/HAO 5 - Center for Astrophysics/Harvard University 6 - HAO/NCAR 7 - NCAR/HAO 8 - NCAR 9 - Center for Astrophysics/Harvard University 10 - Center for Astrophysics/Harvard University 11 - NCAR/CISL 12 - University of Colorado 13 - NCAR/CISL

Magnetic fields in the sun's outer atmosphere - the corona - control both solar wind acceleration and the dynamics of solar eruptions. We present progress to date on the Data-Optimized Coronal Field Model (DOCFM) project. The goal of this project is to develop a new methodology for assimilating coronal magnetic diagnostic data into magnetohydrodynamic (MHD) models in order to establish not only the magnetic structure of the source region of coronal mass ejections, but also the global field into which it erupts. In particular, we report on 1) new observational diagnostics using coronal linear polarization measurements that detect magnetic nulls and super-radial expansion of magnetic flux tubes; 2) the construction of observing system simulation experiment (OSSEs) for testing methodology; 3) a Radial-basis-function Optimization Approximation Method (ROAM) for obtaining orders-of-magnitude increases in speed vs a full grid search of parameter space; and 4) the application of ROAM to a parameterized flux-rope insertion model in order to diagnose the 3D coronal magnetic field from synthetic coronal polarization observations generated for an OSSE.

Prediction and Testing of Type II Radio Emission, White Light Images, and CME Properties from the Sun to Earth

Abstract ID : 551

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Joachim Schmidt ,joachim.schmidt@sydney.edu.au ,(None) ,Australia , ,Not Presenting[1]
Prof. Iver Cairns ,iver.cains@sydney.edu.au ,(None) ,Australia , ,Presenting[1]
1 - University of Sydney 2 - University of Sydney
Joachim Matthias Schmidt, University of Sydney, Sydney, NSW, Australia and **Iver Cairns**, University of Sydney, Sydney, Australia

Accurate prediction of CME propagation and properties is vital for prediction of space weather at Earth. Type II solar radio emission is well correlated with CMEs and is an important diagnostic for the properties of the CMEs and the coronal and interplanetary plasma. Accordingly we have investigated the detailed properties of a CME event on 29 November to 1 December 2013, observed with the STEREO and Wind spacecraft, which was accompanied by strong intermittent
type II radio emission from about 10 solar radii to 1 AU. We simulate the CME and plasma with the BATS-R-US code, set up carefully using relevant data, and then use a kinetic theory to predict the radio emission from the properties and location of the CME-driven shock. The predicted intensities, frequencies, and timing of the radio emission agree very well with the observations. White light predictions for the CME also agree very well with the observations, both in position (including shape) and relative brightness. Crucially, we show that the CME arrival is predicted within much better than an hour and the predicted velocity, magnetic ?eld, density, and temperature agree very closely with the observations for over 60 hours before and during the CME's passage past the Earth. In particular the Bz component and solar wind speed, vital for prediction of space weather, are very well predicted in magnitude and time. This proves that for this event at least we can closely simulate the changing shape and ?eld parameters of the outward travelling CME, which determine both the radio emission excited by the CME-driven shock and also at least some of the important external parameters for space weather prediction. This state can then be used to start space weather predictions. We will also discuss the time-varying shape of the CME-driven shock for this event.

Space weather in the Saturnian System

Abstract ID : 707

Conflict Declaration : None
Content Motivation : None
Additional Information : Invited presentation

Dr. Maria Andriopoulou ,maria.andriopoulou@oeaw.ac.at ,(Research associate) ,Austria ,Graz ,Not Presenting[1]
Dr. Aikaterini Radioti ,aradioti@ulg.ac.be ,(None) ,Belgium , ,Not Presenting[2]
Dr. Iannis Dandouras ,iannis.dandouras@irap.omp.eu ,(None) ,France , ,Not Presenting[3]
Dr. Athena Coustenis ,athena.coustenis@obspm.fr ,(IAMAS Immediate Past President) ,France ,None ,Not Presenting[4]
Dr. Christina Plainaki ,christina.plainaki@asi.it ,(None) ,Italy , ,Not Presenting[5]
Dr. Jean Lilensten ,jean.lilensten@univ-grenoble-alpes.fr ,(None) ,France , ,Not Presenting[6]
Dr. Anna Milillo ,anna.milillo@iaps.inaf.it ,(None) ,Italy , ,Not Presenting[7]
Dr. Tom Nordheim ,tan2@mssl.ucl.ac.uk ,(None) ,United States , ,Not Presenting[8]
Dr. Davide Grassi ,davide.grassi@iaps.inaf.it ,(None) ,Italy , ,Not Presenting[7]
Dr. Valeria Mangano ,valeria.mangano@iaps.inaf.it ,(None) ,Italy , ,Not Presenting[7]
Dr. Stefano Massetti ,stefano.massetti@iaps.inaf.it ,(None) ,Italy , ,Not Presenting[7]
Dr. STEFANO ORSINI ,stefano.orsini@iaps.inaf.it ,(Senior Scientist) ,Italy ,ROMA ,Not Presenting[7]
Dr. Alice Lucchetti ,alice.lucchetti@oapd.inaf.it ,(None) ,Italy , ,Not Presenting[13]
1 - Space Research Institute, Austrian Academy of Sciences 2 - Laboratoire de Physique Atmosphérique et Planétaire, Institut d'Astrophysique et de Géophysique, Université de Liège 3 - IRAP, University of Toulouse/CNRS 4 - Paris Observatory 5 - ASI - Italian Space Agency 6 - Institut de Planétologie et d'Astrophysique de Grenoble, 7 - INAF-IAPS 8 - Jet Propulsion Laboratory, California Institute of Technology 9 - INAF-IAPS 10 - INAF-IAPS 11 - INAF-IAPS 12 - INAF-IAPS 13 - CISAS, University of Padova

In this talk we summarize the main space weather aspects of the Saturnian System while focusing on the magnetospheric system. The interaction of Saturn's magnetic field with the solar wind generates a giant magnetosphere which is dynamically and chemically coupled to all other components of Saturn's environment: the rings, the exosphere, the icy satellites, the Enceladus' plumes and Titan's upper atmosphere. It is thus dominated by numerous interactions between charged particles, neutral gas and dust in addition to the solar wind interactions, making this system quite complex, but also very interesting to study. Saturn's magnetosphere is also believed to be an intermediate case between the magnetosphere of the Earth and the one of Jupiter. Studying this system thus can provide us with knowledge of other planetary systems as well as their space weather phenomena.

In Situ Observations of Solar Wind Heliospheric Current Sheet Propagation and their relation to the Solar Coronal field

Abstract ID : 736

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. Yong Liu ,liuyong@spaceweather.ac.cn ,(Professor) ,China ,Beijing ,Presenting[1]
Mr. Jun Peng ,jpeng@spaceweather.ac.cn ,(None) ,China , ,Not Presenting[2]
1 - None 2 - National Space Science Center, CAS

The Heliospheric Current Sheet (HCS) is an important structure for understanding the physics of interplanetary space and the space weather prediction. We investigate the HCS arrival time differences between spacecraft to understand the key factors controlling its propagation. By assuming that the source of the solar wind do not evolve except for spinning with the sun, the classical model ignoring the latitudinal differences was first tested with the STEREO observation during the year of 2007. This time period was selected because the sun was quiet and the spacecraft was still close to each other. The classical model matches well with observations for many events but mismatch for those events when the HCS has a smaller inclination angle to the elliptical plane. The latitudinal effect is then considered but do not improve the prediction for all events when the HCS inclination angle is obtained from the PFSS model. Then we calculate the angle based on the time differences between STEREO B and ACE spacecraft and the predicted time differences match well with the observations. An improved model of calculating coronal magnetic field other than PFSS is needed for predicting the HCS inclination angle at 1AU.

Integrated Modeling Studies in the Project for Solar-Terrestrial Environment Prediction (PSTEP)

Abstract ID : 837

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. Kanya Kusano ,kusano@nagoya-u.jp ,(professor) ,Japan ,Nagoya ,Not Presenting[1]
1 - Nagoya University

Project for Solar-Terrestrial Environment Prediction (PSTEP) is a Japanese nation-wide research collaboration, which was recently launched with the support of a Grant-in-Aid for Scientific Research on Innovative Areas from MEXT/Japan. PSTEP aims to develop a synergistic interaction between predictive and scientific studies of the solar-terrestrial environment and to establish the basis for next-generation space weather forecasting using the state-of-the-art observations and the advanced physics-based modeling. For this project, we coordinate the four research groups for 1) the development of a next-generation space weather forecast system, 2) the prediction of solar storms, 3) the prediction of magnetosphere and ionosphere dynamics, and 4) the prediction and understanding of solar cycle activity and its impact on climate with proposal-based research units. By this project, we seek to answer some of the fundamental questions concerning the solar-terrestrial environmental system such as the mechanisms for the onset of solar flares, the mechanism for radiation belt dynamics in the Earth's magnetosphere, and the physical process by which solar activity affects the climate. In this paper, we will explain the basic strategy and the several topical results of PSTEP, for instance on the physics-based scheme for predicting the onset of solar flares, the data-driven simulation of coronal mass ejections for predicting the variation of interplanetary magnetic field B_z, and the integrated study of geo-magnetic field induced current collaborating with electric power company, the multi-scale modeling for predicting the formation and propagation of ionospheric bubbles, and the modeling for predicting the sunspot activity of the next solar cycle. We will also discuss the necessity and effectiveness of international collaboration for the integrated modeling study of space weather prediction.

Characteristics of partial ring current during geomagnetic storms and substorms

Abstract ID : 842

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Sandeep Kumar ,sandeepk.iig@gmail.com ,(Research Associate) ,India ,Navi Mumbai ,Not Presenting[1]
Prof. Bhaskara Veenadhari ,veenaiig@gmail.com ,(None) ,India , ,Not Presenting[1]
Mr Tulasi Ram S ,s.tulasiram@gmail.com ,(None) ,India , ,Not Presenting[3]
Ms. Megha Pandya ,megha.phy14@gmail.com ,(None) ,India , ,Not Presenting[1]
1 - Indian Institute of Geomagnetism 2 - Indian Institute of Geomagnetism 3 - Indian Institute of Geomagnetism, India 4 - Indian Institute of Geomagnetism

There are several important current systems that flow in the near-Earth nightside magnetosphere. Mainly three systems are commonly mentioned: the symmetric ring current, the partial ring current and the magnetotail current. The ring current is highly asymmetric in the main phase and early recovery phase of a magnetic storm and becomes symmetric in the later recovery phase. Some previous studies based on ground-based measurements of H variations have shown that the distribution of the partial ring current pressure peak in the dusk sector. This was further supported by the ring current modeling from global simulations. To identify the dynamics of inner magnetosphere during magnetic storms and substorms, the contribution and understanding of these current systems are essential and important. There exist a number of studies to understand these currents systems using satellite data and global ground magnetic data. However, still several unaddressed questions remain to probe the inner magnetopshere current systems through magnetic storms and substorm processes and their temporal and spatial characteristics. During main phase of a magnetic storm, PRC plays an important role, as we know region 1 and region 2 field aligned currents are very important factor to observe undershielding and overshielding electric fields at equatorial latitudes penetrated from high latitudes. Several questions remain unresolved about the asymmetric current like how does this current segment close, how often does it exist and what will be the expected magnetic perturbation associated with this temporary current system? We made an attempt to answer these questions using extensively ground magnetic data from Indian, Japanese along with other sectors worldwide and satellite data for solar cycle 23 and 24 geomagnetic storms and substorms.

Storm time ion composition variations in the near earth plasma sheet using space borne measurements

Abstract ID : 847

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Ms. megha pandya ,megha.pandya14@gmail.com ,(Senior Research Fellow) ,India ,Mumbai ,Not Presenting[1]
Prof. B. Veenadhari ,bveena@iigs.iigm.res.in ,(None) ,India , ,Not Presenting[2]
Dr. Sandeep Kumar ,sandeepk.iig@gmail.com ,(Research Associate) ,India ,Navi Mumbai ,Not Presenting[3]
Mr Geoffrey Reeves ,geoff@reevesresearch.org ,(None) ,United States , ,Not Presenting[4]
Dr. Masahito Nose ,nose@kugi.kyoto-u.ac.jp ,(None) ,Japan ,Kyoto ,Not Presenting[5]
1 - None 2 - Indian Institute of Geomagnetism (IIG) 3 - Indian Institute of Geomagnetism 4 - Los Alamos National Laboratory 5 - World Data Center for Geomagnetism, Kyoto, Kyoto University

Streaming solar wind particles and ionospheric O^+ ions play an important role in the global dynamics of the Earth's magnetosphere. The major particle source for the plasma sheet ions is solar wind and ionosphere. The ion composition of the near-Earth plasma sheet changes with the geomagnetic conditions. The solar wind ions contributes the most to the plasma sheet population during geomagnetically quiet conditions while, ionosphere contributes exclusively during the geomagnetic storm conditions. Its ion composition change during different interplanetary conditions is compared using energetic particle flux data obtained from Geotail spacecraft and Van Allen probes. Intense and moderate geomagnetic storms from solar cycle 23 and 24 with ion composition variations in the near-Earth plasma sheet are compared. Intense geomagnetic storms shows higher O^+/H^+ and He^+/H^+ energy density ratio than the moderate ones while there is a strong geomagnetic storm dependence on singly charged heavy O^+ ions. The energy density of H^+, O^+ and He^+ ions also depends on the magnitude and duration of southward IMF Bz and solar wind dynamic pressure. The ion composition changes in plasma sheet are comparable to the ring current region, as reported in previous studies indicating transport of ionospheric ions from plasma sheet to the ring current region through mass dependent acceleration by convection electric field. Some of the results regarding the intense and moderate events for solar cycle 23 and 24 will be discussed in the meeting.

Separating different contributions for the South Atlantic Anomaly variability

Abstract ID : 968

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Content Motivation : None
Additional Information : None

Mr. Joao Domingos ,jmrdomingos@gmail.com ,(Ph. D. Student) ,Portugal ,Coimbra ,Not Presenting[1]
Dr. Dominque Jault ,jaultd@univ-grenoble-alpes.fr ,(None) ,France , ,Not Presenting[2]
Dr. Alexandra Pais ,pais@fis.uc.pt ,(None) ,Portugal , ,Not Presenting[3]
Prof. Mioara MANDEA ,mioara.mandea@cnes.fr ,(Innovation, Application and Science Directorate) ,France ,Paris ,Not Presenting[4]
1 - University of Coimbra / University of Grenoble-Alpes 2 - University of Grenoble-Alpes 3 - University of Coimbra 4 - CNES - Centre National d'Etudes Spatiales

The South Atlantic Anomaly (SAA) is a Space Weather feature that strongly impacts near Earth space navigation. In this region, the magnetic field intensity is unusually low and the flux of charged particles, trapped in the inner Van Allen radiation belts, is maximum. The SAA time variability depends on the secular variation of 1) the main field, 2) the solar cycle and 3) the response time of the thermosphere. The high energy protons are trapped in L-shells, which are surfaces obtained by rotating the lines of force of the eccentric dipole. Using COV-OBS magnetic field model to compute the L-shell reference frame that follows the eccentric dipole component of the main field, we separate the first contribution. This accounts for the westward drift of the SAA. To study the evolution of the particle flux anomaly in this reference frame from 1989 to 2014, we rely on a Principal Component Analysis (PCA) of POES NOAA proton flux data. The data series used is concatenated from three separate satellites (POES NOAA 10, 12 and 15) which overlap for a few months time. Three PCA modes account for the time evolution related to solar effects. Both the first and second modes have a good correlation with the thermospheric density, which varies in response to the solar cycle. The first mode represents the total intensity variation of the particle flux in the SAA, and the second the movement of the anomaly between different L-shells. A phase lag between the two PCA time functions is indicative of differential depletion within the Van Allen belts. The proposed analysis allows us to well recover the westward drift rate, as well as the latitudinal and longitudinal solar cycle oscillations. We investigate whether a trend in the protons flux associated with the decrease of the Earth's dipole can be detected. Moreover, the developments made here would enable us to forecast the impact of the South Atlantic Anomaly on space weather. A model of the evolution of the eccentric dipole field (magnitude, offset and tilt) would suffice, together with a model for the solar cycle evolution.

The relationship between Na exospheric emission and Space Weather at Mercury

Abstract ID : 1034

Conflict Declaration : None
Content Motivation : Planetary Space Weather
Additional Information : None

Dr. STEFANO ORSINI ,stefano.orsini@iaps.inaf.it ,(Senior Scientist) ,Italy ,ROMA ,Not Presenting[1]
Dr. Valeria Mangano ,valeria.mangano@iaps.inaf.it ,(None) ,Italy , ,Not Presenting[1]
Dr. Christina Plainaki ,christina.plainaki@asi.it ,(None) ,Italy , ,Not Presenting[3]
Dr. Alessandro Mura ,alessandro.mura@iaps.inaf.it ,(None) ,Italy , ,Not Presenting[1]
Dr. Anna Milillo ,anna.milillo@iaps.inaf.it ,(None) ,Italy , ,Not Presenting[1]
Dr. Stefano Massetti ,stefano.massetti@iaps.inaf.it ,(None) ,Italy , ,Not Presenting[1]
Dr. Elisabetta De Angelis ,elisabetta.deangelis@iaps.inaf.it ,(None) ,Italy , ,Not Presenting[1]
Dr. Rosanna Rispoli ,rosanna.rispoli@iaps.inaf.it ,(None) ,Italy , ,Not Presenting[1]
Dr. Francesco Lazzarotto ,francesco.lazzarotto@iaps.inaf.it ,(None) ,Italy , ,Not Presenting[1]
Dr. Alessandro Aronica ,alessandro.aronica@iaps.inaf.it ,(None) ,Italy , ,Not Presenting[1]
Dr. Jim Raines ,jraines@umich.edu ,(None) ,United States , ,Not Presenting[11]
1 - INAF-IAPS 2 - INAF-IAPS 3 - ASI - Italian Space Agency 4 - INAF-IAPS 5 - INAF-IAPS 6 - INAF-IAPS 7 - INAF-IAPS 8 - INAF-IAPS 9 - INAF-IAPS 10 - INAF-IAPS 11 - Department of Climate and Space Sciences and Engineering, University of Michigan, Ann Arbor, MI

In this paper, we speculate on the Hermean exosphere Na hourly average distributions, as observed by the ground-based Themis solar telescope, and published by Mangano et al. ,2015 (*). From 2009 to 2013, we have selected 26 different days, when the Na signal was observed for 3 or more hours within each selected observation day, in good seeing conditions (sigma <2).
We notice the occurrence of basically opposite configurations, i.e. i) most common, the Na signal is localized above the poles; ii) occasionally, the signal is diffused above the sub-solar region.
In order to identify these Na observations as possible tracers of Space Weather at Mercury, we compare these different Na emission configurations with the time profiles of proton fluxes (FIPS) and magnetic field (MAG) data, as measured in-situ by MESSENGER, when such data were available. This occurrence refers to 10 of the selected 26 days. Only in one occasion (2012, Sept 20) the Na signal is all the time diffused above the subsolar region, and IMF data indicate the occurrence of significant solar perturbations. The possible link between these Na patterns and the solar-hermean relationships is briefly discussed.
(*) *Mangano, et al., PSS, 115, 102-109, doy: 10.1016/j.pss.2015.04.001, 2015.*

Ground-based space science from polar regions

Abstract ID : 1059

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. Michael Kosch ,mkosch@sansa.org.za ,(Chief Scientist) ,South Africa ,Hermanus ,Not Presenting[1]
1 - SANSA

Polar regions provide an excellent opportunity to perform high-quality but relatively low-cost space science and space weather monitoring from the ground. The focus is on coherent and incoherent scatter radar, as well as multi-wavelength optical observations of the ionosphere and thermosphere from Antarctica and the Arctic. Novel scientific studies include (1) the phenomenon of black as well as anti-black auroras, which are quite distinct from the normal white auroras, (2) how thermospheric neutral winds are strongly influenced by the auroras, and (3) the wave-plasma interaction resonances associated with artificially-induced auroras.

A New Scheme to Infer the Maximum Dst of Earth-directed CMEs

Abstract ID : 1148

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Spiros Patsourakos ,spatsour@cc.uoi.gr ,(None) ,Greece ,Ioannina ,Presenting[1]
Dr. Manolis Georgoulis ,manolis.georgoulis@academyofathens.gr ,(None) ,Greece , ,Not Presenting[2]
1 - Department of Physics, University of Ioannina 2 - RCAAM of the Academy of Athens

The Disturbance Storm Time (Dst) is a commonly-used geomagnetic index to describe geomagnetic storms
and their severity. Coronal Mass Ejections (CMEs) reaching 1 AU, which are characterized with intense southward magnetic fields are typically associated with the stronger geomagnetic storms. Therefore, it is
important to devise robust methods of Dst-prediction for space-weather purposes and applications.
We present a new scheme to infer the maximum Dst of Earth-directed CMEs. It is based on simple analytical theory and empirical relationships applied to coronagraphic and photospheric observations of CMEs and their source regions, respectively. An obvious advantage of our scheme is that it could supply Dst predictions with a lead-in of few days before the actual arrival of the corresponding CME at 1 AU.

Ionospheric Specifications and Forecasts using the GAIM Data Assimilation Models

Abstract ID : 1224

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. Ludger Scherliess ,ludger.scherliess@usu.edu ,(Associate Professor) ,United States ,Logan ,Presenting[1]
Dr. Robert Schunk ,rws4405@yahoo.com ,(None) ,United States , ,Not Presenting[1]
Dr. Larry Gardner ,larry.gardner@usu.edu ,(None) ,United States , ,Not Presenting[1]
Dr. Lie Zhu ,lie.zhu@usu.edu ,(None) ,United States , ,Not Presenting[1]
Dr. Vince Eccles ,vince@spacenv.com ,(None) ,United States , ,Not Presenting[1]
1 - Utah State University 2 - Utah State University 3 - Utah State University 4 - Utah State University 5 - Utah State University

Data assimilation is a technique that combines observational data with physics-based models to provide improved specifications and forecasts of the physical system. Over the past decades physics-based data assimilation models have been used in many areas of science and engineering and have found extensive use in meteorology and oceanography. More recently, data assimilation models have also become prevalent for specifications and forecasts of the ionosphere. This increased use of ionospheric data assimilation models coincides with the increase in data suitable for assimilation. We have developed several different data assimilation models, including the Global Assimilation of Ionospheric Measurements Gauss-Markov (GAIM-GM) and Full Physics (GAIM-FP) models. Both models assimilate a multitude of different data types, including ground-based GPS/TEC, occultation, bottomside electron density profiles from ionosondes, in-situ electron densities, and space-based UV radiance measurements. The GAIM-GM model is a simpler model that uses the physics-based Ionosphere Forecast Model (IFM) as a background model as well as a statistical process in the Kalman filter. The GAIM-FP model is a more sophisticated model that uses a physics-based ionosphere-plasmasphere model (IPM) and an Ensemble Kalman filter technique. The primary GAIM-FP output is in the form of 3-dimensional electron density distributions from 90 km to near geosynchronous altitude. However, the model also provides information about the ionospheric drivers including the thermospheric winds and composition as well as the low-latitude ionospheric electric fields. We will present the differences and similarities of ionospheric specifications and forecasts obtained from our data assimilation models, compare them with independent observations and show examples of the estimated thermospheric parameters.

Dynamic Mapping and Ensemble Modeling of Solar Eruptive Phenomena

Abstract ID : 1383

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Barbara Thompson ,barbara.j.thompson@gmail.com ,(None) ,United States ,Greenbelt ,Not Presenting[1]
1 - NASA GSFC

Recent methods in data segmentation have allowed dynamic mapping of eruptive phenomena in the solar corona. The simplest examples isolate minima and maxima, and the techniques have been used to extract the dynamics in long-term evolution of comet tails, erupting material, spicules, and EUV dimming regions. These have helped lead to an improved understanding of the kinematic properties of coronal mass ejections (CMEs) and CME-associated phenomena. However, there are several challenges in characterizing the kinematic properties of CMEs. Most rapidly-evolving eruptions are accompanied by changes in the surrounding corona. The larger the impact on the surrounding corona, the more difficult it is to separate the "main" CME from the CME-associated brightenings. Complicating the issue is the range of observed propagation properties: super-radial expansion, asymmetric expansion, non-radial propagation, and alterations in the direction of propagation. These properties can be a function of both the internal magnetic structure of the CME and the structure of the corona through which the CME is propagating.
Despite the advances in mapping eruptive phenomena, there is still non-trivial error in the estimates of CME kinematics. Recent efforts in modeling CME propagation take into account the variation in CME properties, using an "ensemble" of sampled parameters to derive the variation in potential model outcomes. We will cover the application of new mapping methods to dynamic phenomena and the physical implications of interpreting the results, and discuss the means by which the inherent error in these methods can be incorporated via ensemble modeling.

A Unique Method for Non-Linear Force-Free Field Models of Coronal Magnetic Fields: Applications of the the Flux Rope Insertion

Abstract ID : 1432

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Antonia Savcheva ,asavcheva@cfa.harvard.edu ,(Astrophysicist) ,United States ,Cambridge ,Not Presenting[1]
1 - Center for Astrophysics/Harvard University

The flux rope insertion method for creating 3D coronal magnetic field models of solar active regions of various topologies is the first and still one of only two methods that uses line-of-sight magnetogram data as a lower boundary condition, and a range of coronal observations to constrain the models. It is also unique in the fact that since it is based on magnetofriction, i.e. reduced MHD, it does not necessarily need to reach non-linear force-free field (NLFFF) equilibrium, which turns out to be powerful for modelling erupting configurations, at which other NLFFF extrapolations largely fail. The method has successfully produced NLFFF models of large polar crown filaments, active region filaments and sigmoids over time and in the instances just before their eruptions in different ambient configurations. It produced the first models to be used for 2D and 3D topology analysis in different configurations. Based on geometry, energy, instability, and topology analysis in stable and unstable models produced with this method have unveiled basic properties of the stability, energy storage, and release in flux ropes in NLFFFs to significantly new discoveries that confirm the standard 3D flare/CME model and can potentially be used to increase our predictive capability of how and why solar eruptions come about.

JA2 - The Referencing Of Geophysical Data Products: The Role Of Dois (IAGA, IAMAS, IAPSO)

Recent activity of DOI-minting to solar-terrestrial physics data in Japan

Abstract ID : 565

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Masahito Nose ,nose@kugi.kyoto-u.ac.jp ,(None) ,Japan ,Kyoto ,Presenting[1]

Dr. Yasuhiro Murayama ,murayama@nict.go.jp ,(Research Executive Director, ICSU-WDS Scientific Committee) ,Japan ,Tokyo ,Not Presenting[2]

Dr. Takenari Kinoshita ,t-kinoshita@jamstec.go.jp ,(None) ,Japan , ,Not Presenting[3]

Dr. Yukinobu Koyama ,y-koyama@oita-ct.ac.jp ,(None) ,Japan , ,Not Presenting[4]

Dr. Michi Nishioka ,nishioka@nict.go.jp ,(None) ,Japan , ,Not Presenting[5]

Dr. Mamoru Ishii ,mishii@nict.go.jp ,(None) ,Japan , ,Not Presenting[5]

Dr. Manabu Kunitake ,kunitake@nict.go.jp ,(None) ,Japan , ,Not Presenting[5]

Dr. Koji Imai ,koji.imai@nict.go.jp ,(None) ,Japan , ,Not Presenting[5]

Prof. Toshihiko Iyemori ,iyemori@kugi.kyoto-u.ac.jp ,(None) ,Japan , ,Not Presenting[9]

Prof. Takashi Watanabe ,c62d51ef58@yahoo.co.jp ,(None) ,Japan , ,Not Presenting[5]

1 - World Data Center for Geomagnetism, Kyoto, Kyoto University 2 - National Institute of Information and Communications Technology 3 - NoneJapan Agency for Marine-Earth Science and Technology 4 - Oita National College of Technology 5 - National Institute for Information Communications Technology 6 - National Institute for Information Communications Technology 7 - National Institute for Information Communications Technology 8 - National Institute for Information Communications Technology 9 - World Data Center for Geomagnetism, Kyoto, Kyoto Universit 10 - National Institute for Information Communications Technology

The Japanese government has found an importance of "Open Science" and is now going to promote its associated activities in Japan. In the end of March 2015, a report entitled "Promoting Open Science in Japan" was published by the expert panel on Open Science, based on Global Perspectives, Cabinet Office. According to the report, research data should be made openly available, although they are subject to constraints that ensure ethical, legal, and commercial protections. To accelerate data availability, it is needed to prepare data identifiers, such as digital object identifiers (DOIs), and to foster a practice of citation for research data. This is because the citation for research data provides the following benefits: (1) Readers can more easily locate the data used in the paper,

obtain necessary information of the data (i.e., metadata), and validate the findings of the paper; (2) readers can also easily discover datasets which are relevant to their interests but have not been noticed; and (3) data contributors/data centers can gain professional recognition and rewards for their labors to publish and manage data set in the same way as for traditional publications.
Recognizing their importance, solar-terrestrial physics (STP) data centers in Japan have been working to mint DOI to their database. We participated from October 2014 in a 1-year pilot program for DOI-minting to science data launched by Japan Link Center, which is one of the DOI registration agencies. In the pilot program, a procedure of the DOI-minting for STP data was established. As a result of close collaboration with Japan Link Center, the first case of data-DOI in Japan (doi:10.17591/55838dbd6c0ad) was created in June 2015. The first case of data citation in Japan was also made. As of March 2017, there are 17 data-DOIs for the STP data in Japan. This includes DOIs for the geomagnetic indices: the Dst index (doi:10.17593/14515-74000) and the Wp index (doi: 10.17593/13437-46800). We will present our activities of DOI-minting to solar-terrestrial physics data in Japan and discuss its future perspective.

On recognition of "primary data" producers through DOI of "secondary" data

Abstract ID : 802

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yasuhiro Murayama ,murayama@nict.go.jp ,(Research Executive Director, ICSU-WDS Scientific Committee) ,Japan ,Tokyo ,Not Presenting[1]

1 - National Institute of Information and Communications Technology

Adding permanent identifiers (DOIs) to datasets is an important practice for data citation providing attribution to researchers and contributors who create, process, manage data (hereinafter "data producers"). This data-DOI practice is becoming increasingly popular and is gradually being extended to many more scientific communities. In specific scientific disciplines (e.g., Earth and Planetary Sciences), some studies are conducted based on data directly retrieved from experiments, observations, and/or simulation, etc. (hereinafter "primary" data or PD), while there are other studies based on data generated from compilation and/or further data processing of PD (hereinafter "secondary" data or SD). SD is sometimes generated from processing multiple PD products (e.g., at different geographical locations, at different time, at different observational techniques/conditions and so on). In a research field where SD is more popularly used, the current data-DOI mechanism may not be sufficient in supporting data producers to keep sustainability of their data creation/curation/management works of PDs, because it is often difficult to ensure they receive proper recognition (and with it, enhanced reputation) even when SD generated from their PD products are used frequently and correctly cited in a number of research papers. In this paper, we attempt to focus on this difficulty for PD producers and we propose a revision in a metadata schema that enables the PD producers' work is appropriately recognized.

Geophysical data publishing under the “Earth Science DataBase” project

Abstract ID : 886

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Anatoly Soloviev ,a.soloviev@gcras.ru ,(Deputy Director for Science) ,Russia ,Moscow ,Presenting[1]

Dr. Ernest Kedrov ,e.kedrov@gcras.ru ,(None) ,Russia , ,Not Presenting[1]

Dr. Natalia Sergeyeva ,n.sergeyeva@gcras.ru ,(None) ,Russia , ,Not Presenting[1]

Ms. Aleksandra Astapenkova ,a.astapenkova@gcras.ru ,(None) ,Russia , ,Not Presenting[1]

1 - Geophysical Center of the Russian Academy of Sciences 2 - Geophysical Center of the Russian Academy of Sciences 3 - Geophysical Center of the Russian Academy of Sciences 4 - Geophysical Center of the Russian Academy of Sciences

ICSU World Data System, CODATA, DataCite, CrossRef, Force 11 and other organizations join forces and collaborate for the purpose of facilitation of access to high-quality scientific data for researchers and acknowledgement of the scientific data as valuable result of the research that is used during the creation of scientific products and is to be cited as well as other scientific sources of information such as articles, books etc. The registration of objects of scientific content with the assignment of the digital object identifier (DOI) has become customary. Currently the DOI system is extended to a wide variety of observational data considered now as adequate results of research and should be cited as other scientific sources of information.
At the same time the "Earth Science DataBase" (ESDB) project was initiated by the Geophysical Center RAS in 2014 on the basis of the WDC for Solar-Terrestrial Physics, a regular member of ICSU-WDS. The focus is on creation of the modern system of geophysical data registration, publication and DOI assignment through CrossRef system, used for unique identification of intellectual property. The goals of the project are (i) accumulation of observational data collected in Russia since 1957, and new data under the current international projects; (ii) providing persistence linking to registered data; (iii) preservation of data using, in particular, connections between ESDB central and local repositories using "multiple resolution" technology supported by CrossRef. The system, being constantly expanded, represents a structure for persistent intellectual content identification and management of intellectual content, metadata, linking users with content suppliers. Metadata base including detailed description of data itself and information about data producer and publisher is introduced in the system.
Since 2014, the following data sets have been registered in the ESDB system: database including 6 catalogues of Solar proton events over 1970-2008, database on historical recordings from 22 geomagnetic observatories in USSR/Russia over 1983-2009, database on continuous recordings from "Klimovskaya" geomagnetic observatory and "Saint-Petersburg" INTERMAGNET observatory since 2012, and seismotectonics map of Eastern Siberia. It also includes 26 individual data sets, including 2015 definitive data from INTERMAGNET observatory "Saint-Petersburg". Each data set, catalogue and database is accompanied with individual response page, located in the central repository of ESDB: http://esdb.gcras.ru/.
We believe that similar initiatives worldwide are the valuable contribution to development of the international data system and the availability of information on the geosciences in general.

Using Digital Object Identifiers in INTERMAGNET

Abstract ID : 1021

Conflict Declaration : I am a co-convenor of session JA2

Content Motivation : Move forward work on DOIs across the geomagnetic community

Additional Information : None

Mr. Simon Flower ,smf@bgs.ac.uk ,(IT Manager) ,United Kingdom ,Edinburgh ,Not Presenting[1]

Dr. Juergen Matzka ,jmat@gfz-potsdam.de ,(scientist) ,Germany ,Potsdam ,Not Presenting[2]

Dr. Kirsten Elger ,kelger@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[3]

1 - None 2 - GFZ 3 - GFZ German Research Centre for Geosciences, Potsdam

Publishing datasets with assigned Digital Object Identifiers (DOI) has emerged as best practice to follow the increasing international requests for open access to research data. They provide a citable way for persistent data access guaranteeing the reproducibility of research results and a mechanism for data providers to receive credit for their work. However, these objectives can be difficult to reconcile where long term time series data are being collected, and especially when research results are based on database querying of a constantly growing data collection. We review the Digital Object Identifier system, how it relates to time series data and particularly to data from Geomagnetic Observatories. We present current practice at BGS and GFZ as well as our plans for applying Digital Object Identifiers to observatory data on the institute and INTERMAGNET level and report progress on these plans.

Approach to Assignment and Management of DOIs for Oceanographic Data

Abstract ID : 1195

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Toru Suzuki ,suzuki@mirc.jha.jp ,(Deputy Director General) ,Japan ,Tokyo ,Not Presenting[1]

1 - Marine Information Research Center

It is important to assign a DOI not only scientific paper but also data used in its paper in order for data originator, holder, and manager as same as paper authors to obtain an appropriate evaluation. It is also expected that excellent resources are gathered so that new scientific fields are created. Although the oceanography is a comprehensive science including physical, chemical, biogeochemical fields, it focuses on an observational data by research vessels and various sensors on platforms such as buoys and gliders. The World Ocean Database (WOD) is most used global oceanographic database which are collected by National Oceanographic Data Center in UNESCO IOC member states under the International Oceanographic Data and Information Exchange (IODE) framework. The WOD is now published through unification format and quality controls by National Center for Environmental Information (NCEI), NOAA, USA, as IOC/IODE recommended project with NOAA's DOI. Furthermore ocean carbon dioxide community achieved global data synthesis for ocean surface and interior. These descriptions were published by the Earth System Science Data, the data publishing journal with DOI and database were storage in data assembly center respectively. As national oceanographic data bank which is one of elements of IODE framework, the Japan Oceanographic Data Center (JODC) receives oceanographic data from domestic research organizations and institutes, and publish them through the JODC Data Online Service System (J-DOSS) and also submit them to NCEI, NOAA. Nearly half of data in J-DOSS are submitted by fisheries research institutes of local governments which have been deployed regular observational stations at offshore of their territories and observed since the middle of 1960's. Those data firstly shares in fisheries community for catch forecast and so on immediately (real-time mode), and JODC usually receives them several years later, sometime through calibration and quality control if needed, as same as other institutions (delayed mode). We therefore must look more carefully how to assign and to manage DOIs for oceanographic data.

Doi for BCMT dataset of magnetic observatories

Abstract ID : 1300

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Pierdavide Coïsson ,coisson@ipgp.fr ,(Associate Physicist) ,France ,Chambon la forêt ,Presenting[1]

Dr. Vincent Lesur ,lesur@ipgp.fr ,(Head of magnetic observatories) ,France ,Paris ,Not Presenting[2]

Dr. Virginie Maury ,maury@ipgp.fr ,(None) ,France , ,Not Presenting[1]

Dr. Aude Chambodut ,aude.chambodut@unistra.fr ,(None) ,France ,None ,Not Presenting[4]

1 - Institut de Physique du Globe de Paris 2 - Institut de Physique du Globe de Paris 3 - Institut de Physique du Globe de Paris 4 - Ecole et Observatoire des Sciences de la Terre

The French Bureau Central du Magnetisme Terrestre (BCMT) operates currently 16 magnetic observatories distributed all over the world and maintains a database of more than a hundred year of magnetic data, including additional former observatories in France (2) and in foreign countries (3). Most of them are or had been operated in collaboration with other institutions.
With the aim of providing a simple, persistant and reliable way to refer to observatories definitive data, it has been proposed to the partner institutes to attribute a single doi for the complete dataset of BCMT definitive magnetic observatory data. The doi for this dataset is going to be available by July 2017.
The landing page for the BCMT dataset is going to be hosted on the IPGP data center and includes a description of the dataset covered by this doi and all observatories which partner institutions agreed to this doi. Direct links to the data of each observatory hosted on BCMT ftp server are also provided to facilitate data access.

International Service of Geomagnetic Indices: Current status

Abstract ID : 1344

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Aude Chambodut ,aude@unistra.fr ,(None) ,France ,Strasbourg ,Presenting[1]

Dr. Véronique Mendel ,vmendel.info@free.fr ,(None) ,France , ,Not Presenting[2]

Dr. Armelle Bernard ,armelle.bernard@unistra.fr ,(None) ,France , ,Not Presenting[3]

Mr. Jean-Marc Brendle ,brendle@unistra.fr ,(None) ,France , ,Not Presenting[3]

Dr. Juan José Curto ,jjcurto@obsebre.es ,(GPS: 40.8210, 0.4955) ,Spain ,Roquetes ,Not Presenting[5]

Dr. Juergen Matzka ,jmat@gfz-potsdam.de ,(scientist) ,Germany ,Potsdam ,Not Presenting[6]

1 - EOST - University of Strasbourg 2 - PrivateCompany 3 - EOST - CNRS UMS830 4 - EOST - CNRS UMS830 5 - Observatori de l'Ebre 6 - GFZ

The International Service of Geomagnetic Indices (ISGI) is in charge of the elaboration and dissemination of IAGA's endorsed geomagnetic indices and lists of remarkable magnetic events through its official Web portal.
This is possible thanks to reports of magnetic observatories distributed all over the planet and thanks to work done by the 6 ISGI-Collaborating-Institutes (ISGI-CIs: Ebro Observatori, Spain; GFZ, Potsdam, Germany; WDC, Kyoto, Japan; AARI, St Petersburg, Russian Federation; DTU Space, Copenhagen, Denmark; EOST, Strasbourg, France).
ISGI official Web portal known a complete upgrade in 2014-2015 at the occasion of its headquarters' moving from LATMOS to EOST. In 2017, a second phase of update is in progress to meet the actual requirements towards users and stakeholders. Various elements are currently settled by or in close cooperation with ISGI-CIs:
- DOI referencing in order to get full recognition,
- Licence choices to clearly set allowed actions onto the available datasets, but also their protection,
-APIs design for interoperability,
- Metadata editing for data mining and standardised information.
As a regular Member of ICSU World Data System, ISGI participates to various on-going projects on data management structuration. The example of the EPOS European Project (European Plate Observing System), which aims at implementing an operational and sustainable platform of Earth science services, is given.

JA3 - Frontier Challenges In Data Assimilation And Ensemble Forecasting For The Atmosphere, Ocean And Solid Earth. (IAGA, IAMAS, IAPSO)

On the improvement of data assimilation by better use of ensemble information

Abstract ID : 93

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Neill Bowler ,neill.bowler@metoffice.gov.uk ,(Scientist - Ensemble data assimilation) ,United Kingdom ,Exeter ,Not Presenting[1]

Dr. Gordon Inverarity ,gordon.inverarity@metoffice.gov.uk ,(None) ,United Kingdom ,None ,Not Presenting[1]

Mr Adam Clayton ,adam.clayton@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr Mohamed Jardak ,mohamed.jardak@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr Andrew Lorenc ,andrew.lorenc@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr Warren Tennant ,warren.tennant@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr Marek Wlasak ,marek.wlasak@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - Met Office 2 - Met Office 3 - Met Office 4 - Met Office 5 - Met Office 6 - Met Office 7 - Met Office

For data assimilation to work well it is necessary to have an accurate estimate of the errors in the prior forecast. Traditionally these errors have been modelled by a static (time-independent) covariance model. We can supplement this model using information from an ensemble prediction system, which provides time-varying information on the background errors. However, due to computational constraints only a small ensemble can be run. To address the sampling errors introduced by the limited size of the ensemble a number methods can be used.

We currently use hybrid data assimilation which gives a low weight to the ensemble information. Increasing the weight to the ensemble component improves the forecast quality in some regions of the globe, but not in others. This can be mitigated to some extent by allowing these weights to vary regionally, but this introduces transition zones where these weights vary which may create undesirable effects. Thus we find that there is no good compromise which increases the forecast quality everywhere.

Localization is the process of reducing sample correlations at large distances since they are likely to be spurious. Since different physical processes dominate in different parts of the atmosphere the

best localization length for one region of the globe not the best in others. To counter this we have tested running the localization on a series of wavebands, each representing different horizontal length-scales in the ensemble. This allows large-scale structures to be localized with broader localization functions and makes clear improvements to the forecast skill.

The sampling errors in the ensemble information can be reduced by using ensemble information from older forecast cycles (lagging) or from using ensemble information from the incorrect time (shifting). This can greatly increase the effective ensemble size without greatly increasing the computational cost. This has been seen to bring considerable forecast improvements.

With each of these developments there are a number of tuneable parameters which need to be adjusted to optimize ensemble performance. One theme which runs through this work is the tension between getting good performance and spending lots of time tuning each particular setting.

Role of sensitive physical parameter combinations in reducing simulation and forecast errors of sensible heat flux and latent heat flux in China

Abstract ID : 129

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Guodong Sun ,sungd@mail.iap.ac.cn ,(None) ,China ,Beijing ,Not Presenting[1]

Dr. Fei Peng ,pf_spring@163.com ,(None) ,China , ,Not Presenting[2]

Dr. Mu Mu ,mumu@fudan.edu.cn ,(None) ,China , ,Not Presenting[3]

1 - LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences 2 - Numerical Weather Prediction Center, China Meteorological Administration 3 - Institute of Atmospheric Sciences, Fudan University

Surface turbulent fluxes (sensible heat flux (SH) and latent heat flux (LH)) are recognized as key components of energy exchanges at the surface-atmosphere interface. It is important to improve the ability to simulate SH and LH by reducing parameter errors in the model .Since there exist quite a few parameters and related physical processes are nonlinear , it is crucial to investigate the nonlinear combinational effects of multiple-parameter uncertainty on the simulate or (and) forecast results .A new approach based on conditional nonlinear optimal perturbation related to parameters (CNOP-P) is employed within the Common Land Surface Model (CoLM). The results by the new approach is compared to that using the traditional method (such as the one-at-a-time (OAT) approach). The latter method ranks parameters one by one according to the sensitivity of each parameter and could fail to judge the sensitivity of the parameter combination.Numerical results show differences between the sensitivity of the parameter combinations using the new approach and the top ranked sensitive parameter using the OAT approach in dry and wet regions of China for SH and LH. By reducing the parameter error within the sensitive parameter combination, prediction is improved in China. Elevated extents of SH (84.3%) and LH (78.3%) calculated from the sensitive parameter combination using the new approach are higher than those of SH (57.2%) and LH (48.5%) using the OAT approach in semi-arid regions. This result suggests that it is essential to investigate the sensitivity of the parameter combination to lower simulation and prediction errors. The new approach for determining parameter combinations based on the CNOP-P is a promising method.

On the development of a better ensemble prediction system

Abstract ID : 142

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Neill Bowler ,neill.bowler@metoffice.gov.uk ,(Scientist - Ensemble data assimilation) ,United Kingdom ,Exeter ,Not Presenting[1]

Mr. Lucian Anton ,lucian.anton@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Gordon Inverarity ,gordon.inverarity@metoffice.gov.uk ,(None) ,United Kingdom ,None ,Not Presenting[1]

Mr Mohamed Jardak ,mohamed.jardak@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr Adam Clayton ,adam.clayton@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr Marek Wlasak ,marek.wlasak@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - Met Office 2 - Met Office 3 - Met Office 4 - Met Office 5 - Met Office 6 - Met Office

For many years the Met Office has run a short-range ensemble prediction system (EPS) using an ensemble transform Kalman filter (ETKF) to calculate the perturbations to the initial condition. Although this implementation has many advantages it also has a number of shortcomings that need to be addressed. Therefore we have developed an improvement to the EPS based on an ensemble of 4-dimensional ensemble-variational assimilations (En-4DEnVar). This change increases the link between the data assimilation and the EPS, hopefully meaning that the ensemble perturbations are more representative of the forecast errors seen by the assimilation.

Initial results indicated that the change to the EPS brought significant benefits to the data assimilation, as hoped. However, the code was very slow to run, and a reduction in the ensemble spread meant that the EPS forecast performance was worse than the ETKF. Further work has focused on various steps taken within En-4DEnVar to improve the EPS performance and computational efficiency.

To address problems with the ensemble spread we have looked at the model-uncertainty description. Additive inflation has proved very successful - where an archive of increments is randomly sampled and added to model trajectory each time-step. This gives good performance, but the added increments are independent of the weather of the day. Thus we have been working on other schemes which aim at a more physically-based description of the model error.

A separate issue to the ensemble spread is to look at the average error of the ensemble mean. Although the ensemble of data assimilations naturally generates its own analysis it may be better to recentre the ensemble on the analysis generated by the high-resolution "deterministic" system. This can improve forecast performance, but means that the EPS will tend to shift whenever the high-resolution system jumps. A compromise solution is to partially recentre the analysis around the high-resolution system. This can lead to improvements in the EPS performance. Increasing the ensemble size has an effect on the analysis quality, and therefore on the optimal amount of recentring to apply.

Relationships between optimal precursors triggering NAO onset and optimally growing initial errors during NAO prediction

Abstract ID : 154

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Guokun Dai ,daiguokun90@163.com ,(post doctor) ,China ,Shanghai ,Presenting[1]

Dr. Mu Mu ,mumu@fudan.edu.cn ,(None) ,China , ,Not Presenting[1]

Dr. Zhina Jiang ,jzn@camscma.cn ,(None) ,China , ,Not Presenting[3]

1 - Institute of Atmospheric Sciences, Fudan University 2 - Institute of Atmospheric Sciences, Fudan University 3 - State Key Laboratory of Severe Weather, Chinese Academy of Meteorological Sciences

Based on a viewpoint that the North Atlantic Oscillation (NAO) is a nonlinear initial-value problem, we study the predictability of NAO event onset by investigating the links between the optimal precursor (OPR) to its onset and the optimally growing initial error (OGE) in onset prediction. The problem is explored by the method of conditional nonlinear optimal perturbation with a triangular T21, three-level, quasigeostrophic global spectral model.

There are two kinds of OPRs triggering the positive event (NAO+) and the negative event (NAO-) respectively. For each OPR, there are two types of OGEs: a type-1 OGE, which causes an overprediction of NAO onset, and a type-2 OGE, which underestimates the NAO onset. Numerical results show that with the optimization time of 3 days, a type-1 OGE bears a great resemblance to OPR, and the similarity coefficient between them is 0.98 for both NAO+ and NAO-. A type-2 OGE is also characterized by a similar pattern to OPR, but with an opposite sign. With the extension of the optimization time into 7 days, the similarity coefficient between OPR and type-1 (type-2) OGE gradually decreases to 0.82 (-0.81) for NAO- and 0.87 (-0.57) for NAO+. However, in the linear regime, such high similarity between OPR and OGE can only be found with the optimization time of 3 days.

Further analysis reveals that a type-1 (type-2) OGE has a similar growth behavior to that of the corresponding OPR of the same-phase (opposite-phase) NAO event, both of which develop into a dipole NAO anomaly pattern. This similarity between OPR and OGE suggests that the nonlinear process plays an important role in the NAO predictability, which simultaneously provides a theoretical foundation for its targeted observations.

A stochastic re-analysis of transient motions within the Earth's core

Abstract ID : 165

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. nicolas gillet ,nicolas.gillet@univ-grenoble-alpes.fr ,(Researcher) ,France ,Grenoble ,Not Presenting[1]

Dr. julien aubert ,aubert@ipgp.fr ,(None) ,France , ,Not Presenting[2]

Dr. Olivier Barrois ,olivier.barrois@univ-grenoble-alpes.fr ,(None) ,France , ,Not Presenting[3]

1 - CNRS 2 - IPGP 3 - ISTerre

Geodynamo simulations currently reproduce well the static characteristics of the observed geomagnetic field. However, even the most up-to-date computations miss important features required to understand geomagnetic records on interannual to decadal time-scales. We thus re-analyse transient motions at the surface of the Earth's outer core under spatial constraints derived from geodynamo simulations, with a model state advected in time using order one stochastic equations (in agreement with the occurrence of geomagnetic jerks). The use of an Ensemble Kalman filter allows to estimate uncertainties on core flows as a function of length and time-scales. From synthetic experiments, we find crucial to account for time-correlated subgrid errors to obtain an unbiased reconstruction. This is achieved through an augmented state approach. We show that a non-negligible signature of magnetic diffusion should be considered at large length-scales, even on short periods. We apply our algorithm to the COV-OBS.x1 model over the period 1940-2015. We estimate the reliability of the retrieved velocities, confirming the existence of an eccentric, planetary-scale westward gyre. We present probability densities for the several contributions to the rate of change of the magnetic field, in particular to the axial dipole decay.

Ne'er for the faint of heart: Analysis and forecast error covariance estimates using the adjoint of 4D-Var

Abstract ID : 215

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Andrew Moore ,ammoore@ucsc.edu ,(Professor) ,United States ,Santa Cruz ,Not Presenting[1]

1 - University of California Santa Cruz

Reliable measures of analysis errors in estimates of the ocean circulation derived from data assimilation remain elusive, as do the ensuing forecast errors. Theoretical considerations reveal that this information can be derived from the adjoint of the entire data assimilation and forecast system, although the computational cost may be very burdensome. Nevertheless, the effort may yield considerable pay-offs since the adjoint of an analysis-forecast system can be mined for a wealth of other valuable information. In this presentation, these ideas will be explored for a baroclinically unstable ocean circulation using 4D-Var. The properties of the expected analysis and forecast error covariance during different phases of the analysis and forecast cycle are presented in relation to the underlying dynamics of the circulation.

Perturbation Methods for Ensemble Data Assimilation

Abstract ID : 291

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Kazuo Saito ,ksaito@mri-jma.go.jp ,(Senior Director for Research Affairs) ,Japan ,Tsukuba ,Presenting[1]

Mr. Masaru Kunii ,mkunii@mri-ma.go.jp ,(None) ,Japan , ,Not Presenting[1]

Mr. Takuya Kurihana ,s1310764@u.tsukuba.ac.jp ,(None) ,Japan , ,Not Presenting[3]

Dr. Le Duc ,leduc@jamstec.go.jp ,(None) ,Japan , ,Not Presenting[4]

1 - Meteorological Research Institute 2 - Meteorological Research Institute 3 - University of Tsukuba
4 - Japan Agency for Marine-Earth Science and Technology

Ensemble data assimilation methods are becoming widely used as the analysis methods which have potential to improve the accuracy of numerical weather prediction. Ensemble data assimilation methods have an advantage in terms of the development cost over the 4-dimensional variational method, however, their performances are still arguable and likely have room for further improvement. In ensemble data assimilation, the forecast error, which is necessary in data assimilation, is estimated by perturbations of the ensemble forecast, while characteristics of the ensemble forecast strongly depend on how the initial ensemble was generated. The ensemble transform (ET), eigenvalue decomposition of the analysis error covariance matrix, is widely used as the initial ensemble perturbation generator for the most ensemble data assimilation including ensemble Kalman filter such as LETKF and the ensemble variational method (EnVAR). The ensemble transform has an advantage in that the magnitude of perturbations (initial ensemble spread) can reflect the magnitude of the analysis error, but on the other hand, it is known that the growth of the errors is slower than other methods such as the singular vector method and the BGM method. In the previous studies for the mesoscale ensemble system (e.g., Saito et al.; 2011; 2012), perturbations from LETKF were not necessarily better than other methods as the initial perturbations, which may affect the accuracy of the analysis field. Non-diagonal components in the transform matrix likely contaminate the synoptic scale structure of the bred vectors in the ensemble forecast in the assimilation window when the localization is applied.

We started to tackle this problem, and in the presentation, some preliminary results using SPEEDY-LETKF such as the power spectra of diagonal and off-diagonal perturbations and evaluation of forecast errors of the perturbed members will be shown.

References

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Relationship between optimal initial errors and optimal precursors for Indian Ocean dipole predictions

Abstract ID : 343

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Rong Feng ,fengrong@lasg.iap.ac.cn ,(assistent research) ,China ,Beijing ,Not Presenting[1]

Dr. Mu Mu ,mumu@fudan.edu.cn ,(None) ,China , ,Not Presenting[2]

Prof. Wansuo Duan ,duanws@lasg.iap.ac.cn ,(Deputy director & Professor) ,China ,Beijing ,Not Presenting[1]

1 - Institute of Atmospheric Physics, Chinese Academy of Sciences 2 - Institute of Atmospheric Sciences, Fudan University 3 - Institute of Atmospheric Physics, Chinese Academy of Sciences

In this study, we explored the spatial patterns of winter predictability barrier (WPB)-related optimal initial errors and optimal precursors for positive Indian Ocean dipole (IOD) events and analyzed the associated physical mechanisms. The different "predictions" are only caused by the different initial conditions without regard to the effects of model errors on "predictions". The two types of WPB-related optimal initial errors are almost opposite for start months July (-1) and July (0). And they both present a west-east dipole pattern in the tropical Indian Ocean, with the max errors located at the thermocline depth. Bjerknes feedback and ocean waves play an important role in the growth of prediction errors. These two physical mechanisms compete with each other in the period July-December and ocean waves dominate in the period January-June. The spatial patterns of optimal precursors and the physical mechanisms for their developments are similar to those of WPB-related optimal initial errors. It's worth noting that the large values of the WPB-related optimal initial errors and optimal precursors are localized within a few locations, which probably represent the sensitive areas of targeted observations for positive IOD events. The great similarities between WPB-related optimal initial errors and optimal precursors suggest that if intensive observations are carried out over these areas, this will not only reduce initial errors and then the prediction errors, but also detect the signal of IOD events in advance, which greatly improve the forecast skill of positive IOD events.

Tsunami Scenario in Bay of Bengal

Abstract ID : 364

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. HARSH GUPTA ,harshg123@gmail.com ,(Distinguished Scientist) ,India ,Hyderabad ,Not Presenting[1]

Dr. Vineet K Gahalaut ,vkgahalaut@yahoo.com ,(None) ,India , ,Not Presenting[2]

1 - National Geophysical Research Institute 2 - National Centre for Seismology

The 26th December 2004 Sumatra earthquake of Mw 9.2 and the resultant tsunami that claimed ~ 250000 human lives in south and south east Asian countries was one of the worst natural disaster. Several studies have been conducted to freshly assess the past tsunamis as well as develop tsunami scenarios in view of vulnerability of the region. Here we examine vulnerability of the northern Bay of Bengal to tsunamis. Very high population density in the coastal areas, with a population of ~ 100 million, makes it important to have factual assessment of the tsunami hazard. We find that Bay of Bengal region is characterized by oblique plate motion leading to strike-slip dominated earthquakes with low tsunami generating potential. The deformation front associated with the plate boundary between the India and Sunda plates is confined either to land areas or very shallow sea and consequently a great earthquake is unlikely to displace enough water to create a large tsunami. We examined the available information about the 1762 Arakan earthquake. Although the earthquake might have led to some geomorphological changes in the coastal region, there is no convincing evidence that it created a large tsunami. It is inferred that while a great earthquake could occur in the Arakan region, the physiographic environment is not conducive for generation of a large tsunami.

Similarities Between optimal Precursors and Optimally Growing initial Errors and targeted observations in weather and climate predictions

Abstract ID : 411

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Mu Mu ,mumu@fudan.edu.cn ,(None) ,China , ,Not Presenting[1]

1 - Institute of Atmospheric Sciences, Fudan University

In this presentation, I will report some progresses on studies of the first kind of predictability in atmospheres and oceans. In numerical weather and climate predictions, there are two essential issues related to the initial conditions, one is the precursor (signal) of the event to be forecasted, another is the errors (noise) added on the true state. Any successful prediction of an event depends on whether the initial analysis field contains the signal and the noise is small enough.
By using the approach of conditional nonlinear optimal perturbation (CNOP),we investigated the optimal Precursor (OPE) and Optimally Growing initial Error (OGE) problems of El Niño -Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), the North Atlantic Oscillation (NAO) and Kuroshio large meander (KLM)?It is interesting that we have found that OPEs and OGEs of these atmospheric and oceanic events share great similarities in terms of localization and spatial structure. Further analysis show that for each event, i.e. ENSO, the mechanisms of evolutions of the OPR and OGE are the same, which is the well-known Bjerknes positive feedback.
The similarities suggest the ideas of targeted observations in the sensitivity area to better detect the early signals for the events and reduce the initial errors so as to improve the forecast skill. The encouraging results of observation system simulation experiments will be briefly summarized.

Predictability barrier of IOD predictions and related target observation

Abstract ID : 437

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Da Liu ,april_liuda@126.com ,(post Doctor) ,China ,Beijing ,Not Presenting[1]

Prof. Wansuo Duan ,duanws@lasg.iap.ac.cn ,(Deputy director & Professor) ,China ,Beijing ,Not Presenting[2]

1 - LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences; University of Chinese Academy of Sciences 2 - Institute of Atmospheric Physics, Chinese Academy of Sciences

In this study, we investigate the influence of initial uncertainties occurring in both the tropical Pacific and the Indian Oceans on the predictability of the Indian Ocean Dipole (IOD) events forecast by using the Geophysical Fluid Dynamics Laboratory (GFDL) CM2p1 coupled model. By perturbing the initial oceanic temperature over tropical Pacific and India Oceans, we find that the initial uncertainties of tropical oceanic temperatures with a particular spatial structure often cause large prediction errors for IOD events and especially present a significant season-dependent evolution with the largest error growth occurring in boreal winter or/and summer. This indicates that the IOD events forecast occurs winter or/and summer predictability barriers. The related particular initial uncertainties present two kinds of spatial structures. One presents its main errors in Indian Ocean and exhibits positive sea surface anomaly (SSTA) in the tropical western Indian Ocean and negative SSTA in the south-eastern Indian Ocean and often causes a significant winter predictability barriers (WPB). The other has the pattern with the main errors occurring in tropical Pacific and having the negative SSTA in the tropical eastern Pacific Ocean. It is inferred that WPB of IOD events is closely related to the initial errors in the Indian Ocean, while the SPB is mainly related to the errors in the tropical Pacific Ocean. Sensitivity experiments and physical consideration verify this inference. In addition, we notice that these two types of initial errors feature that large errors concentrate a localized region, which locates either in tropical Indian Ocean or tropical Pacific or in both of these two ocean basins. These regions may represent the sensitive areas for targeting observations of IOD predictions. The sensitivity areas in both tropical Pacific and Indian Oceans may indicate that the target observations in the tropical Pacific and Indian Oceans should be simultaneously taken into account.

Impact of sea surface temperature observations on an eddy-resolving ocean reanalysis of the Agulhas system

Abstract ID : 443

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Bjorn Backeberg ,BBackeberg@csir.co.za ,(Principal Researcher) ,South Africa ,Cape Town ,Not Presenting[1]

Dr. Marjolaine Krug ,mkrug@csir.co.za ,(Dr.) ,South Africa ,Cape Town ,Not Presenting[2]

Mr. Tharone Rapeti ,t.rapeti09@gmail.com ,(None) ,South Africa , ,Not Presenting[3]

Dr. Francois Counillon ,francois.counillon@nersc.no ,(None) ,Norway , ,Not Presenting[4]

1 - CSIR 2 - Council for Scientific and Industrial Research 3 - UCT 4 - NERSC

The Agulhas Current system is a highly dynamic region influencing the oceanography of coastal and shelf regions through a range of mesoscale and submesoscale processes. In the absence of coherent in-situ and satellite-based observing systems in the region, data assimilative ocean models play crucial roles in both routine monitoring and forecasting of the ocean environment. Additionally, the ocean reanalyses provided by such systems help advance our understanding of the complex interactions between the current, mesoscale and submesoscale eddies, the shelf and the coast. Assimilating along-track sea level anomalies (SLA) from satellite altimeters in a regional implementation of the Hybrid Coordinate Ocean Model (HYCOM) using the Ensemble Optimal Interpolation (EnOI) has been shown to improve the placement of mesoscale features, reducing the surface velocity errors in the region. In this study, we perform an observing system experiment where we evaluate the impact of including sea surface temperatures (SST) from the Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) in the assimilation scheme. By comparing the unassimilated model run, two assimilation experiments (SLA-only and SLA+OSTIA) against ocean current observations from Globcurrent, AVISO, surface currents derived from the Advanced Synthetic Aperture Radar and in situ ADCP measurements we quantify the relative benefit of assimilating along-track SLA and OSTIA SSTs in the Agulhas Current. Preliminary results indicate that including OSTIA SSTs in the assimilation results in unrealistically enhanced variability offshore of the Agulhas Current core, with a widening and weakening of the current core. We investigate possible reasons for this degradation, including model biases and observation post processing.

A study on ensemble forecast associated with conditional nonlinear optimal perturbations

Abstract ID : 448

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Ye Wang ,wangye@henu.edu.cn ,(PhD student) ,China ,Beijing ,Presenting[1]

Prof. Wansuo Duan ,duanws@lasg.iap.ac.cn ,(Deputy director & Professor) ,China ,Beijing ,Not Presenting[2]

1 - LASG,Institute of Atmospheric Physics, Chinese Academy of Sciences; University of Chinese Academy of Sciences 2 - Institute of Atmospheric Physics, Chinese Academy of Sciences

Orthogonal linear singular vectors (SVs) have been widely adopted in studies of ensemble forecasting. However, the linearity of SVs limits the skill of ensemble forecast. In the present study, the orthogonal conditional nonlinear optimal perturbations (CNOPs) are used to yield the initial perturbations for ensemble forecast within the frame of the Lorenz-96 model. It is found that the ensemble forecast skills generated by the CNOPs are often higher than those generated by the SVs for the latter period of forecast. Furthermore, the CNOPs provide much better spread-skill relationship during this period. However, for the former period of forecast, the SVs tend to present much better ensemble forecast skill than the CNOPs do. This result suggests that the ensemble forecast skill could be increased during the whole forecast period if the combination of CNOPs and SVs can be made. In addition, we show that the ensemble forecast skill increases to be a maximum with the increscent number of ensemble members and decreases subsequently. Therefore, the argument that the more the ensemble members, the higher the ensemble forecast skill does not hold. Further analysis demonstrates that the fast-growing initial perturbations are favorable for the increase of ensemble forecast skill while the slowly-growing or decaying initial perturbations decrease the ensemble forecast skill. This result shed light on that an appropriate size of ensemble members is helpful for the ensemble forecast reaching the higher skill. In sum, the combination of CNOPs and SVs, together with an appropriate size of ensemble members, could greatly enhance the ensemble forecast skill.

Automatic model calibration for improving WRF model forecasting

Abstract ID : 546

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Qingyun Duan ,qyduan@bnu.edu.cn ,(100875) ,China ,Beijing ,Presenting[1]

Dr. Zhenhua Di ,zhdi@bnu.edu.cn ,(None) ,China , ,Not Presenting[1]

Dr. Wei Gong ,gongwei2012@bnu.edu.cn ,(None) ,China , ,Not Presenting[1]

Mr. Chenwei Shen ,shencw@mail.bnu.edu.cn ,(None) ,China , ,Not Presenting[1]

Miss. Jiping Quan ,jpquan@mail.bnu.edu.cn ,(None) ,China , ,Not Presenting[1]

1 - Beijing Normal University 2 - Beijing Normal University 3 - Beijing Normal University 4 - Beijing Normal University 5 - Beijing Normal University

Automatic model calibration refers to the process in which the parameters of a dynamical model are tuned using mathematical optimization methods to minimize the aggregated difference between model predictions and corresponding observations. This approach is not widely practiced so far in numerical weather predictions because of difficulties related to model complexities such as high-dimensionalities of model parameters and model outputs, and the extraordinary demand of computational resources. This paper presents a platform called Uncertainty Quantification Python Laboratory (UQ-PyL) to perform automatic calibration of WRF model. The key functions of UQ-PyL include design of experiment (DoE), uncertainty analysis, global sensitivity analysis, surrogate modeling, and multi-objective optimization. We intend to demonstrate how UQ-PyL can be used to improve the predictive skill of the WRF model with a case study involving 5-day weather forecasting in the Greater Beijing region. Through numerous calibration and validation experiments, we found that automatic model calibration can improve predictive skill of the WRF model significantly according to numerous skill metrics.

Target observations for two types of El Nino events prediction and its role in reducing spring predictability barrier influences

Abstract ID : 559

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Wansuo Duan ,duanws@lasg.iap.ac.cn ,(Deputy director & Professor) ,China ,Beijing ,Not Presenting[1]

Mr. Ben Tian ,tbqy@163.com ,(None) ,China , ,Presenting[2]

1 - Institute of Atmospheric Physics, Chinese Academy of Sciences 2 - Laboratory for Climate Studies, National Climate Center, China Meteorological Administration

In this paper, the spring predictability barrier (SPB) problem for two types of El Niño events and related target observations are investigated. This is enabled by tracing the evolution of a conditional nonlinear optimal perturbation (CNOP) that acts as the initial error with the biggest negative effect on the El Niño predictions. We show that the CNOP-type errors for CP-El Niño events can be classified into two types: the first are CP-type-1 errors possessing a sea surface temperature anomaly (SSTA) pattern with negative anomalies in the equatorial central western Pacific, positive anomalies in the equatorial eastern Pacific, and accompanied by a thermocline depth anomaly pattern with positive anomalies along the equator. The second are, CP-type-2 errors presenting an SSTA pattern in the central eastern equatorial Pacific, with a dipole structure of negative anomalies in the east and positive anomalies in the west, and a thermocline depth anomaly pattern with a slight deepening along the equator. CP-type-1 errors grow in a manner similar to an EP-El Niño event and grow significantly during boreal spring, leading to a significant SPB for the CP-El Niño. CP-type-2 errors initially present as a process similar to a La Niña-like decay, prior to transitioning into a growth phase of an EP-El Niño-like event; but they fail to cause a SPB. For the EP-El Niño events, the CNOP-type errors are also classified into two types: EP-type-1 errors and 2 errors. The former is similar to a CP-type-1 error, while the latter presents with an almost opposite pattern. Both EP-type-1 and 2 errors yield a significant SPB for EP-El Niño events. For both CP- and EP-El Niño, their CNOP-type errors that cause a prominent SPB are concentrated in the central and eastern tropical Pacific. This may indicate that the prediction uncertainties of both types of El Niño events are sensitive to the initial errors in this region. Especially, hindcast experiments verify this inference. The region therefore represent a common sensitive area for the targeted observation of the two types of El Niño events, which may provide useful information to the new observing plan of tropical Pacific (TPOS20).

Catalyzing Innovation in Weather Science: the World Weather Research Programme

Abstract ID : 776

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Julia Keller ,jkeller@wmo.int ,(None) ,Switzerland ,1211 Geneva -2 ,Not Presenting[1]

Prof. Sarah Jones ,sarah.jones@dwd.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Julia Keller ,jkeller@wmo.int ,(None) ,Switzerland ,1211 Geneva -2 ,Presenting[1]

1 - World Meteorological Organization 2 - Deutscher Wetterdienst 3 - World Meteorological Organization

Despite significant increase in weather forecast skill during the last 15 years or so, major loss event statistics constantly remind us of the gaps between sctientifc knowledge and its beneficial application to both routine and complex weather-related problems facing society. With its new implementation plan, the World Meteorological Organization´s World Weather Research Programme, has developed a research strategy towards the seamless prediction of the Earth system from minutes to months. The World Weather Research Programme was established in 1998 for addressing the growing societal impacts of a range of high-impact weather events over various time- and space scales, such as landfalling tropical cyclones and heavy rainfall. Since its foundation the World Weather Research Programme initiated, endorsed, and facilitated various international research activities that required an especially large critical mass of effort, and that achieved immense progress in Weather Science. As the science is advancing critical questions are arising such as about the potential sources of predictability on weekly, monthly and longer time-scales which are poorly understood up to now; seamless prediction from minutes to months; optimal use of local and global observing capabilities in data assimilation, coupled modelling, and the effective utilization of massively-parallel supercomputers. In addition, communication for forecasts, warnings and their uncertainty, prediction of impacts and novel demands emerging from a diversification of user needs raise new challenges for weather related research. All of these challenges can only be met through strong interdisciplinary and international collaborations.
This presentation will introduce the research strategy developed by the World Weather Research Progamme for the period 2016 - 2023, with a particular focus on research activities in data assimilation, coupled modelling, ensemble forecasting and aspects of predictability on time scales from minutes to seasons. It will further present opportunities for the research community to become engaged in and to benefit from the activities of the World Weather Research Programme.

A discussion of marine biogeochemical ocean data assimilation

Abstract ID : 803

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Christopher Edwards ,cedwards@ucsc.edu ,(Professor) ,United States ,Santa Cruz ,Not Presenting[1]

1 - University of California, Santa Cruz

In ocean sciences data assimilation methods have advanced considerably over many decades on both global and regional scales. While assimilation of observations into physical circulation models now occurs routinely for reanalyses and operational systems, the rigorous constraint of marine biogeochemical model fields using data is less mature. Nonetheless, important progress has also been made in this arena, and biogeochemical reanalyses are increasingly available. Some challenges faced include non-Gaussian error statistics, limited data availability, and unbalanced initial states. This talk will review these issues and some recent biogechemical data assimilative applications using both sequential and variational techniques. It will include a discussion of new efforts toward fully coupled physical and biogeochemical data assimilation using a 4-dimensional variational approach. Developed orginally in meteorology, this method applies a hybrid technique in which biogeochemical fields are assumed to be lognormally distributed while preserving Gaussian distributions for physical fields and their errors. An incremental form of this method has been developed and applied in the California Current System.

The GIGG-Delta filter: Data assimilation for intermittent variables with skewed uncertainty distributions like cloud, precipitation and ice.

Abstract ID : 887

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Craig Bishop ,craig.bishop@nrlmry.navy.mil ,(Meteorologist) ,United States ,Monterey ,Not Presenting[1]

1 - Naval Research Laboratory

The uncertainty distributions of forecasts of intermittent variables such as clouds, precipitation, fire and ice often feature a finite probability of zero and/or skewness. For such variables, existing data assimilation techniques such as 4DVAR, the Ensemble Kalman Filter (EnKF) and the Particle Filter (PF) fail when a finite amount of the variable is reliably observed but the prior forecast uncertainty distribution assigns zero forecast error variance to the observed variable. Here we extend the previously developed Gamma, Inverse-Gamma and Gaussian (GIGG) variation on the EnKF to accommodate finite probabilities of zero. The resulting GIGG-Delta filter has the property that when rain (for example) is reliably observed, the GIGG-Delta filter always produces a posterior ensemble of raining ensemble members even if not one of the prior forecast ensemble members contain rain. In addition, the GIGG-Delta filter accurately solves Bayes' theorem when the prior and observational uncertainties are given by gamma and inverse-gamma pdfs, respectively. The performance of the GIGG-Delta filter is compared against that of the EnKF and a logarithmic variation of the EnKF in an idealized univariate model. The GIGG-Delta is found to outperform both the standard and logarithmic forms of the EnKF. Although the ensemble variance of the logarithmic EnKF matches error variance in log-space, it is under-dispersive in physical space. The multivariate performance of the GIGG-delta filter is then tested by applying it to a newly developed 70 variable chaotic coupled model that includes a rain-like variable. The GIGG-delta filter is again found to outperform the EnKF.

Insights into millennial-scale core dynamics through archeomagnetic data assimilation

Abstract ID : 958

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sabrina Sanchez ,sanchezs@mps.mpg.de ,(Max Planck Institute for Solar System Research) ,Germany ,Gottingen ,Not Presenting[1]

Mr. Alexandre Fournier ,fournier@ipgp.fr ,(None) ,France ,Paris ,Not Presenting[2]

Dr. julien aubert ,aubert@ipgp.fr ,(None) ,France , ,Not Presenting[3]

Dr. Yves Gallet ,gallet@ipgp.fr ,(None) ,France , ,Not Presenting[2]

Dr. Emmanuel Cosme ,emmanuel.cosme@ujf-grenoble.fr ,(None) ,France , ,Not Presenting[5]

1 - Max Planck Institute for Solar System Research 2 - Institut de Physique du Globe de Paris 3 - IPGP 4 - Institut de Physique du Globe de Paris 5 - Université Grenoble Alpes-CNRS

The Earth's magnetic field varies in a broad spectrum of time-scales. While rapid changes are connected to external sources, the long-term variations correspond to the dynamics of the liquid outer core. Such longer term dynamics is only accessible by indirect observations, the archeomagnetic data. The heterogeneous spatial and temporal character of the archaeomagnetic data catalog, however, does not allow for a well-constrained inversion of the core field. Instead, the inverse problem is generally regularized by imposing prior constraints limiting the complexity of the field. To supplement the information provided by the sparse archaeomagnetic dataset, we consider the extra information on the magnetic field given by numerical simulations of the geodynamo. In this study, we explore how a sequential data assimilation framework can help improving the estimation of the field in the archeomagnetic context. We use the Ensemble Kalman Filter, which considers the propagation in time by an ensemble of numerical dynamo models in a sequence of forecast-and-analysis cycles. The constant feeding of archeomagnetic observations into the model can allow for the estimation of not only the observable, but also of the hidden variables of the dynamo system, such as the magnetic field in depth and the flow throughout the core. In this work, the assimilation of archaeomagnetic-like synthetic data is tested by means of closed-loop experiments. The estimation shows a good retrieval of the large-scale features of the simulation through an assimilation interval of a few millennia, despite the clustering of data over the Northern Hemisphere. This result shows the efficient propagation of information through the hemispheres due to the high degree of equatorial symmetry of the underlying model, and opens up the possibility for the assimilation of real archaeomagnetic observations. However, the application to real data is challenging, since archaeomagnetic observations are affected by considerable dating and experimental errors. Further development of this work will allow for a better understanding and estimation of the physical processes operating in the core on millennial time scales.

Use of Satellite Magnetic Field Observations in Data Assimilation Studies of Core Dynamics

Abstract ID : 1026

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Chris Finlay ,cfinlay@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[1]

Dr. Olivier Barrois ,olivier.barrois@univ-grenoble-alpes.fr ,(None) ,France , ,Not Presenting[2]

Mr. Magnus Hammer ,magdh@space.dtu.dk ,(None) ,Denmark ,Holte ,Not Presenting[1]

Dr. nicolas gillet ,nicolas.gillet@univ-grenoble-alpes.fr ,(Researcher) ,France ,Grenoble ,Not Presenting[4]

1 - DTU Space, Technical University of Denmark 2 - ISTerre 3 - DTU Space, Technical University of Denmark 4 - CNRS

The next generation of models of core dynamics will be based on data assimilation techniques, and involve the combination of magnetic field observations with physics-based models of core processes. In this talk I will review the geomagnetic observations available for this activity. Perhaps the most important data for such studies of the present geodynamo are magnetic measurements by low-Earth-orbit satellites. Such observations have been almost continuously available since 1999 and are today the primary means of monitoring global-scale changes in the geomagnetic field. A serious obstacle to using satellite observations within a data assimilation scheme is the lack of suitable data error covariance information. This is is essential if physics-based models are to be optimally adjusted according to the observations. Present schemes for incorporating satellite data indirectly via spherical harmonic models will be described, and possible limitations of this strategy will be discussed. An alternative approach is to construct time series of point estimates (sometimes called 'virtual observatories' e.g. Mandea and Olsen, 2006) from satellite data on a global grid of locations. It is then possible to characterise the covariances between locations in a form that is useful for data assimilation studies. Data error covariances derived in this way from Swarm and CHAMP data will be presented. Finally, we shall briefly discuss our efforts to assimilate Swarm and CHAMP data into a model of core dynamics based on geodynamo simulation statistics.

Analyzing the ocean with the latest ECCO Ocean State Estimate

Abstract ID : 1155

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ichiro Fukumori ,fukumori@jpl.nasa.gov ,(Principal Scientist) ,United States ,Pasadena ,Not Presenting[1]

Dr. Ou Wang ,Ou.Wang@jpl.nasa.gov ,(None) ,United States , ,Not Presenting[2]

Dr. Ian Fenty ,Ian.Fenty@jpl.nasa.gov ,(None) ,United States , ,Not Presenting[2]

Dr. Gael Forget ,gforget@mit.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Patrick Heimbach ,heimbach@ices.utexas.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Rui Ponte ,rponte@aer.com ,(None) ,United States ,Lexington, MA 02421-3126 ,Not Presenting[6]

1 - Jet Propulsion Laboratory, California Institute of Technology 2 - JPL/Caltech 3 - JPL/Caltech 4 - Massachusetts Institute of Technology 5 - Univ. Texas at Austin 6 - AER

Interannual to decadal variations of the ocean are described using the latest estimate from the "Estimating the Circulation and Climate of the Ocean" (ECCO) project (http://ecco-group.org). The estimate, called ECCO-V4 or version 4, combines a state-of-the-art ocean general circulation model (MITgcm) with nearly all extant observations of the ocean from 1992 to 2015, including sea level from satellites (e.g., Jason-2), and in situ hydrographic profiles from ships (e.g., WOCE) and floats (e.g., Argo). The model is of moderate spatial resolution (40-100km) but with a domain that is truly global including the Arctic Ocean. The estimate's enhancements from its earlier releases include its longer period (4 additional years), use of new observations (e.g., GRACE ocean bottom pressure and Aquarius sea surface salinity), model improvements (e.g., geothermal heating, sea ice model), and accounting of correlated uncertainties (e.g., forcing bias).

The new analysis has improved agreements with observations than before, allowing a more accurate accounting of processes contributing to their variation. In particular, the ECCO analysis is characterized by its physical consistency in the sense of the estimate's temporal evolution being accounted for explicitly in terms of physical processes resolved by the model. The estimation's infrastructure (e.g., model adjoint) allows analyses that cannot be easily performed from observations or models alone.

The new estimate and its infrastructure will be presented with a focus on sea level variations and associated changes in ocean heat and mass. Regional and vertical distribution of the variable heat and mass fields will be explored and the nature of their evolution will be examined in relation to the ocean circulation.

Assimilation of the remotely sensed ice concentration data into the CICE model

Abstract ID : 1158

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Max Yaremchuk ,max.yaremchuk@nrlssc.navy.mil ,(Oceanographer) ,United States ,Stennis Space Center ,Presenting[1]

Ms. Tammy Townsend ,tammy.townsend@nrlssc.navy.mil ,(None) ,United States , ,Not Presenting[1]

Dr. Gleb Panteleev ,gleb.panteleev@nrlssc.navy.mil ,(None) ,United States , ,Not Presenting[1]

Dr. David Hebert ,david.hebert@nrlssc.navy.mil ,(None) ,United States , ,Not Presenting[1]

Mr. Rick Allard ,rick.allard@nrlssc.navy.mil ,(None) ,United States , ,Not Presenting[1]

1 - NRL 2 - NRL 3 - NRL 4 - NRL 5 - NRL

We explore the impact of ice velocity information and gaussianized innovations on the performance of the CICE-HYCOM varaitional data assimilation system. The gaussianization transform and its inverse are computed at the analysis step and exploit similarity between the PDFs of IC innovations and increments. Degaussianization of the innovations is augmented by an additional 2dVar algorithm optimizing the estimate of the background error variance field with respect to the innovations obtained after the analysis. The background error correlation model for gaussianized IC increments is formulated in terms of the Green function of the diffusion equation. The respective diffusion operator and integration time are specified by the ice velocity field which provides the magnitude and orientation of the principal axis of the diffusion tensor.
Performance of the technique has been tested with a regional configuration of the CICE-HYCOM system in the Beaufort Sea assimilating SSMI and IMS data acquired in September of 2015. Assimilation experiments have shown faster convergence of the iterative solver in the gaussianized case and better 24-hour forecast skill compared to the operational system, which currently employs an isotropic correlation model without gaussianization.

Skillful climate forecasts of the tropical Indo-Pacific using model-based analogs

Abstract ID : 1159

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Matt Newman ,matt.newman@noaa.gov ,(Senior Research Scientist) ,United States ,Boulder ,Presenting[1]

Mr. Michael Alexander ,Michael.Alexander@noaa.gov ,(Meteorologist) ,United States ,Boulder ,Not Presenting[2]

Dr. Hui Ding ,hui.ding@noaa.gov ,(None) ,United States , ,Presenting[1]

1 - University of Colorado/CIRES and NOAA/ESRL/PSD 2 - NOAA/Earth System Research Laboratory 3 - University of Colorado/CIRES and NOAA/ESRL/PSD

We explore the idea that for forecast lead times sufficiently long that the forecast model has largely drifted to its own climatology, model initialization should be directly in the model phase space, not in the phase space of nature. There are many sophisticated approaches that might be used to address this problem. We will instead take the simple approach of constructing an ensemble of model states closest to each observed initial state, where the model states are taken from long control runs of CGCMs that correspond to the forecast CGCMs. Then the ensemble mean of the evolution of those model states is our forecast. That is, we construct analog models of CGCMs, where the data "library" is not observations but rather the free-running model itself.
This "model-analog" technique is applied to half (four) of the CGCMs comprising the North American Multimodel Ensemble (NMME): NCAR-CCSM4, NCAR-CESM1, GFDL CM2.1, and GFDL CM2.5 (FLOR). The lengths of the corresponding control model run range from 700-4000 years, allowing a sensitivity test to both data availability and ensemble size. Model-analogs are determined only over the tropical IndoPacific domain, using monthly SST and SSH anomalies. In a perfect model framework, where the first 200 years of each run are withheld for verification while the remaining model output comprises the (seasonally-varying) analog data library, we obtain tropical Pacific SST skill found by other perfect model studies, with a Nino3.4 correlation above 0.5 for forecast leads up to 24 months. Interestingly, this perfect model predictability appears largely linear.
We then apply the technique to make hindcasts for the years 1982-2009 for leads of 1-12 months, initializing with observed SST and SSH anomalies over that period. The model-analog hindcast skill is comparable to (and often slightly better than) the corresponding CGCM hindcast skill throughout the tropical Pacific both for the individual models and, when the model-analog hindcasts are averaged together, for the NMME mean. This suggests the possibility that any CGCM with a sufficiently long control run may be used to produce skillful forecasts of monthly tropical IndoPacific SST anomalies, without additional development of its data assimilation system.

Towards understanding the impact of assimilating along-track SLA data on simulated eddy characteristics in the Agulhas System

Abstract ID : 1328

Conflict Declaration : None

Content Motivation : Operational ocean forecasting has the potential to benefit several key areas. Amongst others, these include safety of life at sea and support to fisheries industry, search and rescue as well as recreation and tourism. The role of numerical models in this regard is especially important given the lack of coherent in-situ observing systems in the ocean in general (when compared to terrestrial environments), and especially the dynamically complex Agulhas region. Data assimilation has the potential to add significant value in accuracy to numerical modelling efforts. However, data assimilative model results should be interrogated and evaluated, such that we can be certain that solutions are being usefully constrained toward reality. This study evaluates the impact of data assimilation in simulating mesoscale eddies into a HYCOM model. The accurate simulation of these features is of critical importance to the overall success of the model, as they are major transporters of heat, salt and organic material, and are thus both physical and biological drivers oceanographic drivers.

Additional Information : None

Mr. Marc de Vos ,marc.devos@weathersa.co.za ,(Marine Scientist) ,South Africa ,Cape Town ,Not Presenting[1]

Dr. Bjorn Backeberg ,BBackeberg@csir.co.za ,(Principal Researcher) ,South Africa ,Cape Town ,Not Presenting[2]

Dr. Francois Counillon ,francois.counillon@nersc.no ,(None) ,Norway , ,Not Presenting[3]

1 - South African Weather Service 2 - CSIR 3 - NERSC

The impact of assimilating along-track sea level anomaly (SLA) data into a regional Hybrid Coordinate Ocean Model (HYCOM) is investigated with regard to the simulation of mesoscale eddy characteristics in the Agulhas System. Eddy characteristics from an assimilated (Assim) and an unassimilated (Free) simulation experiment in HYCOM are compared with each other, using satellite altimetry derived eddy characteristics as a basis to evaluate accuracy. Overall, Assim yields improvements over Free in eddy density distribution and dynamics. Despite these improvements, Assim still simulates too many eddies relative to altimetry, while Free simulates too few. South of Madagascar, however, the number of eddies simulated by both HYCOM experiments appears to be far too low, though Assim offers at least some improvement in this regard. Bearing in mind the overall over-simulation of eddies by Assim, this implies too many eddies elsewhere in the domain. This finding prompted an investigation into the suitability of the altimetry product for use as a reference in this localised domain. This is achieved by assessing the agreement between MADT and SLA from altimetry and SST and SST anomaly signals for the same region. Preliminary results suggest that the altimetry shows good agreement with the SST signal, with eddy contours lining up with warm or cold SST anomalies. This would appear to strengthen the finding that HYCOM is not sustaining sufficient eddy activity in this region.
The study yields important lessons for the analysis of eddy properties in the Agulhas system. Previous studies using the same and similar data have yielded quite different results in, for example, quantities of eddy kinetic energy (EKE). More specifically, where EKE has been derived from geostrophic velocities computed from continuous fields of SSH, HYCOM EKE has been shown to be excessive in the region south of Madagascar. Here, where EKE is computed only where discrete eddies are

present in this region, quantities are too low. This suggests that caution is required when using EKE as a proxy for eddy activity, and that certain discrepancies only become evident when computing eddy statistics discretely.

Ensemble data assimilation and localization

Abstract ID : 1521

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Chris Snyder ,chriss@ucar.edu ,(None) ,United Kingdom ,None ,Not Presenting[1]

1 - None

Ensemble data assimilation, in various forms, has been enormously successful for geophysical systems over the last 20 years. The basic recipe is to estimate the statistical quantities required in data assimilation schemes from an ensemble of short-range forecasts or simulations. This works great sometimes. In many interesting applications, however, the systems possess many thousands or millions of important degrees of freedom, yet ensembles of only O(100) members can be afforded. Localization--in which the system states at locations separated by a sufficient distance are assumed to be statistically independent--makes ensemble data assimilation feasible and effective in these cases. I will argue that, far from being simply an ad hoc technique, localization is the central, elegant idea that underlies the success of ensemble data assimilation in geophysical problems such as numerical weather prediction.

Data assimilation for operational ocean forecasting and reanalysis

Abstract ID : 1522

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Matthew Martin ,matthew.martin@metoffice.gov.uk ,(None) ,United Kingdom ,None ,Not Presenting[1]

1 - None

Ocean data assimilation systems have been developed at many operational forecasting centres in order to initialise short-range operational ocean forecasts, coupled monthly-to-seasonal forecasts, and for producing ocean reanalyses. Recently there has also been a move to develop coupled ocean-atmosphere data assimilation systems to initialise coupled forecasts on NWP time-scales. An overview of current operational ocean data assimilation systems will be given, with a focus on those used in centres contributing to GODAE OceanView.
Recent developments to the NEMOVAR ocean data assimilation system will also be presented. NEMOVAR is developed collaboratively by CERFACS, ECMWF, INRIA and the Met Office. At the Met Office it is used operationally for global ocean forecasting and reanalysis, for regional shelf-seas forecasting, and as part of a weakly coupled ocean/sea-ice/atmosphere/land data assimilation system. Examples of the developments currently being made in each of these areas will be described. These include recent improvements to the representation of background error covariances which now allow a combination of multiple length-scale Gaussian functions, localised ensemble information, and large-scale EOF-based information. A new variational bias correction scheme for satellite SST data has been implemented which makes good use of information from un-biased reference data when they are available. The implementation of data assimilation in shelf-seas forecasting will also be presented in an application for the North-West European Shelf-Seas. Finally, the demonstration of weakly coupled data assimilation in an operational environment will be described.

Measuring surface deformation from UAVSAR and GPS to Improve Estimates of Future Earthquake Potential

Abstract ID : 1526

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Andrea Donnellan ,andrea.donnellan@jpl.nasa.gov ,(None) ,United States ,None ,Not Presenting[1]

1 - None

Spatio-temporal patterns of crustal deformation are complex with a superposition of long-term tectonic motions and transient deformation from a variety of tectonic and non-tectonic sources. Time scales of deformation can range from seconds to millennia. Spatial scales of deformation can range from mm to plate scale. Tectonic plate motions can be measured with better than 1 mm/yr precision using GPS at specific stations, which are typically about 10 km apart in the tectonically active parts of California. Rates of deformation are nonlinear following large earthquakes and can take years to decay. More recent observations using airborne interferometric synthetic aperture radar (UAVSAR) show extensive triggered slip on faults off the mainshock rupture for moderate to large earthquakes. This triggered slip can be used to identify active faults and estimate earthquake potential on still locked segments of the faults. Additionally, slip on faults evolved over time. Measurements are becoming precise enough that this evolution of slip can be tracked using geodetic imaging. Assimilating these data into crustal deformation models is necessary to constrain the mechanisms of fault and rheology of the crust. We will examine how geodetic imaging can be used to improve earthquake forecasts based on seismic nowcasting.

Climate and ozone layer response to solar irradiance and energetic particle precipitation variability

Abstract ID : 74

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Eugene Rozanov ,eugene.rozanov@pmodwrc.ch ,(Senior Scientist) ,Switzerland ,Davos ,Not Presenting[1]

Dr. Bernd Funke ,bernd@iaa.es ,(Staff Scientist) ,Spain ,Granada ,Not Presenting[2]

Mr Pavle Arsenovic ,pavle.arsenovic@env.ethz.ch ,(None) ,Switzerland , ,Not Presenting[3]

1 - PMOD/WRC and IAC ETHZ 2 - Instituto de Astrofisica de Andalucia CSIC 3 - IAC ETHZ

We applied atmosphere-ocean chemistry-climate model (AOCCM) SOCOL-MPIOM for the study of the ozone layer and climate evolution during the first half of 20th century. This period was chosen because it is characterized by the steady increase of the solar activity coincided with warming climate trend. The model runs were driven by anthropogenic and natural forcing taken in different combinations to elucidate the contribution of different climate forcing agents. In this talk we will demonstrate and compare the influence of energetic particles and solar irradiance. The forcing from energetic precipitating particles includes NOx and HOx production by auroral and radiation belts electrons, solar protons and galactic cosmic rays. The ionization rates inside the model domain (below 80 km) and influx of NOx from the thermospheric source were taken from the dataset prepared for IPCC CMIP-6 project. The solar irradiance evolution was reconstructed from the solar modulation potential and sunspots time series and used for the heating and photolysis rate calculation. The comparison of the ozone and climate evolutions obtained from the model experiments allows estimating the contribution of energetic particles and solar irradiance to the earlier 20th century climate. Preliminary results showed that the contribution of energetic particles is more important for the surface climate over the northern landmasses than solar UV, but over the oceans the contribution from the visible and infrared solar irradiances dominates. The inclusion of the energetic particles helps to reach better agreement between simulated and observed surface air temperature trends over Europe and Eastern US. The comparison of the simulated and observed total ozone evolution will be also discussed.

A 2-day time delay of thermospheric and ionospheric responses to solar irradiation at various UV wavelengthes

Abstract ID : 100

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Shunrong Zhang ,shunrong@haystack.mit.edu ,(None) ,United States ,Westford ,Presenting[1]

Mr Larisa P Goncharenko ,lpg@haystack.mit.edu ,(None) ,United States , ,Not Presenting[2]

Mr Philips Erickson ,pje@haystack.mit.edu ,(None) ,United States , ,Not Presenting[3]

1 - MIT Haystack Observatory 2 - MIT Haystack Observatory, Massachusetts Institute of Technology, Westford, Massachusetts, USA 3 - MIT

It is well known that solar EUV irradiation at various wavelengths drives a significant portion of variability in the ionosphere and theremosphere. However, evidence shows that the upper atmospheric responses are not as straightforward as anticipated. One example of the complexity is conerned with the delayed ionospheic electron density and thermospheric temperature responses to the EUV changes. Using measurements of Millstone Hill Incoherent Scatter Radar for a consective 30-day period in October 2002, we invesigate how ionospheric electron density and temperatures as well as thermospheric temperature (derived from the radar observations) respond to changes in solar EUV radiation flux as measured with the TIMED/SEE photometers and spectrometer at various wavelengths. Exospheric temperature (Tex) is found to be most sensitive to solar EUV flux with an approximately 2-day delay at wavelengths of 27--34 nm. In fact, at 27-34 nm the delay is shorter in the morning and longer in the afternoon. The ionospheric electron density delay is significantly altitude dependent: being 2-3 days in the F2 region, and nearly zero at E-region heights. This study indicates the time scale of redistribution of upper atmospheric enegetics and dynamics under the influences of incoming solar irradaition, and importance of upper atmospheric preconditing.

Solar Radiative Forcing

Abstract ID : 200

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Natalie Krivova ,natalie@mps.mpg.de ,(Group Leader) ,Germany ,Göttingen ,Not Presenting[1]

Dr. Kok Leng Yeo ,yeo@mps.mpg.de ,(None) ,Germany , ,Not Presenting[1]

Prof. Sami K. Solanki ,solanki-office@mps.mpg.de ,(None) ,Germany , ,Not Presenting[1]

1 - MPS 2 - MPS 3 - MPS

The historical variability in solar irradiance is a critical input to climate simulations. The records of direct irradiance measurements are rather short, incomplete in spectral and temporal coverage, and suffer from instrumental artifacts. This calls for model reconstructions of historical irradiance variability. Two classes of such models, termed empirical and semi-empirical, currently exist. Their output shows some significant differences, in particular in the spectral distribution of the variability. The reasons for these differences and the prospects for their resolution will be discussed in this talk.

Downward Wave Reflection as a Mechanism for the Stratosphere-Troposphere Response to the 11-year Solar Cycle

Abstract ID : 229

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Hua Lu ,hlu@bas.ac.uk ,(None) ,United Kingdom ,Cambridge ,Not Presenting[1]

Prof. Lesley Gray ,gray@atm.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Prof. John Turner ,jtu@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Prof. Adam Scaife ,Adam.Scaife@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. Gareth Marshall ,gjma@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - British Antarctive Survey 2 - NCAS-Climate, Department of Atmospheric Physics, Oxford University 3 - British Antarctic Survey 4 - Met Office 5 - British Antarctic Survey

The effects of solar activity on the stratospheric waveguides and downward reflection of planetary waves during northern early to mid- winter are examined. Under high solar (HS) conditions enhanced westerly winds in the subtropical upper stratosphere and the associated changes in the zonal wind curvature led to an altered waveguide geometry across the winter period in the upper stratosphere. In particular, the condition for barotropic instability was more frequently met at 1 hPa near the polar night jet centred at ~55°N. In early winter the corresponding change in wave forcing was characterized by a vertical dipole pattern of the Eliassen-Palm (E-P) flux divergent anomalies in the high-latitude upper stratosphere accompanied by poleward E-P flux anomalies. These wave forcing anomalies corresponded with negative vertical shear of zonal mean winds and the formation of a vertical reflecting surface. Enhanced downward E-P flux anomalies appeared below the negative shear zone; they coincided with more frequent occurrence of negative daily heat fluxes and associated with eastward acceleration and downward group velocity. These downward reflected wave anomalies had a detectable effect on the vertical structure of planetary waves during November to January. The associated changes in tropospheric geopotential height contributed to a more positive phase of the North Atlantic Oscillation in January and February. These results suggest that downward reflection may act as a 'top-down' pathway by which the effects of solar ultraviolet (UV) radiation in the upper stratosphere can be transmitted to the troposphere.

Quarterdiurnal tide in the mesosphere/lower thermosphere

Abstract ID : 257

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Christoph Jacobi ,jacobi@uni-leipzig.de ,(None) ,Germany ,Leipzig ,Presenting[1]

Ms. Amelie Krug ,amelieKrug@gmx.net ,(None) ,Germany , ,Not Presenting[2]

Mr. Christoph Geißler ,christoph.geissler@uni-leipzig.de ,(None) ,Germany , ,Not Presenting[3]

Dr. Eugeny Merzlyakov ,eugmer@rpatyphoon.ru ,(None) ,Russia , ,Not Presenting[4]

1 - University of Leipzig 2 - Universität Leipzig 3 - Universität Leipzig 4 - Institute for Experimental Meteorology, Obninsk

The seasonal and interannual variability of the quarterdiurnal tide is analysed using meteor radar wind observations at the two midlatitude sites Collm and Obninsk and by numerical modeling. Generally tidal amplitudes increase with height. Maximum tidal amplitudes are found in winter. Meridional amplutudes are smaller than zonal ones on an average. Phases mainly differ between summer and winter. Zonal and meridional phases differ by slightly less than 90°. The vertical wavelengths are very long in winter, but shorter and on the order of 20 km in summer. Collm and Obninsk amplitudes and phases agree well, indicating that the migrating quarterdiurnal tide may be responsible for a major part of the observed waves. Bispectrum analysis of Collm tides indicate that nonlinear self-interaction of the semidiurnal tide plays an important role in winter, while direct solar forcing remains the major source of the tide in general. Observations since 1980 show that the tidal amplitudes have increased on a whole, although the increase is not linear but mainly happening during the late 1990s and the early 2000s.

Surface Pressure Responses to Ionospheric Potential Change: Independent Responses to Solar Wind and Internal Atmospheric Electrification

Abstract ID : 400

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Brian Tinsley ,Tinsley@UTDallas.edu ,(Professor Emeritus) ,United States ,Richardson ,Not Presenting[1]

1 - University of Texas at Dallas

Using global reanalysis data we explore day-to-day surface pressure responses to day-to-day changes in ionospheric potential (Vi). We find the high latitude surface pressure response to the interplanetary magnetic field east-west component (IMF By) is present in at least two decadal intervals, and the pressure follows the high latitude Vi changes (caused by the IMF By) that are opposite in the Arctic as compared to the Antarctic. The same pressure responses (in sign and magnitude relative to Vi changes) are found due to global Vi changes generated by low latitude thunderstorms and electrified clouds. The Vi changes are measured by scaling day-to-day vertical electric field changes at Vostok, Antarctica. We show that the high latitude pressure responses are strongest over the East Antarctic and Greenland ice caps in each local Winter and Spring. Regions of surface pressure changes by about 4 hPa are found with Vi changes of 40 kV. A lead-lag analysis shows that the responses maximize within two days of ionospheric potential maxima. The consistent pressure responses to the internal and external electrical inputs strongly supports the mechanism of cloud microphysical responses to the downward ionosphere-earth current density, which is approximately proportional to the product of Vi and the local cosmic ray flux. A speculative scenario involves the opacity of stratus clouds responding to changes in condensation nuclei concentration, due to electro-anti-scavenging protecting ultrafine particles, observed in the Antarctic free troposphere, from coagulation while they grow to cloud condensation nuclei size.

Has past solar activity led to the destruction of ancient civilizations?

Abstract ID : 489

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Jean ROZELOT ,jp.rozelot@orange.fr ,(None) ,France ,NICE ,Not Presenting[1]

1 - None

Most of the past civilizations have undergone a collapse, i.e. a lost of political and socio-economic power, usually accompanied by a dramatic decline in demography. This is the case for example of the collapse of the Akkadian Empire, those of the Classical Mayan civilization or even the Greenland colonies. If social signatures of the collapse varied geographically, such dislocations were sufficient to destabilize the region and to fundamentally alter the social, political, and economic fabric of unified culture. Some cultures were able to dominate such abrupt climatic changes (Tang dynasty in China for instance, due to a more structured society). The solar total irradiance reconstruction down to more than 8000 years back in the past is now available showing a great amplitude modulation, with dimple depths. When looking carefully at the dates of the great collapses and those of the very depressed solar activity strength, curious relationships can be found, that seems not to be a simple coincidence and might be due to sharp climatic changes. Thus, the history of solar output, the history of the Earth's climate and the history of past disasters shape a new global knowledge that encourage to revisit the question for the future.

Contribution of relativistic electron precipitation to ionization of atmosphere and ozone changes

Abstract ID : 578

Conflict Declaration : None

Content Motivation : Invited presentation

Additional Information : None

Dr. Irina Mironova ,irini.mironova@gmail.com ,(Senior Scientist) ,Russia ,St. Petersburg ,Not Presenting[1]

1 - St. Petersburg State University

Estimation of the effect of protons on the chemical composition of the atmosphere was studied in detail in many works. However the role of middle energy electrons and particulary relativistic electrons in ozone variability and climate changes is still not clear due to the fact that the real ionization rates of the atmosphere under the influence of these particles are unknown. One of the issues raised is also related to the range of electron energies that may be most or least important for variations in atmospheric chemical changes.

Here ionization rates of the atmosphere caused by electrons of different energies, taking into account the isotropic and angular distribution of the precipitated particles as well as atmospheric ionization for monoenergetic relativistic electron precipitation including explicitly ionization by Bremsstrahlung radiation is considered. Various electron flux spectra are also discussed here. The electron flux spectra are taken into account for data obtained during balloon measurements of relativistic electrons, observations from satellites, and spectra reconstructed using geomagnetic indices. The ionization rates from these energy spectra cover a wide range of characteristic energies of the precipitating electrons. Ionization created by Bremsstrahlung is also taken into account.

Knowledge of ionization rates during energetic electron precipitation helped for the first time estimate the response of the total ozone column to relativistic electrons precipitation.

Variability of planetary waves: is there an impact of the solar-magnetic field?

Abstract ID : 607

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Lisa Küchelbacher ,lisa.kuechelbacher@dlr.de ,(PhD) ,Germany ,Munich ,Not Presenting[1]

Prof. Michael Bittner ,michael.bittner@dlr.de ,(Professor for Atmospheric Remote Sensing at the University of Augsburg, Physics Department Head of Department "Atmosphere" at DLR-DFD, Oberpfaffenhofen) ,Germany ,Wessling ,Not Presenting[2]

Dr. Sabine Wüst ,sabine.wuest@dlr.de ,(Scientist) ,Germany ,Wessling ,Not Presenting[1]

Mr. Carsten Schmidt ,carsten.schmidt@dlr.de ,(None) ,Germany , ,Not Presenting[1]

Prof. Ralf Koppmann ,koppmann@uni-wuppertal.de ,(None) ,Germany , ,Not Presenting[5]

1 - DLR 2 - DLR-DFD and University of Augsburg 3 - DLR 4 - DLR 5 - University of Wuppertal

Planetary waves are global scale waves, which are well-known as main drivers of the circulation in mid latitudes ensuring meridional energy transport between low and high latitudes especially in the stratosphere. Besides this, they have impact even on mesospheric dynamics. Understanding the variability and long-term changes of the planetary-scale wave activity is therefore mandatory in terms of better understanding possible changes in the larger-scale circulation patterns.
Our database consists of European Centre for Medium-Range Weather Forecasts (ECMWF) Re-Analysis Interim (ERA-Interim) temperature data (0 - 65 km) and GRound based Infrared P-branch Spectrometer (GRIPS) observations of the OH rotational temperature at mesopause heights (ca. 87 km), part of the Network for the Detection of Mesospheric Change (NDMC). We derive a simple dynamical activity index (DAI) that serves as a measure for the planetary wave activity. We get a comparatively long time series for almost the last four decades that shows the characteristics of planetary waves, like annual cycle, wave damping with height and allows analysis of long-term variability and trends.
We find an indication that the planetary wave activity has already changed, but significantly only in the stratosphere. This finding is in agreement with the expectation that a weakening of the meridional temperature gradient leads to improved vertical propagation conditions for planetary waves. With the empirical mode decomposition (EMD) we are able to extract nonstationary signals of the time series. We further find that longer term oscillations (QBO, ENSO, solar cycles) have a noticeable impact on the wave activity variability in all considered heights. Next to the 11-year cycle that is often related to the sun-spot-cycle in many studies, we find a pronounced ~22-year signal. We tentatively interpret this signal as being due to the solar-magnetic-field ("Hale-cycle"). The focus of our presentation is on offering a hypothesis about the physical mechanism of how the solar Hale-cycle might influence planetary wave activity in the atmosphere.

Interannual variability on winds and tides from MLT winds at low latitude in the Southern Hemisphere

Abstract ID : 754

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Lourivaldo Mota Lima ,lourivaldo_mota@yahoo.com.br ,(Professor) ,Brazil ,Campina Grande-PB ,Not Presenting[1]

1 - UEPB

Mesospheric wind data obtained between 1999 and 2016 from measurements by meteor radar at Cachoeira Paulista (22.7°S, 45.0°W), Brazil, were used to investigate the behaviour of the interannual variability in the winds and in the 24-, 12- and 8 -h tide amplitudes. The results indicate that monthly winds did not show quasi-biennial variation (QBO), and suggest that the zonal and meridional winds are intensified during the years of solar maximum, mainly in the summer and winter seasons. The monthly meridional amplitudes of diurnal tide are greater during the westerly phase of QBO at 20 hPa. The modulation of the diurnal tide amplitude by QBO shows a quasi-decadal variation, which is stronger for the solar maximum years. The semidiurnal amplitudes show a relationship with QBO for altitudes above 90 km, whereas the terdiurnal tide variability did not show it. Both semidiurnal and terdiurnal amplitudes behaviour indicated a weak relationship with the 11-year solar activity.

Solar influence on North Atlantic variability

Abstract ID : 895

Conflict Declaration : None

Content Motivation : None

Additional Information : I was invited by C. Jacobi for this contribution.

Dr. Rémi Thiéblemont ,remi.thieblemont@latmos.ipsl.fr ,(Post-doc researcher) ,France ,Guyancourt ,Not Presenting[1]

1 - CNRS

Variability in solar activity has been suggested to have substantial effects on Earth's climate at regional scales. In the North Atlantic sector, the 11-year solar signal has been proposed to project onto a pattern resembling the Arctic Oscillation/North Atlantic Oscillation (AO/NAO) which maximizes by a lag of a few years. This relationship, derived from meteorological reanalysis and historical climate reconstructions, is however not univocally supported by climate model simulations with realistic observed forcings. In particular, the analysis of the solar signal in CMIP5 historical simulations did not reveal any significant NAO response to the solar cycle. I will present the main findings of recent observational and modeling studies that examined the solar/NAO relationship and describe the mechanisms that are proposed to explain the transfer of the solar signal, i.e. from fluctuations of the solar forcing to the surface response. These mechanisms involve complex interactions within the atmosphere-ocean coupled system. Finally, the main issues and future research directions which may help to improve our understanding of solar influences on regional climate will be discussed.

Solar forcing for CMIP6

Abstract ID : 938

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Bernd Funke ,bernd@iaa.es ,(Staff Scientist) ,Spain ,Granada ,Presenting[1]

Prof. Katja Matthes ,kmatthes@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[2]

1 - Instituto de Astrofisica de Andalucia CSIC 2 - GEOMAR Helmholtz Centre for Ocean Research Kiel

We describe the recently generated solar forcing dataset for CMIP6 and highlight in particular changes with respect to the CMIP5 recommendation. The solar forcing is provided for radiative properties, i.e., total solar irradiance (TSI) and solar spectral irradiance (SSI), and F10.7cm radio flux, as well as particle forcing, i.e., geomagnetic indices Ap and Kp, and ionisation rates to account for effects of solar protons, electrons and galactic cosmic rays. This is the first time that a recommendation for solar-driven particle forcing is provided for a CMIP exercise. The solar forcing dataset is provided at daily and monthly resolution separately for the CMIP6 Historical Simulation (1850-2014), for the future (2015-2300), including an additional extreme Maunder Minimum-like sensitivity scenario, as well as for a constant and a time-varying forcing for the preindustrial control simulation. This paper provides an overview on the forcing dataset and how it was created, and discusses implications for climate modeling.

Seasonal and solar cycle variability of the 6.5 day wave in the mesosphere and lower thermosphere over low latitudes

Abstract ID : 1225

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sundararaman Sathishkumar ,sathishmaths@gmail.com ,(Reader/Scientist) ,India ,Tirunelveli ,Not Presenting[1]

1 - Indian Institute of Geomagnetism

The westward propagating planetary wave with 6.5 day period and wave number 1 is a robust feature in the mesosphere and lower thermosphere with prominent seasonal variability as observed in the ground as well as satellite based observations. The long term medium frequency radar observations over Tirunelveli (8.7^{o}N, 77.8^{o}E) for the years 1993-2012 (20 years) and over Hawai (19.8^{o}N, 155.5^{o}W) for the years 1993-2005 (12 years) are used to investigate seasonal, intraseasonal and solar cycle variability of 6.5 day wave in the mesosphere and lower thermosphere (MLT) region. The 6.5 day wave amplified during equinoctial months when the background wind is westward in both location and show a strong semi-annual oscillation (SAO), besides, the zonal component show larger than the meridional in both stations. The amplitudes of 6.5 day waves show stronger over Tirunelveli than Hawai. The preliminary results shows that 6.5 day wave is amplified when the westward phase of Quasi Biennial Oscillation (QBO) in both locations. In addition, it shows weak correlation with solar activity in both stations. Results from a detailed analysis of these observations will be presented and its possible source mechanisms are discussed in the light of current understanding of the 6.5 day wave in the MLT region.

Statistical Study of Solar Forcing of Total Column Ozone Variation Over Three Cities in Kenya

Abstract ID : 1261

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Carolyne Songa ,cmutambi@cuea.edu ,(Lecturer) ,Kenya ,Nairobi ,Not Presenting[1]

Dr. Jared Ndeda ,jndeda6060@gmail.com ,(None) ,Kenya , ,Not Presenting[2]

Dr. Gilbert Ouma ,gouma@uonbi.ac.ke ,(None) ,Kenya , ,Not Presenting[3]

1 - None 2 - Jomo Kenyatta University of Agriculture and Technology 3 - University of Nairobi

In this study, a statistical analysis between three solar activity indices (SAI) namely; sunspot number (ssn), F10.7 index (sf) and Mg II index (mg) and total column ozone (TCO) time series over three cities in Kenya namely; Nairobi (1.17º S; 36.46º E), Kisumu (0.03º S; 34.45º E) and Mombasa (4.02º S; 39.43º E) for the period 1985 - 2011 are considered. All the statistical analyses are based on 95% confidence level. SAI show decreasing trend at significant levels with highest decrease in international sunspot number and least in Mg II index. SAI are highly correlated with each other at ($0.941< r < 0.976$, $p < 0.001$) and are significantly positively correlated with TCO over the study period except Mg II index at Kisumu. TCO and SAI have correlations at both long and short lags. F10.7 index has an immediate impact and Mg II index has a delayed impact on TCO. A linear relationship exists between the two variables. An increase in TCO of about 2 - 3 % (Nairobi), 1 - 2% (Kisumu) and 3 - 4 % (Mombasa) is attributed to solar activity indices. 3 - 5% of the TCO at Nairobi, Kisumu and Mombasa can be predicted by the SAI.

Modeling and Predicting of Solar Forcing of Total Column Ozone over Kenya Using Regression and Artificial Neural Networks

Abstract ID : 1263

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Carolyne Songa ,cmutambi@cuea.edu ,(Lecturer) ,Kenya ,Nairobi ,Not Presenting[1]

Dr. Jared Ndeda ,jndeda6060@gmail.com ,(None) ,Kenya , ,Not Presenting[2]

Dr. Gilbert Ouma ,gouma@uonbi.ac.ke ,(None) ,Kenya , ,Not Presenting[3]

Mr. Michael Onyango ,michael.o.onyango@gmail.com ,(None) ,Kenya , ,Not Presenting[3]

:

1 - None 2 - Jomo Kenyatta University of Agriculture and Technology 3 - University of Nairobi 4 - University of Nairobi

In this study, artificial neural networks (ANN) and multiple linear regression (MLR) techniques are employed to develop models to predict total column ozone (TCO) over Kenya namely Nairobi (1.17º S; 36.46º E), Kisumu (0.03º S; 34.45º E) and Mombasa (4.02º S; 39.43º E). Both models use three solar activity indices (SAI), namely sunspot number (ssn), F10.7 index (sf) and Mg II index (mg) as predictors. They are trained, tested and validated using data between January 1985 and August 2012. To verify the quality and reliability of the developed models, several statistical parameters are calculated. An analytical expression derived by performing MLR analysis it emerges that the variable that has significant effect on mean monthly TCO is mg. ANN in the form of multilayer perceptron feed forward (MLFNN) with backpropagation (BP) supervised learning containing 3 nodes in the input layer corresponding to the SAI variables, 15 nodes in the hidden layer and one node corresponding to TCO in the output layer (3:15:1) is generated. Performance results indicate that ANN shows slightly better skills in forecasting TCO as the MLR and MLFNN models provided 2.77% £ RMSE £ 3.10 % and 2.29 % £ RMSE £ 2.56 % of the mean of the observed values respectively. Hence ANN modeling appears to be a promising technique for TCO prediction.

The representation of solar cycle signals in stratospheric ozone in satellite observations and global models

Abstract ID : 1475

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Amanda Maycock ,a.c.maycock@leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Susann Tegtmeier ,stegtmeier@geomar.de ,(None) ,Germany , ,Not Presenting[2]

Prof. Katja Matthes ,kmatthes@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[3]

Dr. Hauke Schmidt ,hauke.schmidt@mpimet.mpg.de ,(None) ,Germany , ,Not Presenting[4]

1 - University of Leeds 2 - GEOMAR 3 - GEOMAR Helmholtz Centre for Ocean Research Kiel 4 - Max Planck Insitute for Meteorology

Changes in incoming solar ultraviolet radiation over the 11-year solar cycle affect stratospheric ozone abundances. It is important to quantify the magnitude, structure and seasonality of the associated solar-ozone response (SOR) to understand the impact of the 11-year solar cycle on climate. This study uses multiple linear regression to analyse the SOR in a number of recently updated satellite datasets and global (chemistry-)climate models. We find a substantial decrease in the magnitude of the SOR in the tropical upper stratosphere in SAGE II v7.0 mixing ratio dataset compared to the v6.2. This difference is shown to be largely attributable to the change in the independent stratospheric temperature dataset used to convert SAGE II ozone number densities to mixing ratios, which are subject to considerable uncertainties. We further analyse three extended ozone datasets that combine SAGE II v7.0 number density data with more recent GOMOS or OSIRIS measurements. The extended SAGE-OSIRIS dataset shows a smaller and less statistically significant SOR across much of the tropical upper stratosphere compared to the SAGE II data alone. In contrast, the two SAGE-GOMOS datasets show SORs that compare better with the original SAGE II data and therefore appear to provide a more reliable estimate of the SOR. We further analyse the SOR in CCMI models and three ozone databases developed for climate models. The SPARC/AC&C Ozone Database used in CMIP5 simulations shows a substantially larger SOR in the tropical upper stratosphere of up to 5% compared to around 2% in the new SPARC/CCMI Ozone Database for CMIP6, which is based on CCMI integrations. Experiments with the MPI-ESM model show that the decrease in SOR in CMIP6 leads to a reduction by around a factor of 2 in the peak tropical stratospheric temperature response to the solar cycle. CMIP6 models without interactive chemistry are therefore expected to show a weaker stratospheric response to the solar cycle compared to equivalent CMIP5 models.

Bottom water exchange between the Argentine and Brazil basins of the Southwest Atlantic.

Abstract ID : 31

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Dmitry Frey ,dima.frey@gmail.com ,(PhD Student) ,Russia ,None ,Not Presenting[1]

Dr. Eugene Morozov ,egmorozov@mail.ru ,(Head of Laboratory) ,Russia ,Moscow ,Not Presenting[2]

Mr Nikolay Makarenko ,makarenko@hydro.nsc.ru ,(None) ,South Africa , ,Not Presenting[3]

Dr. Roman Tarakanov ,rtarakanov@gmail.com ,(Leading Researcher) ,Russia ,Moscow ,Not Presenting[2]

1 - None 2 - Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia 3 - Lavrentiev Institute of Hydrodynamics, Russian Academy of Sciences, Novosibirsk, Russia 4 - Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia

The deepest and coldest waters of the major part of the Atlantic Ocean are of the Antarctic origin. These waters propagate from the Weddell Sea to the north filling the lower part of the ocean basins. Interbasin exchange of bottom waters occurs through depressions in the topographic obstacles. Velocities of the propagation are less than 1 cm/s within ocean basins, but the flow accelerates significantly in narrow underwater channels.
Rio Grande Rise and Santos Plateau divide the Argentine and Brazil basins of the Southwest Atlantic. From the Argentine Basin, Antarctic Bottom Water (AABW) enters the Brazil Basin along three pathways: through the Vema and Hunter channels and over the deep Santos Plateau. The Vema Channel is the deepest one among them and the coldest water propagates through this channel. The depths of the channel exceed 4600 m, the width is about 20 km and the length is more than 700 km. The Vema Channel is one of the best examples for the analysis of the bottom flows.
The properties of AABW in the Southwest Atlantic were studied on the basis of hydrographic measurements carried out onboard R/V "Akademik Sergey Vavilov" by the Shirshov Institute of Oceanology. The velocities of flows were measured by lowered acoustic Doppler current profiler (LADCP) in a few parts of the channel. In addition to experimental investigations, the near-bottom circulation in the region was studied numerically using the general model of ocean circulation INMOM (Institute of Numerical Mathematics Ocean Model). The computation shows the strong flow from the Argentine to Brazil basin along the Vema Channel and allows us to study the hydrodynamic features of the near-bottom current. The role of small channels over the Santos Plateau in the interbasin exchange was also studied both experimentally and numerically.
This research was supported by the Russian Science Foundation (project 16-17-10149).

Why does plastic debris accumulate in the subtropical gyres? Using drifting buoys and virtual particles to investigate large-scale surface convergence patterns

Abstract ID : 254

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Erik van Sebille ,erikvansebille@gmail.com ,(None) ,Netherlands ,Utrecht ,Not Presenting[1]

Mr. Ronan McAdam ,ronan.mcadam11@imperial.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - Utrecht University 2 - Imperial College London

The total amount of plastic floating on the surface of the ocean is estimated to be a few hundred thousand metric tonnes. Roughly half of this plastic resides in the centres of the five subtropical gyres, in what are often referred to as the garbage patches. Within these gyres, plastic concentrations can be five orders of magnitude higher than in other parts of the ocean.

However, it is unclear how and why the plastic accumulates in the gyres. While Ekman convergence theory can explain large-scale patterns to first order, it does not provide the full picture. For one, the garbage patches are never found in the centres of the gyres, but rather are located in either the western or eastern half of the gyres.

Here, we use the trajectories of surface drifters, augmented with virtual particles in numerical models, to shed light on the transport pathways and timescales from the world's coasts into the open ocean. We show that there is a strong depth-dependence of the convergence, with drogued buoys and particles accumulating in different regions than undrogued ones.

Our findings are relevant for increasing the understanding the basin-scale pathways of floating debris such as plastic, and for assessment of technologies to clean up that plastic. Furthermore, they also provide new insights into the role of submesoscale eddies and other processes in the formation of the Ekman convergence zones.

Glider-based multidisciplinary observations in the Faroe-Shetland Channel

Abstract ID : 332

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[1]

Dr. Rob Hall ,robert.hall@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Nathan Merchant ,nathan.merchant@cefas.co.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. Barbara Berx ,b.berx@marlab.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Mr. Pierre Cauchy ,p.cauchy@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Bastien Queste ,b.queste@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Denise Risch ,Denise.Risch@sams.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]

1 - University of East Anglia 2 - University of East Anglia 3 - Cefas 4 - Marine Scotland 5 - University of East Anglia 6 - University of East Anglia 7 - SAMS

The Faroe-Shetland Channel is a key route for the export of dense water from the Norwegian and Greenland Seas, part of the overturning circulation of the North Atlantic. The complex topography, narrow channel and strong internal tides generated at the Wyville Thomson Ridge are thought to drive turbulence that mixes the water masses and modifies their properties. This region also provides a passage for migrating whale species in summer.

In May-June 2017 we are deploying two Seagliders in the Faroe-Shetland Channel on the Wyville Thompson Ridge. Both gliders will behave as virtual moorings, profiling the water column every 2 hours, close to a current meter mooring maintained by Marine Scotland Science for many years. In addition to temperature and salinity, one glider will carry a passive acoustic hydrophone and the other glider will carry sensors to determine turbulent mixing rates from shear and temperature microstructure. The gliders provide an estimate of the dive-average-current velocity.

Here we present the first results of this glider campaign. The variability of the water masses will first be discussed broadly in terms of water mass properties and their dependence on current direction. The internal wave period, amplitude and available potential energy throughout the water column will be quantified from the time series of density. Turbulent kinetic dissipation rate will be evaluated from the microstructure glider and related to the presence of internal wave breaking. The soundscape will be assessed, including the presence of marine mammal vocalisations, together with a novel application of passive acoustic time series to estimate wind speed.

Spatial and temporal variability of temperature and salinity in the upper layer ocean using the global Argo array

Abstract ID : 341

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Shigeki Hosoda ,hosodas@jamstec.go.jp ,(None) ,Japan ,Yokosuka ,Presenting[1]

Dr. Kanako Sato ,k_sato@jamstec.go.jp ,(None) ,Japan , ,Not Presenting[1]

1 - JAMSTEC 2 - JAMSTEC

Based on the huge amount of Argo float data, we analyze statistical values for spatial and temporal variability of oceanic temperature and salinity, especially focusing on decorrelation length and signal/noise ratio. Since the international Argo program was started, the number of active Argo float exceeded 3000 in late 2007, and then the number of accumulated profile data had been over 1,000,000 in 2011. The long-term and huge Argo data enable us get statistical information of spatial and temporal variability more accurately. Previous analyses for decorrelation length and signal/noise ratio were conducted mainly using temperature data of eXpendable BathyThermograph (XBT) (e.g., White, 1995; Meyer et al., 1982). However, sampling area of XBT data is temporally and spatially biased because of limited observational or voluntary ship courses. Recent huge amount of Argo float observe not only temperature but also salinity accurately. Therefore, using 16-year Argo float data, we show 4-D statistical structures of accurate decorrelation length and signal/noise ratio. Here we separate the global ocean into 25 areas, which is finer than in the previous study (Resinyanskii et al., 2010). After sorting all profiling data for each areas, the profiling data are interpolated on 23 levels from 10 to 2000 dbar (Akima, 1970). Then covariance of anomalies are calculated for temperature and salinity fields, sorting into 20km bins of zonal and meridional distances between observations from 0 - 3000km, respectively. Also, temporal covariance is calculated from sorted profiling data into 5-day bins from Jan. 2001 to Dec. 2016, referring spatial covariance estimated above. Based on these temporal and spatial covariance maps, we then estimate decorrelation lengths for time, horizontal and vertical directions every areas. The basic statistical information shown in this study is estimated based only on the purely observational data from the global Argo array. Therefore, this information is useful for not only applications for objective analyses and optimal interpolation mapping but also improvement and validation of data assimilation and numerical simulation models.

Deep cataracts as important hot spots of the global abyssal mixing

Abstract ID : 389

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Roman Tarakanov ,rtarakanov@gmail.com ,(Leading Researcher) ,Russia ,Moscow ,Not Presenting[1]

1 - Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia

An eastward baroclinic pressure gradient is formed at depths greater 3000 m between the West and East Atlantic due to the presence of the abyssal thermocline west of the Mid-Atlantic Ridge (MAR). As the water of the abyssal thermocline flows through the gaps in the Ridge into the East Atlantic this thermocline is eroded due to interaction with the bottom, and near-bottom temperature essentially increases in the eastward flow. This process is accompanied by the transfer of potential energy contenting in the thermocline (relative to more homogeneous abyssal water of the East Atlantic) into kinetic energy. This transfer must localize in the regions where the abyssal flow descends just after the sills (deep cataracts) and/or passes the narrows of the abyssal channels. Dissipation of released kinetic energy will lead to mixing of the bottom water in the flow. Analysis of CTD-measurements (available in WOD13 database) in several fractures of the MAR (Kane, Vema, Romanche, Chain f.z.) shows that the flow passing such regions has greatest jumps up in the near-bottom temperature and consequently the strongest mixing. This fact points to the leading role of the above described mechanism of the abyssal mixing around the MAR in comparison with the generally accepted mechanism associating this mixing with the destruction of internal tidal waves.
Deep cataract mixing explains the well-known fact of lesser mixing in the Vema F.Z. (11N) compared with the equatorial Romanche and Chain f.z. Equatorial fractures have numerous sequential high sills and narrows located along their entire lengths. All sills and narrows of the Vema F.Z. are at 41-40 W and their number is smaller. Besides, the abyssal thermocline in the Vema F.Z. is considerably weaker compared to the equator that determines lesser content of the potential energy, which can transfer into kinetic energy as the thermocline is eroded.

First results from CASSIS project: Southwestern Atlantic currents from in-situ and satellite altimetry

Abstract ID : 392

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Martin Saraceno ,saraceno@cima.fcen.uba.ar ,(Researcher) ,Argentina ,Buenos Aires ,Presenting[1]

Dr. Ramiro Ferrari ,ramiro.ferrari@cima.fcen.uba.ar ,(None) ,Argentina , ,Not Presenting[2]

Miss. Loreley Lago ,loreleylago@gmail.com ,(None) ,Argentina , ,Not Presenting[3]

Dr. Christine Provost ,cp@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[4]

Mr Alberto Piola ,apiola@hidro.gov.ar ,(None) ,Argentina , ,Not Presenting[5]

Miss. Guillermina F. Paniagua ,guillermina.paniagua@cima.fcen.uba.ar ,(Ph D student) ,Argentina ,Ciudad Autónoma de Buenos Aires ,Not Presenting[1]

Miss. Camila Artana ,camila.artana@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[7]

1 - CONICET-UBA 2 - CONICET 3 - CONICET-INIDEP 4 - CNRS 5 - Univ. Buenos Aires 6 - CONICET-UBA 7 - LOCEAN

The CASSIS project is a French-Argentine cooperation to study the circulation in the Southwestern Atlantic from in situ and satellite altimetry data. Seven moorings that measure currents, temperature, conductivity and pressure and a fully equipped oceanographic buoy are collecting in situ data since December 2014. During the first year (December 2014-November 2015) the moorings were deployed below Jason-2 satellite altimeter track #26, covering the northern portion of the Malvinas Current (MC) and Patagonian continental shelf (PCS). In December 2015 the instruments were recovered and redeployed for another year along a zonal section at 44.7ºS. The deployment scheme allows to simultaneously monitor the PCS and MC flows. Preliminary results obtained from the northern section are discussed here and in a complementary presentation in this session (Paniagua et al). In-situ surface currents and geostrophic velocities obtained from satellite altimetry are significantly correlated at the shelf-break (0.7). In the continental shelf correlation is low and significant (0.3) only when the Ekman component is added to the satellite data. During specific events associated with the presence of mesoscale eddies at the shelf-break and to the passage of synoptic storms at the continental shelf, differences between remote and in-situ currents are larger. At all locations mean direction of depth-integrated currents show a strong bathymetric control. At the shelf break the variability of the depth-integrated MC velocities is strongly correlated with mesoscale activity in the Brazil-Malvinas confluence region. The annual and interannual variability of the position of the Brazil-Malvinas front is discussed in light of the new in situ observations and satellite altimetry, sea surface temperature and chlorophyll-a data.

The Annual Cycle of Upper-Ocean Potential Vorticity and its Relationship with Submesoscale Instabilities: Insights from Mooring Observations

Abstract ID : 470

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Xiaolong Yu ,xy6g13@soton.ac.uk ,(PhD candidate) ,United Kingdom ,Southampton ,Presenting[1]

Dr. Alberto Naveira Garabato ,acng@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Adrian Martin ,adrian.martin@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. Liam Brannigan ,liam.brannigan@misu.su.se ,(None) ,Sweden , ,Not Presenting[4]

Dr. Christian Buckingham ,chrcki@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[5]

1 - University of Southampton 2 - University of Southampton 3 - National Oceanography Center Southampton 4 - Stockholm University 5 - British Antarctic Survey

Potential vorticity (PV) is a key ingredient to understand the competing processes in deepening and shoaling the ocean surface boundary layer (OSBL). Previous PV studies were mainly based on numerical simulations. Here we use a year-long, meso- and submesoscale resolving time series of buoyancy and horizontal velocity, obtained from mooring observations in the Northeast Atlantic under the auspices of the U.K. OSMOSIS programme, to investigate the upper-ocean PV budget and its relationship with submesoscale frontal instabilities. Results show that non-advective PV changes in the OSBL are balanced by the frictional and diabatic components of J vector in an integral sense. Deep mixed layers (up to about 350 m) during wintertime are attributed to persistent atmospheric cooling, predominantly through gravitational instability. However, on shorter time scales, conditions favourable to symmetric instability are often observed when winds are aligned with the frontal flow. The ensuing overturning instabilities rapidly re-stratify the mixed layer and limit the reduction of PV, as indicated by the approximate balance between the temporal change of PV and the advection of PV below the convective layer. These results emphasize the key role of submesoscale instabilities in determining the evolution of the OSBL.

Advances in the estimation of surface heat fluxes and thermohaline variability in Terra Nova Bay Polynya - Ross Sea, Antarctica

Abstract ID : 638

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Giannetta Fusco ,giannetta.fusco@uniparthenope.it ,(None) ,Italy ,Napoli ,Not Presenting[1]

Miss. Manuela Sansiviero ,manuela.sansiviero@uniparthenope.it ,(None) ,Italy , ,Not Presenting[2]

Dr. Giuseppe Aulicino ,giuseppe.aulicino@uniparthenope.it ,(None) ,Italy , ,Not Presenting[1]

Mr. Massimiliano Esposito ,massimiliano.esposito@studenti.uniparthenope.it ,(None) ,Italy , ,Not Presenting[2]

Miss. Francesca Giordano ,francesca.giordano@uniparthenope.it ,(None) ,Italy , ,Not Presenting[2]

Prof. Giorgio Budillon ,giorgio.budillon@uniparthenope.it ,(None) ,Italy , ,Not Presenting[1]

1 - University of Naples "Parthenope", Italy 2 - University of Naples 'Parthenope' 3 - University of Naples "Parthenope", Italy 4 - University of Naples 'Parthenope' 5 - University of Naples 'Parthenope' 6 - University of Naples "Parthenope", Italy

The Ross Sea is characterized by the presence of persistent ice-free areas during the austral winter (polynyas). One of which is recurrently detected in the coastal area of Terra Nova Bay (TNB) and is important in the modification of the thermohaline structure of the whole Ross Sea. Brine release during sea ice formation increases the salinity of the subsurface water, resulting in the formation of High Salinity Shelf Water (HSSW), the densest water mass of the Southern Ocean. The aim of this study is to investigate the processes that occur in the TNB polynya and the role of the air-sea interactions in the determination of its opening, activity and on the HSSW production that can ventilate the abyssal ocean circulation. First, we analysed the role of the katabatic winds using meteorological data by the Automatic Weather Station Eneide and Rita and ECMWF data, from 1994 to 2015. In the second step the open water fractions from 2005 and 2015, detected by the Ice Surface Temperature (IST) imagery derived from the MODIS data, were used to estimate the opening and the activity of the polynya during the winter season. Then, we estimated the surface heat budget via empirical formulae in the investigated period. During the freezing season, heat flux from the ocean to the atmosphere can be assumed to result directly in ice production considering that ocean column is at its freezing point. Assuming that ice production rate depends on the net heat flux and on the polynya extension, it is possible to calculate the total production of salt released during sea ice formation and HSSW volume. The HSSW production results switched from the lowest values during the first years of the investigated period to the highest values for the last period. Finally a comparison between the estimated HSSW production and the salinity observed within the TNB water column show similar tendency in the last years after 2002, while during the period 1995-1998 the behaviour is different. Our results could be explained by a different contribution of the Circumpolar Deep Water inflow and HSSW production in the TNB area.

The role of the bottom turbulence generated by the tide in the characterisation of the deep dynamic of the Western Ionian Sea

Abstract ID : 758

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Nadia Lo Bue ,nadia.lobue@ingv.it ,(None) ,Italy ,rome ,Presenting[1]

Dr. Vincenzo Artale ,vincenzo.artale@enea.it ,(None) ,Italy , ,Not Presenting[2]

Dr. Salvatore Marullo ,salvatore.marullo@enea.it ,(None) ,Italy , ,Not Presenting[2]

Dr. Manuel Bensi ,mbensi@inogs.it ,(None) ,Italy , ,Not Presenting[4]

Mr. Giuseppe Siena ,gsiena@inogs.it ,(None) ,Italy , ,Not Presenting[4]

Prof. Angelo Rubino ,rubino@unive.it ,(None) ,Italy , ,Not Presenting[6]

Dr. Francesco Placenti ,francesco.placenti@iamc.cnr.it ,(None) ,Italy , ,Not Presenting[7]

Dr. Vanessa Cardin ,vcardin@inogs.it ,(None) ,Italy , ,Not Presenting[4]

Dr. Vedrana Kovacevic ,vkoracevic@inogs.it ,(None) ,Italy , ,Not Presenting[4]

Dr. Laura Beranzoli ,laura.beranzoli@ingv.it ,(None) ,Italy , ,Not Presenting[1]

1 - INGV 2 - ENEA 3 - ENEA 4 - OGS 5 - OGS 6 - Dipartimento di Scienze Ambientali, Informatica e Statistica, Università Ca' Foscari di Venezia 7 - IAMC–CNR 8 - OGS 9 - OGS 10 - INGV

Several studies on the ocean dynamics carried out in the last decades have reintroduced the importance of understanding deep dynamics in the assessment of the general circulation. The new awareness about the unsteady state of the abyssal circulation encourages scientists to wonder about the deep mechanisms that significantly contribute to the internal variability and, consequently, to the ocean circulation.
Same as for global ocean, the abyssal processes that rule the Mediterranean circulation are still relatively unknowns, especially those involving its deepest parts, such as the Ionian Sea (maximum depth 5200 m), where the coverage of data is still inadequate. This basin plays a crucial role in the dynamic of the Mediterranean circulation, operating as a collector that controls exchanges between the eastern and western margin of the Mediterranean Sea. Here, the knowledge about mechanisms governing relations among thermohaline circulation, vertical diffusion, and deep convection are not still completely understood. At the same way, the interaction of the abyssal flows with the bathymetry is often neglected, although the breaking of internal waves strongly depends on the roughness of the morphology and it is responsible for important mixing processes affecting the vertical stratification and, in turn, the deep circulation.
In consideration of results found by Rubino et al. (2012) documenting the presence of oscillations at near-inertial frequency associated with mesoscale cyclones and anti-cyclones in the deep (> 2500m depth) Ionian Sea, this work focuses on the characterisation of the hydrological and dynamical variability of the Western Ionian abyssal water over the last three decades. Thanks to a recovery activity of available deep data carried out within the framework of the Italian RITMARE project, a revised and updated dataset has been produced, allowing us to investigate on the breaking and

propagation of internal waves. This new analysis highlights the importance of the bottom turbulence due to the internal waves breaking modulated by tides, adding new information on the complex characterization of the bottom Ionian dynamics.

Variable elemental composition of organic new production and its potential effect on oceanic CO2 uptake during glacials

Abstract ID : 868

Conflict Declaration : None

Content Motivation : None

Additional Information : Galbraith, E. D. and A. C. Martiny, 2015: A simple nutrient-dependence mechanism for predicting the stoichiometry of marine ecosystems. PNAS, 112 (27).

Ms. Malin Oedalen ,malin.odalen@misu.su.se ,(PhD student) ,Sweden ,Stockholm ,Not Presenting[1]

Prof. Jonas Nycander ,jonas@misu.su.se ,(None) ,Sweden , ,Not Presenting[2]

Dr. Kevin Oliver ,K.Oliver@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - Department of Meteorology, Stockholm University 2 - Stockholm University 3 - National Oceanography Centre, University of Southampton

During the latest glacial cycles, atmospheric CO_2 was lowered by about 100 ppm. It is likely that most of this CO_2 went into the ocean, which is by far the largest reservoir of carbon on Earth and thus has the largest capacity for increased carbon storage. One of the processes that has been suggested to be dominant in this transition is an increased efficiency of the biological carbon uptake in the surface ocean and/or of the export of organic carbon to the deep ocean. The magnitude of this biological carbon uptake is limited by the amount of available nutrients, which are essential for the production of organic matter. It is commonly assumed in both theoretical and numerical models that the ratios of these elemental nutrients to carbon are constant. This may be true on average, but they have proven to be highly variable on a local scale and between species of organisms. If the number of carbon atoms that are taken up per nutrient atom can increase when nutrient availability is scarce, this variability is likely to significantly impact the potential for oceanic CO_2 uptake during glacials. Such plasticity of the elemental composition of organic matter has been suggested by e.g. Galbraith and Martiny (2015). In this study, we test the phosphate concentration dependent model introduced by Galbraith and Martiny (2015), and how it might influence the oceanic CO_2 uptake. We use an Earth system model of intermediate complexity (cGENIE) and incorporate the phosphate dependent model of biological carbon uptake in its representation of ocean biogeochemistry. Preliminary results indicate that the effect of variable elemental composition in production of organic matter is significant and can not be ruled out as a contributor to the oceanic uptake of CO_2 during glacials. Our results suggest that this type of simple nutrient concentration dependent model of organic new production could improve the ability of climate models to accurately simulate the role of ocean biology. This will be beneficial when attempting to simulate glacial cycles as well as other climate scenarios.

Equatorial Deep Jets in the Atlantic Ocean studied by observations and ocean general circulation models

Abstract ID : 965

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Peter Brandt ,simone@sofrica.com ,(None) ,Germany ,Kiel ,Presenting[1]

Prof. Richard J. Greatbatch ,rgreatbatch@geomar.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Martin Claus ,mclaus@geomar.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Franz Philip Tuchen ,ftuchen@geomar.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Jan-Dirk Matthiessen ,jmatthiessen@geomar.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Robert Kopte ,rkopte@geomar.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Francois Ascani ,fascani@hawaii.edu ,(None) ,United States , ,Not Presenting[7]

Dr. John M. Toole ,jtoole@whoi.edu ,(None) ,United States , ,Not Presenting[8]

1 - GEOMAR 2 - GEOMAR Helmholtz Centre for Ocean Research Kiel 3 - GEOMAR 4 - GEOMAR 5 - GEOMAR 6 - GEOMAR 7 - University of Hawaii 8 - Woods Hole Oceanographic Institution

More than 12 years of moored velocity observations in the central equatorial Atlantic at 23°W show that the variability of zonal velocity along the equator is associated with the propagation of equatorial Kelvin and Rossby waves. These waves form resonant equatorial basin modes at distinct periods. While semi-annual and annual variations are dominated by the 2nd and 4th baroclinic modes respectively, interannual variations are dominated by higher baroclinic modes. The latter are called equatorial deep jets (EDJs) having, in the Atlantic, an oscillation period of about 4.5 years. The meridional velocity in the moored records fluctuates instead at a period around 30 days, which can be ascribed to the presence of tropical instability waves. The downward propagation of intraseasonal wave energy was discussed as a possible mechanism providing energy to the EDJs. However, this mechanism as well as the generation mechanism of EDJs is not fully understood yet. Here we analyze the moored velocity data from the equator as well as from two additional moorings 0.75° off the equator, deployed simultaneously for few years, to show that the intraseasonal variability gets distorted by the presence of lower frequency zonal velocity variability. Below the Equatorial Undercurrent, this causes a systematic convergence of intra-seasonal momentum flux such that the seasonal cycle and the EDJs are energized thereby counteracting dissipation. This observational evidence of an energy transfer from high to low frequency variability confirms results obtained by idealized and realistic simulations with ocean general circulation models.

Abissal Circulation in the South Atlantic and Transports Across Vema Channel in an Global Eddy-Resolving OGCM

Abstract ID : 1116

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr Edmo Campos ,edmo@usp.br ,(None) ,Brazil , ,Presenting[1]

Dr. Eugene Morozov ,egmorozov@mail.ru ,(Head of Laboratory) ,Russia ,Moscow ,Not Presenting[2]

1 - Univ. Sao Paulo 2 - Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia

The output of a numerical experiment with an eddy-resolving, global implementation of the Hybrid Coordinate Ocean Model (HYCOM) is analyzed to study the Antarctic Bottom Water (AABW) pathways in the South Atlantic and the meridional transports across the Vema Channel. Despite not being set up specifically to study the dynamics of the deep ocean, the experiment reproduces reasonably well the near bottom water mass structure, capturing the spreading of the Lower Circumpolar Deep Water (LCDW) and the AABW. The analyses show that the densest waters originated in the Weddel Sea sinks to the bottom layers and flows northward, filling the deeper regions of the Argentine Basin, between South America and the Middle Atlantic Ridge. Since most of this water is confined to depths greater than 4000m, it can only flow to the north through the narrow passage of the Vema Chanel. Time series of near bottom velocity at points along 34.5S show intense high-frequency variability, most likely associated with energetic mesoscale eddies in the deep current. The volume and heat volume transports across the Vema Channel also present significant interannual and higher frequency variability, with mean values in general accordance with observations.

The Southern Ocean's mass, heat, and salt transports derived from numerical model simulations based on ARGO data and ECMWF wind

Abstract ID : 1229

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Konstantin Lebedev ,klebedev@ocean.ru ,(Scientist) ,Russia ,Moscow ,Not Presenting[1]

Dr. Roman Tarakanov ,rtarakanov@gmail.com ,(Leading Researcher) ,Russia ,Moscow ,Presenting[2]

1 - Shirshov Institute of Oceanology 2 - Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia

The mass, heat, and salt transports over several regions of the Antarctic Circumpolar Current and at its northern boundary (35° S) were calculated using the newly developed Argo-Based Model for Investigation of the Global Ocean (AMIGO), which consists of a block for variational interpolation of the profiles of drifting Argo floats to a regular grid and a block for model hydrodynamic adjustment of variationally interpolated fields. Such a method makes it possible to obtain a full set of oceanographic characteristics - temperature, salinity, density, and current velocity - using irregularly located Argo measurements (the principle of the variational interpolation technique entails minimization of the misfit between the interpolated fields defined on the regular grid and irregularly distributed data; hence the optimal solution passes as close to the data as possible). The simulations were performed for the entire globe limited in the north by 85.5° N using 1° grid spacing in both longitude and latitude. At the depths exceeding 2000 m, in which Argo data are lacking, the temperature and salinity data were taken from the WOA-09 database. The wind stress in the corresponding month (year, season) was specified from the ECMWF ERA-Interim reanalysis data. The calculations cover the 12-year period from 2005 to 2016. The results are presented as monthly, seasonal, and annual data and climatological mean fields. The spatial resolution of the data is one degree in latitude and longitude, and the temporal resolution is one month. Seasonal and intra-decadal variation of the Southern Ocean's transports was studied. The most prominent feature of the suggested method is the application of the variational technique of data interpolation to a regular grid for processing the Argo profiles with subsequent model hydrodynamic adjustment of the interpolated fields. The data enjoys free public access on the Internet at: http://argo.ocean.ru/. The study was supported by the Russian Science Foundation (project 16-17-10149).

A seasonal comparison of nitrogen uptake and nitrification in the South Atlantic Southern Ocean

Abstract ID : 1320

Conflict Declaration : None

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Additional Information : None

Mr. Mhlangabezi Mdutyana ,mmdutyana@yahoo.com ,(PhD Candidate) ,South Africa ,City ,Presenting[1]

Dr. Raissa Philibert ,raiphilibert@gmail.com ,(None) ,South Africa , ,Not Presenting[2]

Prof. Bess Ward ,bbw@princeton.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Sarah Fawcett ,sarah.fawcett@uct.ac.za ,(None) ,South Africa , ,Not Presenting[4]

Dr. Sandy Thomalla ,sandy.thomalla@gmail.com ,(None) ,South Africa , ,Not Presenting[5]

1 - UCT/CSIR 2 - Lwandle Technologies 3 - Princeton University 4 - University of Cape Town 5 - CSIR

M. Mdutyana[1,2], S.J. Thomalla[1,2], R. Philibert[3], B.B. Ward[4], S.E. Fawcett[1]
[1]Department of Oceanography, University of Cape Town, Private Bag X3, Rondebosch, Cape Town 7701, South Africa, [2]Ocean Systems and Climate Group, CSIR, P.O. Box 320 Stellenbosch, 7599, South Africa, [3]Lwandle Technologies, Private Bag X3, Plumstead, Cape Town, 7801, South Africa, [4]Department of Geosciences, Princeton University, Princeton, New Jersey, USA
Primary production fueled by nitrate is often equated with carbon (C) export from the euphotic zone. This "new production paradigm" assumes that nitrification (oxidation of ammonium to nitrite and nitrate) does not occur in surface waters. While euphotic zone nitrification has been measured in numerous regions, there are few data from the Southern Ocean. On two cruises across the Southern Ocean, nitrogen (N) uptake and oxidation were measured throughout the mixed layer. In winter, mixed layer nitrate uptake was low (average of 0.29 mmol N m^{-2} d^{-1}) while ammonium uptake was surprisingly high (average of 7.64 mmol N m^{-2} d^{-1}). Primary productivity was also low, indicating a decoupling of C and N uptake, likely due to ammonium consumption by heterotrophic bacteria. Summertime nitrate uptake rates averaged 3.25 mmol N m^{-2} d^{-1}, and 75% of the stations were characterised by ammonium uptake rates <2 mmol N m^{-2} d^{-1}. The average summer *f*-ratio of 0.60 is consistent with high nitrate dependence and the potential for significant C export, provided euphotic zone nitrification was minimal. Measured rates of ammonia and nitrite oxidation (vNH_4^+ and vNO_2^-) were very low in the summer euphotic zone, with nitrification accounting for ~4% of the nitrate consumed. This suggests that equating nitrate uptake with export production is reasonable in summer. In winter however, vNH_4^+ and vNO_2^- averaged 3.5 and 7.76 mmol N m^{-2} d^{-1}, respectively; these rates are 50-100% of the N uptake rates, confirming that the new production paradigm does not apply to the wintertime Southern Ocean. This work underscores the need to adequately represent the seasonal variability in Southern Ocean nitrate uptake and nitrification in global biogeochemical models in order to prevent inaccurate estimates of carbon export.

Why increasing the ocean resolution of Earth System Models ? the case of IPSLCM6

Abstract ID : 1350

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Julie Deshayes ,Julie.Deshayes@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[1]

1 - CNRS

The ocean circulation produced by CMIP5 climate models suffers from substantial biases, for the mean state and the mechanisms of variability, presumably due to the coarse resolution of the ocean horizontal grid, of the order of 1 degree. Indeed, increasing the horizontal resolution in ocean models, from 1 degree to eddy permitting or resolving resolution, has been shown to improve the mean circulation in the North Atlantic, the mean distribution of biogeochemical tracers in the Arctic, and variability in the Agulhas Leakage, for example. Notwithstanding, eddy resolving configurations are still too expensive to be used for climate simulations. Eddy permitting configurations, on the other hand, require ad-hoc choice of subgrid-scale parameterizations, which should be determined by the scientific question to be investigated. Besides, simulations at those resolutions remain dependent on numerical schemes for momentum and tracers. Sensitivity experiments reveal that those choices require trade-offs when comparing model outputs to observations, which are likely to be driven by the scientific foci of the developing team. As a conclusion, increasing the ocean resolution of an Earth System Model has to be supported by sound motivation so as to set a clear tuning strategy of the high resolution ocean configuration. This will be illustrated for the case of IPSLCM6.

Teleconnections of the South Atlantic Subtropical Mode Water at interannual scales

Abstract ID : 1421

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr Olga Sato ,olga.sato@usp.br ,(None) ,Brazil , ,Not Presenting[1]

Mr. Piero Bernado ,piero.bernardo@usp.br ,(None) ,Brazil , ,Not Presenting[2]

Dr. Andrea Taschetto ,a.taschetto@unsw.edu.au ,(None) ,Australia , ,Not Presenting[3]

Prof. Paulo Polito ,polito@usp.br ,(None) ,Brazil , ,Not Presenting[2]

1 - Univ. Sao Paulo 2 - University of São Paulo 3 - University of New South Wales 4 - University of São Paulo

Mode water are distinct volume of water due to a remarkably low stratification and located in the upper layers of the ocean. They are mainly formed from winter to mid--spring, a period characterized by severe weather conditions over the subtropical oceans with high intensity winds associated with low temperature and low relative humidity brought by the polar air masses. The convective mixing promoted during the winter, deepens the mixed layer, and causes the outcropping of a previously formed mode water to the surface. Later, with the development of a seasonal thermocline during the spring and summer months, isolates that layer from the surface between the seasonal and the permanent thermoclines. The South Atlantic subtropical mode water (SASTMW) is present in three regions: i) the Brazil--Malvinas confluence and the Brazil Current recirculation gyre on the western side of the basin, ii) near the Agulhas retroflection region in eastern side of the basin, and iii) along the southern edge of the gyre. We investigate how much of the interannual to longer scales variability found in the total volume of SASTMW is a response to teleconnections. For this analysis, we use the following data: a 3D field of global temperature and salinity data at monthly mean resolution based on in situ data, In Situ Analysis System (ISAS) from IFREMER, and model outputs from the Community Earth System Model (CESM) and the Australian Community Climate and Earth-System Simulator (ACCESS). In addition to ENSO variability, variations of the sea surface temperature in the southwestern South Atlantic, particularly in the Brazil-Malvinas Confluence, seem to be related to oscillations in the Southern Annular Mode (SAM) via changes in the wind stress field and water subduction as Ekman pumping. Therefore, correlations between the SASTMW volume and interannual indices such as Niño3 and 3.4, SAM, and the Tripole Index for the Interdecadal Pacific Oscillation (TPI(IPO)) are investigated.

Comparing the Southern Ocean Surface Water pH in a High Resolution Coupled Climate Model and the CMIP5 Earth System Models With Observationally-based Metrics

Abstract ID : 1457

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Joellen Russell ,jrussell@email.arizona.edu ,(Associate Professor Department of Geosciences) ,United States ,Tucson ,Not Presenting[1]

1 - University of Arizona

We examine the relationships between the distribution of pH in the surface waters of the Southern Ocean, the air/sea flux of carbon dioxide, and the upwelling of old, low pH water. Efforts to determine the relative effects of these processes have been hampered by the enormous computational resources required to simulate ocean biogeochemistry in eddy-resolving coupled climate models. Using observationally-based metrics from biogeochemically-sensored floats (part of the SOCCOM project), the recently released GLODAP-V2, and the Southern Ocean State Estimate, we assess the relationship between upwelling and uptake on the distribution of surface pH in the CMIP5 ESM historical simulations. We will compare these moderate resolution simulations to that from a high-resolution eddy-resolving coupled climate model (GFDL-CM2.6) simulation. We assess the mean, the seasonally-varying and the interannually-varying surface pH from the simulations.

Climatologies and Long-term Sea Surface Temperature Trends around Southern Africa from the Pathfinder v5.3 Climate Data Record

Abstract ID : 1491

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Deirdre Byrne ,dbyrne.dea@gmail.com ,(specialist scientist) ,South Africa ,Cape Town ,Not Presenting[1]

Dr. Sheekela Baker-Yeboah ,sheekela.baker-yeboah@noaa.gov ,(None) ,United States , ,Not Presenting[2]

1 - None 2 - National Oceanic and Atmospheric Administration

The Pathfinder Sea Surface Temperature (SST) Climate Data Record (CDR) provides a fundamental resource for describing surface ocean environmental conditions. Extending from late 1981 through 2015, this dataset represents the longest environmental record available for large areas of the ocean. Extensively calibrated with in situ data and carefully quality controlled, the L3C data have a four (4) km spatial resolution, permitting studies of scales at one (1) degree or less. In this work, we derive a harmonic climatology as a baseline dataset, and evaluate the seasonal cycle at various sites around southern Africa and the world. We examine extreme departures from climatologically normal conditions. Finally, we also quantify long-term SST trends in some areas of interest around southern Africa.

P02 - Physics and biogeochemistry of semi-enclosed and shelf seas (IAPSO)

Observed wave climate variation at the open part of the Black Sea

Abstract ID : 113

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. BORIS DIVINSKII ,divin@ocean.ru ,(Senior Scientist) ,Russia ,Gelendzhik ,Not Presenting[1]

Prof. Ruben Kosyan ,rkosyan@hotmail.com ,(Head of the Lithodynamics and Geology Labaratory) ,Russia ,Gelendzhik ,Not Presenting[1]

1 - Southern Branch of the Shirshov Institute of Oceanology 2 - Southern Branch of the Shirshov Institute of Oceanology

The main objective of the present study is the analysis of the stormy activity in the Black Sea during the last 38 years. Our studies revealed climatic trends in the spatial distribution of wave energy and made possible to determine the main frequencies of wave energy fluctuations.
The main results of our study are as follows:
1. We obtained a large dataset consisting of the fields of calculated parameters of wind waves in the Black and Azov seas with a time step of 1 hour covering a period of 38 years (from 1979 to 2016).
2. Spatial inhomogeneity in the distribution of the wind waves power over the Black Sea is clearly seen. Interannual fluctuations are most significant in the western part of the sea. The central and eastern parts of the sea are more homogeneous. The total annual power of waves in the western region of the Black Sea exceeds 2-3 times the power of waves in the eastern part of the sea.
3. The wave climate in the western part of the sea is determined by the strong and extremely strong storms, while in the eastern part the dominating role belongs to moderate storms.
4. In the last 38 years, redistribution of wave energy with respect to the directions of its propagation has been observed over the Black Sea. In the western part of the sea, this fact is reflected in the increase of the part of the northeastern directions of waves, while the northwestern waves decrease. In the eastern part of the sea the contribution of wind waves from the southeastern direction increases and the northwestern waves become weaker.
5. We revealed the peculiarities related to the time structure of the wind waves power and indices of the atmospheric circulation. The period of the maximum correlation between the wind waves power and the North Atlantic Oscillation indices is 0.5 year and the period of the maximum correlation with the Arctic Oscillation indices is 1.8 years. Both correlations are negative.

Co-author: Prof. Ruben Kosyan, Southern Branch of the Shirshov Institute of Oceanology, Russia

Long-term wave measurements for large-scale climate characterization.

Abstract ID : 193

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Angela Pomaro ,angela.pomaro@ve.ismar.cnr.it ,(Research Fellow) ,Italy ,Venezia ,Presenting[1]

Dr. Piero Lionello ,piero.lionello@unisalento.it ,(None) ,Italy , ,Not Presenting[2]

Dr. Luigi Cavaleri ,luigi.cavaleri@ve.ismar.cnr.it ,(None) ,Italy , ,Not Presenting[1]

Dr. Luciana Bertotti ,luciana.bertotti@ve.ismar.cnr.it ,(None) ,Italy , ,Not Presenting[1]

1 - CNR-ISMAR Institute of Marine Sciences 2 - University of Salento 3 - CNR-ISMAR Institute of Marine Sciences 4 - CNR-ISMAR Institute of Marine Sciences

Multi-decadal time series of wave data needed for climate studies are generally provided by long term model simulations (hindcasts). Valuable as they are, these estimates are necessarily affected by the approximations involved within the modelling process.
On the contrary, multi-decadal observed time series are rare and not exempt of problems. Local effects may prevent the identification of trends that are indeed present at large scale. Of course, where available for several decades, measured data are of great value for a number of reasons and can be valuable clues to delve further into the physics of the processes of interest, especially if considering that waves, as an integrated product of the local climate can provide related compact and meaningful information.
The present study refers to the analysis of the 37-year long directional wave time-series recorded between 1979 and 2015 at the CNR-ISMAR (Institute of Marine Sciences of the Italian National Research Council) "Acqua Alta" oceanographic research tower, located in the Northern Adriatic Sea, 15 km offshore the Venice lagoon, on 16 m depth.
We explore the dataset both to characterize the local average climate and its variability, and to detect the possible long-term trends that might be suggestive of, or emphasize, large scale circulation patterns and trends.
In addition, we take advantage of the availability for the area of interest of a 20-year long dataset of directional spectra (in frequency and direction), from the advanced high resolution WAve Model (WAM) driven by the wind fields produced at the European Centre for Medium-Range Weather Forecasts (ECMWF), which offers an independent, but theoretically corresponding and significantly long dataset, allowing to penetrate the wave problem through different perspectives.
In particular, a characterization of wave conditions and storminess based on wave spectra helps bringing out a detailed description of the different wave regimes, their associated meteorological conditions and their variation in time and geographical space.
Hence we explore long-term trends of the relevant wave parameters in order to assess the possible correlation between the local scale and the general climate and its evolution, thus helping the overall understanding of models capability to reproduce the physical processes in a climate change perspective.

Multi-model analysis of the Adriatic-Ionian thermohaline circulation using an ensemble of multi-decadal regional ocean simulations

Abstract ID : 205

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Natalija Dunic ,dunic@izor.hr ,(PhD student) ,Croatia ,Split ,Not Presenting[1]

Mr Jadranka Sepic ,sepic@izor.hr ,(None) ,Croatia , ,Not Presenting[1]

Dr. Samuel Somot ,samuel.somot@meteo.fr ,(None) ,France , ,Not Presenting[3]

Ms. Florence Sevault ,florence.sevault@meteo.fr ,(None) ,France , ,Not Presenting[3]

Mr. Pierre Nabat ,pierre.nabat@meteo.fr ,(None) ,France , ,Not Presenting[3]

Mr. Thomas Arsouze ,thomas.arsouze@ensta-paristech.fr ,(None) ,France , ,Not Presenting[6]

Dr. Gabriel Jorda ,gabriel.jorda@uib.cat ,(None) ,Spain , ,Not Presenting[7]

Dr. Ivica Vilibic ,vilibic@izor.hr ,(research scientist) ,Croatia ,Split ,Not Presenting[1]

Dr. Romain Pennel ,romain.pennel@lmd.polytechnique.fr ,(None) ,France , ,Not Presenting[9]

Mr. Robin Waldman ,robin.waldman@meteo.fr ,(None) ,France , ,Not Presenting[3]

1 - Institute of Oceanography and Fisheries 2 - Institute of Oceanography and Fisheries 3 - CNRM (CNRS/Météo-France) 4 - CNRM (CNRS/Météo-France) 5 - CNRM (CNRS/Météo-France) 6 - ENSTA-ParisTech, Université Paris-Saclay; IPSL/Laboratoire de Météorologie Dynamique, Ecole Polytechnique, ENS, UPMC, ENPC, CNRS 7 - IMEDEA (CSIC-UIB) 8 - Institute of Oceanography and Fisheries 9 - IPSL/Laboratoire de Météorologie Dynamique, Ecole Polytechnique, ENS, UPMC, ENPC, CNRS 10 - CNRM (CNRS/Météo-France)

Dense water formation (DWF) is the major driver of the Adriatic thermohaline circulation (THC) and water mass exchanges with the Ionian Sea and Eastern Mediterranean. It is highly variable in both space (down to 1 km) and time (down to 1 hour), demanding mesoscale approach in both atmospheric and ocean modelling. Recent analysis based on long-term in-situ measurements revealed a possible change in the Adriatic THC, showing a significant reduction of the DWF processes. On top of that, the circulation and Adriatic thermohaline properties resemble substantial decadal variations, which are coherent with the sea level height fluctuations in the northern Ionian Sea. This phenomenon is called Adriatic-Ionian Bimodal Oscillating System (BiOS). An initial study has shown that a regional ocean hindcast model succeeded to reproduce only partially the patterns of the BiOS, so that an extension of the analysis to a variety of state-of-the-art hindcast models is required for proper assessment of the changes over a long term. To achieve that, we took seven different NEMOMED regional hindcast simulations covering ERA Interim period (1980-2012) and analyzed them focusing on their capacities to reproduce the Adriatic DWF and the BiOS. Verification of the models has been carried out on the in-situ long-term data collected over the Palagruža Sill transect, at Jabuka Pit and deep South Adriatic Pit, as well as on the AVISO+ satellite altimetry data. We performed multi-model analysis in order to investigate the effects of spatial (from 10 to nearly 2 km) and vertical (43 to 75 z-levels) resolution, atmosphere model resolution (50 and 12 km) and high-

frequency coupling, as well as the effects of the aerosol representation. In addition, we investigated impact of freshwater forcing using different climatologies or river coupling on the interannual and decadal variations of the Adriatic-Ionian thermohaline properties.

Top down controls on the onset and development of shelf sea seasonal stratification.

Abstract ID : 261

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Matthew Palmer ,rolm@noc.ac.uk ,(Physical Oceanographer) ,United Kingdom ,Liverpool ,Not Presenting[1]

Dr. Sarah Wakelin ,slwa@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Ms. Jenny Jardine ,j.jardine@liverpool.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Ms. Juliane Wihsgott ,J.Wihsgott@liverpool.ac.uk ,(PhD research student) ,United Kingdom ,Liverpool ,Not Presenting[3]

Dr. Charlotte Williams ,chwill@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - UK National Oceanography Centre 2 - National Oceanography Centre, UK 3 - University of Liverpool 4 - University of Liverpool 5 - National Oceanography Centre, UK

We present new data from a series of ocean glider deployments on the European continental shelf to investigate the mechanistic control of the vertical structure of density stratification in shelf seas. Central to this presentation is a nine-month, 120 km long repeat transect between mid-shelf and the shelf break that shows how variable controls by surface forcing, internal waves and topography drives spatial and temporal variability in temperature, salinity and density structure. We include coincident hydrography and turbulence results from Ocean Microstructure Gliders (OMG), combined with measurements from a nearby buoy fitted with meteorological and ocean surface sensors to explicitly resolve the influence of the different forcing mechanisms across the continental shelf.
Intuitively, our results show that tidal forcing provides the dominant source of bottom mixed layer control, with the spring-neap cycle and relative changes in topography causing the majority of observed variability. The ocean surface boundary layer depth is controlled by buoyancy input from solar heating and atmospheric cooling balanced predominantly by wind driven mixing, with only occasional instances where surface waves contribute significantly. While an active internal wave field is observed throughout stratified periods we find only weak levels of internal mixing, except in regions close to extreme topography such as at the shelf break and in close proximity to submarine banks. We employ a simple 1-D model to predict vertical structure based on observed boundary layer forcing alone, using a variety of suggested length scales that balance the relative contributions from wind, wave and buoyancy forcing to set surface layer mixing depths. Results are compared with observations to test the capability of this simple dynamical approach in replicating the seasonality of the vertical shelf sea structure. Output from a regional scale, fully-coupled hydrodynamic model (NEMO) is then used to quantify the impact of the variety of surface forcing mechanisms on seasonal structure across the entire continental shelf.

High-resolution Seaglider observations of tidal flows and frontal dynamics in a tidally energetic shelf sea

Abstract ID : 265

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Peter Sheehan ,p.sheehan@uea.ac.uk ,(PhD Student) ,United Kingdom ,Norwich ,Not Presenting[1]

Dr. Alejandro Gallego ,a.gallego@marlab.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Barbara Berx ,b.berx@marlab.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Rob Hall ,robert.hall@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[1]

Dr. Sarah Hughes ,s.hughes@marlab.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Bastien Queste ,bastien@gmail.com ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of East Anglia 2 - Marine Scotland 3 - Marine Scotland 4 - University of East Anglia 5 - University of East Anglia 6 - Marine Scotland 7 - University of East Anglia

Understanding and predicting the location of seasonal fronts in shelf seas is important for accurately describing regional circulation patterns, for model validation, and for understanding biogeochemical fluxes. A key driver is the mixing caused by tidal currents counteracting the stratification caused by surface heat fluxes and freshwater influence. Here, we discuss the use of ocean gliders to quantify tidal currents and investigate the resulting frontal dynamics. A two-month Seaglider deployment in the northern North Sea repeatedly occupied the JONSIS line, a zonal hydrographic section to the east of the Orkney Islands (0 - 2.23°W at 59.28°N), and provided dive-average current velocities derived from the glider's displacement during each dive. The time series is divided into three spatial bins by longitude, and harmonic analysis is used to determine the amplitude and phase of the M2 and S2 tides in each bin. The amplitude of each constituent decreases offshore, as expected. The phase of each constituent changes little across the section. The offshore decrease in the amplitude of tidal volume transport is less pronounced, an increase in depth partially offsetting the decrease in amplitude. The results are typically within 10% of the amplitude and phase of the M2 and S2 tides determined by harmonic analysis of year-long current meter observations from the region, and with predictions of the OTPS tidal model. We conclude that Seagliders may be used to characterise tidal flows in tidally energetic shelf seas. A strong bottom front is observed in the glider temperature and salinity distributions along the JONSIS line. The high vertical and horizontal resolution of the Seaglider data permits the front to be more accurately located than in data from previous ship-based occupations, and the ten repeat occupations provide cross-frontal observations at unprecedented temporal resolution. We use the tidal currents to determine whether frontal location is related to the ratio of water depth and the cube of depth-mean tidal speed, as predicted by theory. We find that frontal location is consistent in space, but is not well predicted by theory. Reasons for this, including the influence of horizontal salinity gradients, are discussed.

Monitoring of the Algerian Basin circulation through glider observations, numerical simulations and altimetry during fall 2014-2016

Abstract ID : 272

Conflict Declaration : None

Content Motivation : None

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Dr. Yuri Cotroneo ,yuri.cotroneo@uniparthenope.it ,(Post Doc Research Fellow) ,Italy ,Napoli ,Not Presenting[1]

Dr. Giuseppe Aulicino ,giuseppe.aulicino@uniparthenope.it ,(None) ,Italy , ,Not Presenting[1]

Dr. Simon Ruiz ,simon.ruiz@uib.es ,(None) ,Spain , ,Not Presenting[3]

Dr. Antonio Sanchez Roman ,asanchez@imedea.uib-csic.es ,(None) ,Spain , ,Not Presenting[3]

Dr. Ananda Pascual ,ananda.pascual@imedea.uib-csic.es ,(None) ,Spain , ,Not Presenting[3]

Prof. Giannetta Fusco ,giannetta.fusco@uniparthenope.it ,(None) ,Italy ,Napoli ,Not Presenting[1]

Prof. Joaquim Tintoré ,jtintore@socib.es ,(None) ,Spain , ,Not Presenting[7]

Prof. Giorgio Budillon ,giorgio.budillon@uniparthenope.it ,(None) ,Italy , ,Not Presenting[1]

1 - University of Naples "Parthenope", Italy 2 - University of Naples "Parthenope", Italy 3 - Instituto Mediterráneo de Estudios Avanzados, IMEDEA(CSIC-UIB) 4 - Instituto Mediterráneo de Estudios Avanzados, IMEDEA(CSIC-UIB) 5 - Instituto Mediterráneo de Estudios Avanzados, IMEDEA(CSIC-UIB) 6 - University of Naples "Parthenope", Italy 7 - Instituto Mediterráneo de Estudios Avanzados, IMEDEA(CSIC-UIB), Esporles, Spain, Balearic Islands Coastal Observing and Forecasting System (SOCIB), Palma de Mallorca, Spain 8 - University of Naples "Parthenope", Italy

The Algerian Basin is characterized by the presence of both fresh Atlantic waters and more saline resident Mediterranean ones that interact at different spatial and temporal scale. Rapid and energetic mesoscale structures as meanders, cyclonic and anti-cyclonic eddies, evolve from the Algerian Current that is the main large scale oceanographic feature of the area.
Despite their remarkable importance, this region and its variability are still poorly known and basin-wide knowledge of its mesoscale and sub-mesoscale features is still incomplete.
In order to monitor such complex processes, the Algerian BAsin Circulation Unmanned Survey (ABACUS) was realized during fall 2014-2016 thanks to the support of JERICO-TNA, SOCIB external user competitive access and JERICO NEXT-TNA. A new integrated oceanographic observing system was built up in the Algerian Basin, taking advantages of the combined use of gliders, new generation satellite altimeters and numerical simulations.
Our results confirm the advantages of this multi-platform strategy:

- Mesoscale structures have been successfully monitored with dedicated sampling tracks during ABACUS missions;

- Data collection along fixed monitoring lines provided data for an interesting comparison with model data and alongtrack satellite observations in the study area;
- Dynamic height calculated from glider data and satellite absolute dynamic topography present similar patterns with maximum discrepancies located nearby the Balearic Islands and the Algerian Coast;
- Numerical simulations outputs agree well with the high resolution glider measurements and provide valuable information that strongly complements in situ and remote sensed observations.

High resolution physical and biogeochemical measurements obtained from an underwater glider in the northwestern Mediterranean Sea during the spring bloom

Abstract ID : 498

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Michael Hemming ,m.hemming@uea.ac.uk ,(PhD candidate) ,United Kingdom ,Norwich ,Not Presenting[1]

Dr. Vincenzo Vellucci ,enzo@obs-vlfr.fr ,(None) ,France , ,Not Presenting[2]

Dr. Jacqueline Boutin ,jb@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[3]

Dr. Kiminori Shitashima ,kshita0@kaiyodai.ac.jp ,(None) ,Japan , ,Not Presenting[4]

Dr. Liliane Merlivat ,merlivat@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[3]

Mr. Marcos Cobas-Garcia ,M.Cobas-Garcia@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Dorothee Bakker ,D.Bakker@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr. Gareth Lee ,G.A.Lee@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[1]

Prof. Jan Kaiser ,j.kaiser@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of East Anglia 2 - Laboratoire d'Océanographie de Villefranche-sur-Mer 3 - LOCEAN, Universite Pierre et Marie Curie 4 - Tokyo University of Marine Science and Technology 5 - LOCEAN, Universite Pierre et Marie Curie 6 - University of East Anglia 7 - University of East Anglia 8 - University of East Anglia 9 - University of East Anglia 10 - University of East Anglia

The Mediterranean Sea comprises of just 0.8 % of the global oceanic surface, yet it is regarded as an important sink for anthropogenic carbon due to its physical and biogeochemical characteristics. Autonomous underwater gliders offer the capability of measuring oceanic parameters continuously at high resolution both vertically and horizontally, on timescales that can extend to many months. A unique dataset of high resolution biogeochemical and physical parameters was obtained by an underwater glider at the BOUSSOLE site (7.9 ºE, 43.36 ºN - close to DYFAMED) in the northwestern Mediterranean Sea in March, 2016. This includes measurements of *in situ* pH (total scale) and $p(CO_2)$ collected by an experimental ion sensitive field effect transistor sensor attached to the glider, dissolved oxygen concentrations, chlorophyll fluorescence, optical backscatter, temperature, and salinity. These glider data enabled us to observe horizontal and vertical gradients in high detail over a wide area. Measurements of $f(CO_2)$ collected by the CARIACA sensor at 10 m depth decreased by 100 µmol kg^{-1} (DIC concentration ≈ 40 µmol kg^{-1}) between the 19th and 31st March, which coincided with increases in pH (≈ 0.05), oxygen (≈ 45 µmol kg^{-1}), and chlorophyll (≈ 1.2 mg m^3) measured by the glider at the same depth. This indicated the start of the spring bloom, which preceded a period of intense mixing evidenced by stronger winds measured by the nearby meteorological buoy and deeper mixed layer depths estimated using glider measurements. This unique glider dataset will be presented

alongside satellite observations, data from the BOUSSOLE mooring and the meteorological buoy, and ship measurements collected at the beginning of the deployment, to characterise the physical and biogeochemical variability of the area before and during the spring bloom period.

Measuring pH variability using an experimental sensor on an underwater glider

Abstract ID : 500

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Michael Hemming ,m.hemming@uea.ac.uk ,(PhD candidate) ,United Kingdom ,Norwich ,Not Presenting[1]

Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[1]

Dr. Reiner Onken ,Reiner.Onken@hzg.de ,(None) ,Germany , ,Not Presenting[3]

Dr. Kiminori Shitashima ,kshita0@kaiyodai.ac.jp ,(None) ,Japan , ,Not Presenting[4]

Dr. Dorothee Bakker ,D.Bakker@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Jan Kaiser ,j.kaiser@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr. oliver Legge ,O.Legge@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Jacqueline Boutin ,jb@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[8]

Mr. Gareth Lee ,G.A.Lee@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of East Anglia 2 - University of East Anglia 3 - Helmholtz-Zentrum Insistut fuer Kuestenforschung 4 - Tokyo University of Marine Science and Technology 5 - University of East Anglia 6 - University of East Anglia 7 - University of East Anglia 8 - LOCEAN, Universite Pierre et Marie Curie 9 - University of East Anglia

Autonomous underwater gliders offer the capability of measuring oceanic parameters continuously at high resolution in both vertical and horizontal planes, with timescales that can extend to many months. An experimental ion sensitive field effect transistor (ISFET) sensor measuring pH on the total scale was attached to a glider during the REP14 - MED experiment in June 2014 in the northwestern Mediterranean Sea. During the deployment, pH was sampled at depths of up to 1000 m, along an 80 km transect over a period of 12 days. Water samples were collected from a nearby ship and analysed for dissolved inorganic carbon concentration and total alkalinity to derive pH for validating the ISFET measurements. The vertical resolution of the pH sensor was good (1 to 2 m), but stability was poor, and the sensor drifted in a non-monotonous fashion. In order to remove the sensor drift, a time-dependent, depth-invariant offset was applied throughout the water column for each dive, reducing the spread of the data by approximately two thirds. Furthermore, the ISFET sensor required temperature and pressure-based corrections, which were achieved using linear regression. Correcting for this decreased the apparent sensor pH variability by a further 13 to 31 %. Sunlight caused an apparent sensor pH decrease of up to 0.1 in surface waters around local noon, highlighting the importance of shielding the sensor away from light in future deployments. The corrected pH from the ISFET sensor is presented along with *in* situ temperature, salinity, potential density anomalies (σ_θ), and dissolved oxygen concentrations ($c(O_2)$) measured by the glider, providing insights into physical and biogeochemical variability in this region. pH maxima were identified at the depth of the summer chlorophyll maximum, where high $c(O_2)$ values were also found. Longitudinal pH variations at depth ($\sigma_\theta > 28.8\ \mathrm{kg\ m^{-3}}$) highlighted variability of water masses in this region. Higher pH was observed where salinity was > 38.65, and lower pH was found where salinity ranged between 38.3 and 38.65. It

seemed that the higher pH was associated with saltier Levantine Intermediate Water. Furthermore, shoaling isopycnals closer to shore coinciding with low pH, high salinity, low $c(O_2)$ waters may be indicative of upwelling.

Regional numerical model of microfibres transport in the Baltic Sea

Abstract ID : 570

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Andrei Bagaev ,a.bagaev1984@gmail.com ,(Senior Scientist) ,Russia ,Kaliningrad ,Not Presenting[1]

Dr. Artem Mizyuk ,artem.mizyuk@gmail.com ,(None) ,Russia , ,Not Presenting[2]

Dr. Irina Chubarenko ,irina_chubarenko@mail.ru ,(None) ,Russia , ,Not Presenting[1]

1 - Atlantic branch of P.P.Shirshov Institute of Oceanology RAS 2 - Marine Hydrophysical Institute RAS 3 - Atlantic branch of P.P.Shirshov Institute of Oceanology RAS

A challenging area in the microplastics (MPs) research is the physical principles that determine their transport in the marine environment. Still, these very physical properties are dominant for the crucial MPs behaviour manifestations: zones of and conditions for their accumulation.
According to in situ data collected in our expeditions from various horizons in the Baltic Proper, MPs fibers are the prevalent type of MPs pollution in the Baltic Sea (0.07 to 2.6 fibers per litre in 63% out of 95 water samples). Their vertical distribution is not homogeneous - the highest concentrations are found in the surface and near-bottom layers.
Our research focuses on modelling of MPs fibers transport in the Baltic Sea. For this purpose we used currents fields (from HIROMB model, product of Copernicus Marine Environment Monitoring Service) and introduced a hypothetical source of MPs in the south-eastern Baltic. The results of laboratory experiments on settling velocities of MPs were incorporated into our Lagrangian model of particles transport. In this context we tried to investigate how the final particles distribution in water and at the bottom is influenced by the following parameters: coefficient of horizontal turbulent diffusion, magnitude of the vertical settling velocity, and the velocity threshold for particles' sedimentation.
There is satisfactory ground to assume that adequate reproduction of the fibers distribution in nature requires slow vertical settling and low sedimentation threshold. One more conclusion from the study was that each type of MPs (e.g., floating particles, fibres, flakes, 3d-shaped sinking particles) suggests using a specialized model tuned to a particular spatio-temporal scale and particles' properties.
The MARBLE project is supported by Russian Science Foundation via grant #15-17-10020.

Pycnocline Mixing is Seasonally Stratified Shelf Seas

Abstract ID : 717

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jeff Polton ,jelt@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Ashley Brereton ,ashbre@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Maria Luneva ,mane1@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Karen Guihou ,karen.guihou@gmail.com ,(None) ,United Kingdom , ,Not Presenting[2]

1 - National Oceanography Centre, UK 2 - National Oceanography Centre 3 - National Oceanography Centre 4 - National Oceanography Centre

The shelf seas, relative to their size, contribute a disproportionate fraction to total global primary production. In seasonally stratified shelf seas mixing processes at the pycnocline mediate the transfer of biological and physical fluxes that in turn control this biogeochemical cycle. Regional models generally poorly simulate mixing processes at the pycnocline, instead forming an interface between surface driven mixing and bottom boundary layer driven mixing. It is hypothesised that internal waves, missing from shelf wide regional models, are responsible for missing mixing. Internal tides are diagnosed in a 1.8km Northwest European shelf NEMO simulation and favourably compared against FASTNEt hydrographic observations. We anticipate this new class of fine resolution simulation, which can simulate non-local propagation of momentum along the pycnocline, forms the basis of improved parameterisations for shelf sea mixing. Large eddy simulation techniques are developed to explore this transition to mixing that must otherwise be parameterized in regional models

How does the motion in the ocean breathe life into shelf seas? An autonomous study of vertical mixing and ventilation

Abstract ID : 720

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Charlotte Williams ,chwill@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Matthew Palmer ,rolm@noc.ac.uk ,(Physical Oceanographer) ,United Kingdom ,Liverpool ,Not Presenting[2]

Dr. Claire Mahaffey ,mahaffey@liv.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. Clare Davis ,c.davis2@liv.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - National Oceanography Centre, UK 2 - UK National Oceanography Centre 3 - University of Liverpool 4 - University of Liverpool

Dissolved oxygen (DO) is essential to marine life and is an important parameter used to assess water quality and ecosystem health. Recently, there has been growing evidence that global ocean DO concentrations are decreasing (Schmidtko et al., 2017), with this trend being enhanced in the coastal ocean (Gilbert et al., 2010). Recent model studies suggest that large regions of shelf seas may potentially become hypoxic during seasonal stratification (Ciavatta et al., 2016). However, direct observations of DO concentrations in the shelf sea bottom mixed layer (BML) do not always support these model results, suggesting that models may be currently failing to capture essential processes that help prevent depletion of DO. Subsequently, there is an increasing demand for high spatio-temporally resolved measurements of DO alongside hydrographic measurements and estimates of physical mixing in the coastal ocean in order to elucidate the physical and biogeochemical processes that govern DO distributions and prevent the development of hypoxia. Here, we present physical (temperature, salinity, turbulent dissipation) and biogeochemical (chlorophyll, DO) data collected by an array of 22 ocean gliders over a 15-month sampling period across the Northwest European shelf to address the following research questions:

What is the influence of physical water column structure, turbulent mixing and biological processes on the DO concentrations in the BML in a shelf sea?

Following the onset of seasonal stratification and the spring bloom, we observed a persistent drawdown of DO in the BML, with an initial rate of 0.6 mmol m^{-3} d^{-1} (0.19 % d^{-1}) falling to 0.3 mmol m^{-3} d^{-1} (0.12 % d^{-1}) by the summer months. The persistent drawdown is the result of the thermocline isolating the BML from direct exchange with the atmosphere. In addition there is insufficient light to support photosynthesis in the BML, thus respiration dominates and biological oxygen demand exceeds production. However, we identify a new role of enhanced vertical mixing in the summer in driving diapycnal DO fluxes across the seasonal thermocline, acting to reduce DO drawdown rates. This has significant implications for accurate representation of ocean ventilation mechanisms and oxygen depletion in regional models.

Leading Modes of Interannual Variability of Mediterranean Evaporation and their Relation to Regional Atmospheric Dynamics During Boreal Summer

Abstract ID : 796

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Igor Zveryaev ,igorz@sail.msk.ru ,(Leading Research Scientist) ,Russia ,Moscow ,Not Presenting[1]

Dr. Abdel Hannachi ,a.hannachi@misu.su.se ,(None) ,Sweden , ,Not Presenting[2]

1 - P.P. Shirshov Institute of Oceanology 2 - Stockholm University

Monthly evaporation data for 1958-2015 from the Woods Hole Oceanographic Institution dataset are used to investigate interannual variability of Mediterranean evaporation and its links to regional climate during summer season. An EOF (Empirical Orthogonal Functions) analysis performed on the monthly means (i.e., separately for June, July, August and September time series) revealed three leading modes of evaporation variability, characterized by the monopole (EOF-1), zonal dipole (EOF-2) and zonal tripole (EOF-3) patterns. These modes explain together more than 60% of the total variability of Mediterranean evaporation. It is shown that the EOF-1 reflects interdecadal changes characterized by below normal evaporation in 1970-2000 and above normal evaporation before and after that period. The EOF-2 and EOF-3 reflect interannual and decadal scale variations of Mediterranean evaporation. Analysis of correlations between the leading PCs (principal components) of evaporation and indices of regional teleconnections as well as sea level pressure fields, suggests that there are not very strong, but statistically significant links between Mediterranean evaporation and the Scandinavian teleconnection, East Atlantic teleconnection, Atlantic Multidecadal Oscillation and some of the Asian monsoon indices.

Internal waves on shelf of the Black Sea

Abstract ID : 893

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Elizaveta Khimchenko ,ekhymchenko@gmail.com ,(PhD student) ,Russia ,Moscow ,Not Presenting[1]

Prof. Andrey Serebryany ,serebryany@hotmail.com ,(Principal Scientist) ,Russia ,Moscow ,Not Presenting[2]

1 - P.P. Shirshov Institute of Oceanology 2 - P. P. Shirshov Institute of Oceanology

The Black Sea is closed and almost tide-free sea, despite that here exists field of the internal waves, which sometimes reaching large amplitudes. Internal waves play important role in dynamics of the Black Sea and responsible for the vertical mixing. The range of internal waves extends from waves of the inertial period (near 17 hours for the Black Sea) to short-period waves with periods of several minutes. Internal waves of the mode-1 are dominant, however mode-2 internal waves also occur. Moreover appearance of mode-2 internal waves observed both for inertial and short-period waves. We have been made observations at the North-East shelf of the Black Sea and at the Southern Coast of Crimea for many years. Measurements were conducted from the stationary oceanographic platforms as well as from small vessels equipped with ADCP. It will be given generalization of long-term field observations which were carried out during summer and autumn seasons. It have been revealed differences of internal waves features which propagate at the narrow and ordinary shelves. It will be shown data on internal bore observations and some other features of internal waves connected with their nonlinearity. Generation of the intense internal waves on the Black Sea shelf is provided by several mechanisms which were observed. The main mechanisms are follows: generation due transformation of internal inertial waves propagating on a shelf and approaching coastal waters; generation by moving local fronts on a coastal zone connected with upwelling and downwelling; generation by moving freshened water of plums. Comparison of internal waves spectra of non-tidal and tidal seas will be done. The work was partially supported by RFBR project 16-35-00454 and 17-52-40016.

Rainfall as a trigger for stratification and winter phytoplankton growth in temperate shelf seas

Abstract ID : 1031

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Jenny Jardine ,j.jardine@liverpool.ac.uk ,(None) ,United Kingdom , ,Presenting[1]

Dr. Matthew Palmer ,rolm@noc.ac.uk ,(Physical Oceanographer) ,United Kingdom ,Liverpool ,Not Presenting[2]

Dr. Claire Mahaffey ,Claire.Mahaffey@liverpool.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Jason Holt ,jholt@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Adam Mellor ,adam.mellor@afbini.gov.uk ,(None) ,United Kingdom , ,Not Presenting[5]

Dr. Sarah Wakelin ,slwa@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[6]

Dr. Maria Luneva ,mane1@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]

1 - University of Liverpool 2 - UK National Oceanography Centre 3 - University of Liverpool 4 - UK National Oceanography Centre 5 - Agri-Food and Biosciences Institute 6 - National Oceanography Centre, UK 7 - National Oceanography Centre

We present new data from ocean gliders to investigate the physical controls on stratification and phytoplankton dynamics in a temperate shelf sea, focusing on the winter and the winter-spring transition periods. During winter, daily heating often results in regular but weak near surface stratification that is regularly mixed vertically by night-time convection. Despite low light conditions, this daily cycle promotes daytime pulses of increased chlorophyll fluorescence, indicative of enhanced phytoplankton growth. This cycle is occasionally interrupted when buoyancy inputs are sufficient to outcompete night-time convection, resulting in short-term periods of sustained stratification lasting 2-3 days. Sustained stratification often coincides with a surface freshwater anomaly produced by freshwater input from precipitation, which produces weak but significant freshening of the surface layer of the order of ±0.005 PSU. Comparing rainfall estimates with observed salinity changes confirms precipitation to often be the initiator of these sustained winter stratification periods. Heading towards spring, the influence of precipitation on periods of sustained stratification increases as air and sea surface temperatures equilibrate and surface mixing from winter winds subside. We observe that a heavy downpour during March 2015 was sufficient to trigger broad-scale stratification, leading to seasonal, sustained stratification over much of the continental shelf and thus provided the physical trigger for the subsequent spring phytoplankton bloom. Using energy balance criteria, we quantify the importance of these downpours when triggering sustained halo-thermal stratification and identify a criticality for shelf-wide stratification to form. We further use a realistically forced regional coupled bio-physical model (NEMO-ERSEM) over multiple years to test the broadening temporal and spatial extent of these observations from both a shelf-wide and global context.

Multi-sensor satellite observations of marine basins: the Western Mediterranean case study

Abstract ID : 1035

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Svetlana Karimova ,svetlana.karimova@ulg.ac.be ,(Postdoctoral researcher) ,Belgium ,Liege ,Not Presenting[1]

1 - University of Liege

Satellite remote sensing provides a variety of ways for tracing surface circulation of marine basins and dynamics of their ecosystems. This wealth of data is usually not fully involved in corresponding studies. In the present paper, we are analysing the entire range of satellite data for reconstructing surface circulation of a marine basin and for tracing possible effects of surface hydrodynamics on bioproductivity of the marine ecosystem. As a region of interest, we use the Western Mediterranean Basin. Since the Mediterranean Sea is a classical oligotrophic basin, its bioproductivity is very sensitive to hydrodynamic forcing applied to surface waters.
A general surface circulation of the region of interest in this study is retrieved from a synergy of different satellite, mostly altimetry-based, datasets (AVISO, GlobCurrent, FSLE, etc.). Special attention is being paid to coherent vortical structures, or eddies, which are believed to have the greatest effect on vertical water transport and redistribution of nutrients. Locations of the biggest eddies are extracted from just mentioned datasets as well, while information on smaller ones are captured by different types of satellite imagery. Thus, mesoscale coherent structures are being detected in thermal infrared images. The smaller scales (submesoscale eddies) are being observed with medium resolution synthetic aperture radar imagery.
In order to further trace the possible influence of different circulation features on ecosystem productivity, simultaneously obtained sea surface temperature (SST) and chlorophyll-a concentration (chl-a) fields are being co-analysed. In such studies, negative anomalies of SST are traditionally used as a proxy of intensive vertical water transport, while positive anomalies of chl-a are considered a sign of locally increased bioproductivity. Additional information on upper-water circulation, transport of suspended material, and dynamics of phytoplankton blooms in the region of interest is provided by natural colour imagery and other visible-range satellite products.
This research was supported by the University of Liege and the EU in the context of the FP7-PEOPLE-COFUND-BeIPD project. SAR and MERIS imagery was provided by the European Space Agency. The study has been conducted using E.U. Copernicus Marine Service Information.

Responses of marine environment in the East China Sea to the East Asian mosoon climatic jump

Abstract ID : 1110

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Rongshuo Cai ,rscai@163.com ,(Scientist) ,China ,Xiamen ,Not Presenting[1]

Mr. Junpen Zhang ,zhangjunpeng@tio.org.cn ,(None) ,China , ,Not Presenting[2]

1 - Third Institute of Oceanography, State Oceanic Administration of China 2 - Third Institute of Oceanogaphy, State Oceanic Administration of China

The responses of marine environment (sea surface height (SSH), sea temperature, salinity, and currents) in the East China Sea (ECS) to the East Asian monsoon climatic jump were investigated using a regional ocean model (ROMS). The numerical experiment results indicate that while EAM weakens after the climatic jump around 1976/77, the marine environment in the ECS presents distinct variation characteristics in different seasons. In summer, an obviously positive SSH (a negative sea salinity) anomaly arises in the vicinity of Changjiang river estuary (CRE), Hangzhou Bay and in the south of Yellow Sea, a sea temperature negative anomaly center located in the southwest area of Jeju island, as a results of the accumulation of Changjiang river discharge (CRD) and the coastal sea water in the vicinity of CRE, Hangzhou Bay and in the south of Yellow Sea, and an anomalous cyclonic oceanic currents in the ECS, which are induced by the weakening EAM. Similarly, under the background of the weakening EAM, the anomalous marine environment in winter are caused by the weakening of CRD diffuse, the China coastal currents and the Yellow Sea warm currents, and the strengthening of upper Kuroshio and Taiwan warm currents in the ECS. It is therefore suggested that the climatic jump in East Asian monsoon has a great effect on the marine environment in the ECS. >ECS.

Natural Iron Fertilization of the Patagonian Shelf and Seasonality of the Planktonic Blooms

Abstract ID : 1186

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Yvette Spitz ,yvette@coas.oregonstate.edu ,(Professor/ Scientists) ,United States ,Corvallis ,Presenting[1]

Dr. vincent combes ,vcombes@coas.oregonstate.edu ,(Research Associate) ,United States ,Corvallis ,Not Presenting[1]

Prof. Ricardo P. Matano ,rpm@coas.oregonstate.edu ,(None) ,United States , ,Not Presenting[3]

1 - Oregon State University 2 - Oregon State University 3 - Oregon State University/CEOAS

The Patagonian shelf hosts some of the largest planktonic blooms and one of the richest fisheries of the Southern Ocean. Several physical processes, including shelf break upwelling, tidal mixing, nutrient loads from continental and groundwater discharges and aeolian dust deposition, sustain these blooms. The complex interaction among these forcing and their impacts on the seasonality of the planktonic blooms are analyzed using a high-resolution coupled circulation/iron/ecosystem model. We find that dust deposition provides the main source of micronutrient for the surface summer blooms and that iron entrained from both dust deposition and sediments is driving the spring blooms. These seasonal differences are caused by a strengthening of the vertical stratification during the summer months. This strengthening inhibits the upwelling of iron-enriched waters from the deeper layers.

Age of Gulf of Mexico deep water as determined by 14C measurements

Abstract ID : 1191

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Piers Chapman ,piers.chapman@tamu.edu ,(Professor) ,United States ,College Station ,Presenting[1]

Dr. Steven DiMarco ,dimarco@tamu.edu ,(None) ,United States , ,Not Presenting[1]

Ms. Connie Previti ,cpreviti@tamu.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Robert Key ,key@princeton.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Shari Yvon-Lewis ,syvon-lewis@tamu.edu ,(None) ,United States , ,Not Presenting[1]

1 - Texas A&M University 2 - Texas A&M University 3 - Texas A&M University 4 - Princeton University 5 - Texas A&M University

While the exchange of water through Yucatan Strait is reasonably well known, the age of the deep water in both the Caribbean Sea and Gulf of Mexico is not. We recently measured the radiocarbon concentrations in deep water in the Gulf of Mexico from a line of stations along 890° 30'W. The mean apparent age was found to be about 740 years for water below 900 m, the depth of the Florida Strait sill. Depending on how the corrections for biological activity in the upper water are applied, this converts to a "true" age of between 231 +/- 28 and 293 +/- 74 years. These ages agree with a previous estimate of the age of the deep water in the Gulf of Mexico, and also put upper limits on the age of the deep water in the Caribbean Sea.

Material Transport and Interaction between the East China Sea and the Northwestern Pacific: Joint regional GEOTRACES study in East Asia

Abstract ID : 1231

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Jing Zhang ,jzhang@sci.u-toyama.ac.jp ,(Professor) ,Japan ,Toyama ,Not Presenting[1]

Dr. Qian Liu ,qianliu914@yahoo.com ,(None) ,Japan , ,Not Presenting[2]

Prof. Takeshi Matsuno ,matsuno@riam.kyushu-u.ac.jp ,(None) ,Japan , ,Not Presenting[3]

Dr. Huijun He ,he-hui-jun@163.com ,(None) ,China , ,Not Presenting[4]

1 - Graduate School of Science and Engineering, University of Toyama 2 - Northwest Pacific Region Environmental Cooperation Center 3 - Research Institute for Applied Mechanics, Kyushu University 4 - Key Laboratory of Marine Chemistry Theory and Technology, Ministry of Education, Ocean University of China

Marginal seas in the Western Pacific Ocean are located in the boundary areas between the continents or islands and the open ocean. Under the enhancement of climate change, it is very important to understand what happens in the marginal seas and how materials exchange between land and ocean through the marginal seas.
GEOTRACES takes interest in the theme "continental run off", particularly with the understanding of geochemical elements/isotopes and their transport from the land to the open ocean. However, water masses, as the material transporting carriers, are important but they are difficult to analyze since water masses often have various origins with complicated structures especially in marginal seas and open-ocean interaction dominated areas. To characterize and analyze the water mass structures and to quantify the contributions with high-resolution, in this study, current biogeochemical cruises covering the East China Sea and Kuroshio area connecting to the western North Pacific are introduced. As results, chemical tracers, e.g., rare earth elements and Nd isotope are suitable and conservative as water mass indicators, and are excellent tools for classification and analysis of water masses while coupling with salinity and temperature. These physico-chemical tracers can be applied to characterizing and quantifying (>3) multiple water masses, particularly where there is complex water structure. A three end-member box model for Nd isotope of various water mases including CDW (Changjiang Diluted Water), YSCW (Yellow Sea Cold Water) and KW (Kuroshio Water) indicates that the KW contributes 55% to the Japan Sea, 37% from Yellow Sea Water and 8% from CDW; and approximately over 10% of CDW can influence the Kuroshio and the adjacent area of Northwest Pacific.

A benthic-pelagic nitrogen budget for the continental margin of the Peruvian oxygen minimum zone

Abstract ID : 1337

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Marcus Dengler ,mdengler@geomar.de ,(None) ,Germany ,Kiel ,Presenting[1]

Prof. Lee Bryant ,L.Bryant@bath.ac.uk ,(None) ,United States , ,Not Presenting[2]

Dr. Stefan Sommer ,ssommer@geomar.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Annie Bourbonnais ,abourbonnais@whoi.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Andy Dale ,adale@geomar.de ,(None) ,Germany , ,Not Presenting[5]

Dr. Gerd Krahmann ,gkrahmann@geomar.de ,(None) ,Germany , ,Not Presenting[1]

Prof. Christian Dullo ,adullo@geomar.de ,(None) ,Germany , ,Not Presenting[1]

1 - GEOMAR 2 - University of Bath 3 - GEOMAR 4 - Woods Hole Oceanographic Institution 5 - GEOMAR Helmholtz Center for Ocean Research Kiel 6 - GEOMAR 7 - GEOMAR

Nitrogen (N) loss in oxygen minimum zones (OMZ) accounts for around one-third of global fixed N loss and plays a critical role in the oceanic N inventory. Expanding OMZs in tropical oceans may intensify N loss, reduce primary production, and thereby decrease oceanic CO_2 uptake. However, major uncertainties exist regarding the transport pathways of nutrients and the magnitude of N-loss in OMZs. In this study, a comprehensive data set from the continental margin of the Peruvian OMZ is used to evaluate benthic-pelagic dissolved inorganic N budgets and to investigate the dominant nutrient transport mechanisms. The data set was collected during a 4-week process study in austral summer 2013 along 12°S and consists of velocity time series from moorings, turbulence measurements, CTD/O_2 profiles, nutrient and N_2 gas concentration profiles, and benthic nutrient fluxes measured in situ by landers. Resulting sinks and sources allow net N-losses to be determined and compared to the flux divergences of an excess N_2 gas budget. On the anoxic shelf, near-stagnant circulation and elevated turbulence due to internal waves resulted in a dominant nutrient transport mechanism via diapycnal mixing. Nutrient fluxes due to vertical advection (i.e. upwelling) were insignificant. Enhanced sediment release of ammonium (NH_4) and diapycnal flux convergences of nitrate (NO_3) and nitrite (NO_2) resulted in a net N-loss of 260 nmol L^{-1} d^{-1}. This agrees with the divergence of excess N_2 fluxes. Benthic NH_4 release accounts for about 50% of N-loss, most likely due to coupling with annamox in the water column. On the upper continental slope, N-loss occurred primarily in the near-bottom region of the water column. Here, diapycnal NO_3 fluxes and isopycnal eddy and advective fluxes provide NO_3 for sedimentary uptake and NO_2 production by NO_3 reduction. Combining water column NO_3 and NO_2 flux imbalances with sedimentary NH_4 release resulted in a N-loss of 35 nmol L^{-1} d^{-1}. Again, N-loss of similar magnitude was obtained from an excess N_2 budget. The study indicates that water-column NH_4 sources play only a minor role for N cycling processes along the continental margin of Peru. Results also highlight diapycnal mixing as a key transport mechanism providing nutrients for benthic uptake.

Modulation of upper layer biochemical structure by mesoscale frontal dynamics in the Black Sea

Abstract ID : 1524

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Temel Oguz ,oguz@ims.metu.edu.tr ,(Professor emeritus, senior scientist) ,Turkey ,Izmir ,Not Presenting[1]

1 - Middle East Technical University

The baroclinically unstable Rim Current (RC) and the accompanying salinity front along the continental slope and margin topography around the cyclonic cell of deep interior basin is a well-defined structure of the Black Sea. As inferred by the long-term mean surface chlorophyll-a concentration distribution, the RC frontal zone exhibits stronger plankton production with respect to the cyclonic interior cell and the mechanism governing this feature has not been elucidated to date. The present study relates this feature to the mesoscale frontal dynamics that identifies coastal anticyclones on less dense side of the RC as localized hot spots of plankton production. Frontogenesis is shown to develop along the unstable and nonlinear RC frontal structure to restore the geostrophic balance of along-front current by developing ageostrophic cross-frontal circulation that develops upward (downward) motion on the anticyclonic (cyclonic) onshore (offshore) side of frontal meanders. The upward vertical velocity associated with the frontal dynamics is on the order of 10-20 m d^{-1} and an order of magnitude stronger than that develops in the quasi-geostrophic cyclonic eddies of the interior basin. The relatively strong upwelling of nitrate flux from the nitracline zone enriches the coastal anticyclones and supports high plankton production with respect to the interior basin. The nitrate loss at nitracline is compensated partly by upward flux of ammonium from the anoxic layer and partly by the remineralization of particulate matter within the upper layer water column. The lateral advective transports of nitrate and biota from the local sources by the RC maintain a well-defined narrow peripheral zone and their horizontal stirring by mesoscale features gives rise to a patchy plankton structure throughout the basin. The frontogenetic plankton production is studied more extensively for the open ocean frontal systems but it is a relatively unexplored subject for the coastally-attached boundary currents of the marginal and semi-enclosed seas. The present study points its efficiency the marginal and semi-enclosed seas as well.

P04 - The Meridional Overturning Circulation: Mean State and variability (IAPSO)

An Investigation of Abyssal to Mid-depth Variations in SAMOC Properties

Abstract ID : 13

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Alison Macdonald ,amacdonald@whoi.edu ,(Senior Research Specialist) ,United States ,None ,Not Presenting[1]

Mr Molly Baringer ,molly.baringer@noaa.gov ,(None) ,South Africa ,None ,Not Presenting[2]

Mr Sachiko Yoshida ,syoshida@whoi.edu ,(None) ,South Africa ,None ,Not Presenting[1]

Mr Katherine Kirk ,katherinekirk13@gmail.com ,(None) ,South Africa ,None ,Not Presenting[4]

Mr Xujing Jia Davis ,xdavis@whoi.edu ,(None) ,South Africa ,None ,Not Presenting[5]

Mr Elaine McDonag ,e.mcdonagh@noc.ac.uk ,(None) ,South Africa ,None ,Not Presenting[6]

Dr. Alison Macdonald ,amacdonald@whoi.edu ,(Senior Research Specialist) ,United States ,None ,Presenting[1]

1 - Woods Hole Oceanographic Institution 2 - NOAA/AOML 3 - Woods Hole Oceanographic Institution 4 - NOAA 5 - National Science Foundation and WHOI 6 - NOC 7 - Woods Hole Oceanographic Institution

The South Atlantic Ocean is a crossroads. Influenced by Southern Ocean inflow from both the east and the west, it is a place where deep and bottom water masses formed in northern and southern hemispheres meet. Here, Antarctic Bottom Waters (AABW), North Atlantic Deep Waters (NADW) and Antarctic Intermediate Waters (AAIW) are transformed through mixing, upwelling and subduction in this region where geography subdivides basins, both supporting and inhibiting abyssal inflow and maintaining regional asymmetries in diapycnal mixing. These characteristics allow the South Atlantic to play pivotal interconnected roles in the global overturning circulation, the carbon cycle and the climate system as a whole. At the largest scales, the characteristics of these water masses have been subject to detectable climate-related changes, but much remains to be understood as the complexity of the system leaves fundamental questions concerning the magnitude, and spatial and temporal variation of properties, overturn, pathways and mixing in this unique basin unanswered.
Here we present a new study that encompasses three interrelated aspects of the deep South Atlantic's circulation and water property distributions to shed light a) regional (sub-basin) distributions of properties and their associated carbon, oxygen, nutrient, freshwater and heat budgets; b) pathways and transformation of deep waters through overturn and mixing; and c) the evolution in overturning circulation and properties from the 1990s to present-day. As we begin this investigation the main focus of our research will be the subtropical South Atlantic where recent repeat transects now provide

three or more occupations of long lines and where signals from north, south, east and west can be seen in the deep waters along the zonal lines. We present the first results a statistical examination of observed variability (both inherent and possibly anthropogenic) in water mass properties focusing on waters deeper than about 1000 m, that is intermediate waters and below.

Bottom water flows in the fractures of the Northern Mid-Atlantic Ridge

Abstract ID : 65

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Eugene Morozov ,egmorozov@mail.ru ,(Head of Laboratory) ,Russia ,Moscow ,Not Presenting[1]

Mr Tatiana Demidova ,tad-ocean@mail.ru ,(None) ,Russia , ,Not Presenting[2]

Dr. Roman Tarakanov ,rtarakanov@gmail.com ,(Leading Researcher) ,Russia ,Moscow ,Not Presenting[1]

Mr. Dmitry Frey ,dima.frey@gmail.com ,(PhD Student) ,Russia ,None ,Not Presenting[4]

Mr Nikolay Makarenko ,nick_mak@mail.ru ,(None) ,Russia , ,Not Presenting[5]

1 - Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia 2 - Shirshov Institute of Oceanologt 3 - Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia 4 - None 5 - Lavrentiev Institute of Hydrodynamics

We study the flows of Antarctic Bottom Water through the fracture zones in the northern part of the Mid-Atlantic Ridge based on the field studies in 2014, 2015, and 2016. We measured the thermohaline properties and velocities of the bottom water in several fractures of the Northern Mid-Atlantic Ridge. We analyzed the flows of bottom water in the Strakhov, Bogdanov, Nameless (7°28' N), Vernadsky, Doldrums, Arkhangelsky, Vema, Marathon, Fifteen Twenty, and Kane fracture zones. Previously, targeted scientific research of water properties and currents has been carried out only in the Vema Fracture Zone. These abyssal channels connect the deep basins of the East and West Atlantic. In addition to the known fact that the main portion of water propagates through the Vema Fracture Zone (11° N) we estimated that approximately the same volume propagates through the other fractures. However the pathway for the coldest water is located in the Vema Fracture Zone. Velocities of bottom currents in this fracture reach 45 cm/s. strong interannual variability of the structure and transport through the Vema FZ was found. The transport varies from 0.7 to 1.0 Sv. The core of maximum velocity changes its depth between 4000 m and the bottom at 4650 m. An underwater cataract was found in the southern channel of the Vema FZ. Over a distance of one mile the bottom water rapidly descends from 4560 m to 4720 m (the slope is approximately 1/5). This flow in the cataract is concentrated in a narrow trough 1500 m wide. The velocity at the upper point is 40 cm/s, but at the lower point the velocity decreases to 20 cm/s. Another velocity maximum (17 cm/s) was found at a depth of the sill (4440 m).

Composition and variability of the Denmark Strait Overflow Water in a high-resolution numerical model hindcast simulation

Abstract ID : 220

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Erik Behrens ,erik.behrens@niwa.co.nz ,(Ocean Modeller) ,New Zealand ,Wellington ,Not Presenting[1]

Prof. Arne Biastoch ,abiastoch@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[2]

Dr. Benjamin Harden ,bharden@whoi.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Kjetil Vage ,kjetil.vage@gfi.uib.no ,(None) ,Norway , ,Not Presenting[4]

Prof. Claus Böning ,cboening@geomar.de ,(None) ,Germany , ,Not Presenting[2]

1 - NIWA 2 - GEOMAR Helmholtz Centre for Ocean Research Kiel 3 - WHOI 4 - Geophiscal Institute, University Bergen 5 - GEOMAR Helmholtz Centre for Ocean Research Kiel

The upstream sources and pathways of the Denmark Strait Overflow Water and their variability have been investigated using a high-resolution model hindcast. This global simulation covers the period from 1948 to 2009 and uses a fine model mesh (1/20°) to resolve mesoscale features and the complex current structure north of Iceland explicitly. The three sources of the Denmark Strait Overflow, the shelfbreak East Greenland Current (EGC), the separated EGC, and the North Icelandic Jet, have been analyzed using Eulerian and Lagrangian diagnostics. The shelfbreak EGC contributes the largest fraction in terms of volume and freshwater transport to the Denmark Strait Overflow and is the main driver of the overflow variability. The North Icelandic Jet contributes the densest water to the Denmark Strait Overflow and shows only small temporal transport variations. During summer the net volume and freshwater transports to the south are reduced. On interannual timescales these transports are highly correlated with the large-scale wind stress curl around Iceland and, to some extent, influenced by the North Atlantic Oscillation, with enhanced southward transports during positive phases. The Lagrangian trajectories support the existence of a hypothesized overturning loop along the shelfbreak north of Iceland, where water carried by the North Icelandic Irminger Current is transformed and feeds the North Icelandic Jet. Monitoring these two currents and the region north of the Iceland shelfbreak could provide the potential to track long-term changes in the Denmark Strait Overflow and thus also the AMOC.

AMOC – Simulating the great unknown

Abstract ID : 300

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Arne Biastoch ,abiastoch@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[1]

1 - GEOMAR Helmholtz Centre for Ocean Research Kiel

The Atlantic Meridional Overturning (AMOC) is the prime integral quantity to describe the global ocean circulation in past, current and future times. Through its linkage to meridional heat transport it shapes the global heat distribution and budgets, through its influence on the uptake and transport of trace gases it effectively removes carbon from the surface ocean; both being important mechanisms in determining global climate and modulating climate change. It is therefore of genuine interest to properly simulate the AMOC and its key processes with ocean general circulation models (OGCM). However, the AMOC is also one of the most complicated quantities, not simulated directly but rather appearing as a result of (often originally rather unspectacular) model choices. In my talk, I will review the ability and difficulty of current OGCM in simulating the AMOC. I will demonstrate sometimes trivial 'successes' in simulating the interannual variability of continuous time series such as RAPID, which appears in strong contrast to the difficulty in properly representing decadal changes and long-term trends. I will review the importance of far-field causes and external drivers for changes of the AMOC in the South and North Atlantic oceans and the influence of a properly resolving mesoscale circulation.

Recent advances in theoretical modeling of the meridional overturning circulation

Abstract ID : 369

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Helen Johnson ,helen.johnson@earth.ox.ac.uk ,(Associate Professor) ,United Kingdom ,Oxford ,Not Presenting[1]

1 - University of Oxford

Over the last decade, RAPID-MOCHA and other observations, together with a new generation of ocean and climate models, have provided new and intriguing insight into the Atlantic MOC. Theoretical models have also contributed to changing our view of the AMOC, providing a dynamical framework for understanding the new observations and modelled complexity. In this talk we review recent advances in the theoretical modelling of the AMOC, and the conceptual understanding that has resulted from careful, pared-down thinking about the circulation.
We discuss recent theoretical models that address questions such as (a) the interplay between surface buoyancy and wind forcing, (b) the extent to which the AMOC is adiabatic, (c) interaction between the upper North Atlantic Deep Water cell and the lower Antarctic Bottom Water cell, (d) the role of basin geometry and bathymetry, and (e) the importance of a 3D multiple-basin picture. We review new paradigms for deep water formation in the high-latitude North Atlantic and the impact of diapycnal mixing on vertical motion in the ocean interior. And we discuss advances in our understanding of the AMOC's stability and its scaling with large scale meridional density gradients. Along with reviewing theories for the mean AMOC, we consider models of AMOC variability, both intrinsic to the ocean and in response to surface forcing variability, and we discuss what we have learned from theory about the detection and meridional propagation of AMOC anomalies.
Simple theoretical and conceptual models remain a vital and revealing tool in articulating our current understanding of the AMOC and identifying which processes are most critical to capture in the next generation of numerical ocean and climate models.

On the structure and variability of the Meridional Overturning Circulation in the subtropical North Atlantic

Abstract ID : 384

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Claudia Schmid ,Claudia.Schmid@noaa.gov ,(scientist) ,United States ,Miami ,Not Presenting[1]

Dr. Sudip Majumder ,Sudip.Majumder@noaa.gov ,(None) ,United States , ,Not Presenting[2]

1 - NOAA/AOML 2 - CIMAS/UM and NOAA/AOML

An observations-based monthly time series extending from 1993 to 2015 is used to derive the transports associated with the Meridional Overturning Circulation (MOC) in the subtropical North Atlantic Ocean. This is accomplished by following a method applied in the South Atlantic to estimate the horizontal velocity in the upper 2000 m from Argo observations and sea surface height (this product has been called Argo & SSH). As is the case in the South Atlantic, the boundary regions and the deeper layers need to be padded with climatology for the purpose of deriving the transports associated with the MOC. In addition, Argo & SSH can not provide information on the transport in the Florida Straits. To derive transports there, the Florida Current time series from the MOCHA/RAPID estimates are used in conjunction with Argo & SSH. Initial estimates for 27N from Argo & SSH are in very good agreement with those from MOCHA/RAPID, both in terms of the averages and the variability. The mean strength of the MOC is 17 Sv with a standard deviation of 5 Sv for the two independent estimates, while the mean meridional heat transport is similar (0.9 +/- 0.4 PW for Argo & SSH, 1.1 +/- 0.4 PW for MOCHA/RAPID). At this latitude, the estimated transports from Argo & SSH derived by using a deep reference level rather than a barotropic adjustment of the geostrophic velocity yields very similar results (19 +/- 5 Sv, 1.1 +/- 0.4 PW). At 41N, the results obtained with this Argo & SSH product are in quite good agreement with those derived by Hobbs and Willis (2012), with about 0.5 PW. It is found that the dependence on the adjustment or reference level used to estimate the geostrophic velocity at this latitude is larger than at 27N. The reason for this will be studied. Argo & SSH also results in transports that are consistent with earlier estimates at 37N, with little dependence on the geostrophic approach. A joint analysis of the variability at multiple latitudes will be used to improve the understanding of the MOC and its relationship to various ocean and atmospheric indexes.

Recent advances in South Atlantic and Southern Ocean Meridional Overturning Circulation

Abstract ID : 401

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Maria Paz Chidichimo ,mariapaz.chidichimo@gmail.com ,(Researcher) ,Argentina ,Ciudad Autónoma de Buenos Aires ,Not Presenting[1]

1 - Argentine Research Council (CONICET) / Hydrographic Service

The meridional overturning circulation (MOC) of the ocean plays a key role in the time-variable coupled climate system because of its ability to store and transport heat, fresh water and carbon globally. The South Atlantic Ocean has a unique location connecting the North Atlantic Ocean, were the largest volume of deep water is formed, with the other ocean basins. The North Atlantic Deep Water flows southward along the coast of South America and through the basin interior and it is compensated by northward flow of upper and intermediate waters across the basin. As a result, the South Atlantic transports heat from the pole towards the equator. The Pacific Ocean and the Indian Ocean are connected with the Atlantic basin through circulation pathways south of Africa and South America in the Agulhas retroflection and in the Drake Passage regions, respectively. Models suggest that changes generated in the Southern Ocean are transmitted through inter-ocean exchanges to the northern basins. Models and observations have shown that the water masses formed in remote regions and subsequently transiting the South Atlantic are significantly altered within this basin by processes such as mixing, advection, and local air-sea interactions, which are more intense in regions of high mesoscale activity. These modifications may lead to changes of the MOC strength and variability and the associated meridional heat and freshwater transports. In the past decade, the South Atlantic and Southern Oceans observing systems have expanded with moored arrays and intense hydrographic surveys revealing important information to increase our knowledge and understanding of the variability introduced to the MOC. In this talk, these observational efforts will be reviewed and discussed.

Mechanisms underlying recent decadal changes in subpolar North Atlantic Ocean heat content

Abstract ID : 408

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Rui Ponte ,rponte@aer.com ,(None) ,United States ,Lexington, MA 02421-3126 ,Not Presenting[1]

Dr. Christopher Little ,clittle@aer.com ,(None) ,United States , ,Not Presenting[1]

Dr. Martha Buckley ,mbuckle6@gmu.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Christopher Piecuch ,cpiecuch@aer.com ,(None) ,United States , ,Not Presenting[1]

Dr. Ichiro Fukumori ,ichiro.fukumori@jpl.nasa.gov ,(None) ,United States , ,Not Presenting[5]

1 - AER 2 - AER 3 - George Mason University 4 - AER 5 - Jet Propulsion Laboratory

The subpolar North Atlantic (SPNA) is subject to strong decadal variability, with implications for surface climate and its predictability. In 2004-2005, SPNA decadal upper-ocean and sea-surface temperature trends reversed from warming during 1994-2004 to cooling over 2005-2015. A previous study using hydrographic data, atmospheric reanalyses, and climate models relates this SPNA climate shift to anomalous ocean heat transport by the Atlantic meridional overturning circulation in response to earlier changes in central Labrador Sea conditions. Here, the recent decadal trend reversal in SPNA ocean heat content is studied using a dynamically and kinematically consistent, observationally constrained global ocean state estimate covering 1992-2015. The estimate's physical consistency facilitates quantitative and comprehensive causal attribution of ocean variations. Closed heat budget diagnostics reveal that the SPNA ocean heat content trend reversal is the result of heat advection by midlatitude ocean circulation. Kinematic decompositions reveal that ocean heat transports by horizontal gyre circulations render the primary contributions, whereas effects of deep and intermediate vertical overturning circulation are secondary. The shift in horizontal gyre advection reflects anomalous circulation acting on the mean temperature gradients. Maximum covariance analysis reveals strong covariation between the anomalous horizontal gyre circulation and variations in the local wind stress curl, suggestive of a Sverdrup response. Results have implications for decadal predictability.

The role of eddy resolving ocean resolution in simulating the AMOC

Abstract ID : 478

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Malcolm Roberts ,malcolm.roberts@metoffice.gov.uk ,(Manager, Global high resolution climate modelling) ,United Kingdom ,Exeter ,Presenting[1]

Dr. Pierre Mathiot ,pierre.mathiot@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr Helene Hewitt ,helene.hewitt@metoffice.gov.uk ,(None) ,United Kingdom , ,Presenting[3]

1 - Met Office Hadley Centre 2 - Met Office Hadley Centre 3 - Met Office

Eddy resolving ocean resolution leads to improvements in the simulation of many local features which are key components of the Atlantic Meridional Overturning Circulation (AMOC) including the Gulf Stream and the Nordic overflows. Here we examine the mean state and variability of the AMOC in an eddy resolving version of the Met Office coupled climate model, and compare it to lower resolution counterparts. A key factor for the AMOC at eddy permitting resolution is shown to be the representation of more detailed bathymetry. The change in the AMOC under 4xCO2 forcing is explored in order to address the role resolution plays in determining the response of the AMOC to warming, and the extent to which this is determined by the initial state of the AMOC.

Strong mixing and recirculation in the southwest South Atlantic

Abstract ID : 494

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Daniel Valla ,danovalla@gmail.com ,(Graduate Student) ,Argentina ,Buenos Aires ,Not Presenting[1]

Mr Alberto Piola ,apiola@hidro.gov.ar ,(None) ,Argentina , ,Not Presenting[2]

1 - Servicio de Hidrografía Naval 2 - Univ. Buenos Aires

The Atlantic Meridional Overturning Circulation (AMOC) is associated with the meridional transport of volume, salt and heat, thus playing a central role in global climate. As part of ongoing efforts to monitor the intensity and variability of the South Atlantic component of the AMOC, hydrographic sections extending 650 km from the western boundary have been regularly occupied along a zonal line at 34.5 °S since 2009. This unprecedented high-quality, high-resolution data set is analyzed to establish the average hydrographic conditions of the north-western Argentine Basin, their variations and the pathways of the major water masses flowing through the region. The time averaged section presents a rich vertical structure, which is characterized by the presence of seven distinct layers of northern and southern origin, each with unique property signatures. It also presents a sharp zonal structure in almost all layers which are indicative of ubiquitous recirculation cells. The intermediate levels comprise two water masses originated in the Southern Ocean: the Antarctic Intermediate Water (AAIW) and the Upper Circumpolar Deep Water. The circulation is similar for both layers and displays a previously undetected recirculation cell confined to the western boundary. This pattern extends at least from 34.5 to ~27 °S. The southward branch closely follows the continental slope and flows beneath the Brazil Current, whereas the northward branch flows approximately 200-300 km farther offshore. The latter is responsible for short-circuiting newly form, relatively colder and fresher AAIW into the subtropical domain, which may be subsequently exported to the North Atlantic, thus affecting the return upper limb of the AMOC. The deep level is characterized by the presence of a well-defined Deep Western Boundary Current which conveys recently formed North Atlantic Deep Water (NADW) close to the continental slope at 2700 m depth. A deep recirculation cell is also observed at this level, with a northward branch flowing ~500 km away from the slope and carrying substantially modified NADW from south of 34.5 °S. In addition, significant salinity and dissolved oxygen variations are observed at core of this recirculated NADW between successive CTD occupations, which may be associated with meanders of the DWBC.

AMOC components in the North Atlantic subpolar gyre

Abstract ID : 506

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Rhein Monika ,mrhein@physik.uni-bremen.de ,(None) ,Germany ,Bremen ,Not Presenting[1]

Mr. Mertens Christian ,cmertensl@uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Roessler Achim ,aroessler@uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Kieke Dagmar ,dkieke@uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Klein Birgit ,birgit.klein@bsh.de ,(None) ,Germany , ,Not Presenting[5]

Prof. Claus Böning ,cboening@geomar.de ,(None) ,Germany , ,Not Presenting[6]

1 - IUP-MARUM, Uni Bremen 2 - IUP-MARUM, Uni Bremen 3 - IUP-MARUM, Uni Bremen 4 - IUP-MARUM, Uni Bremen 5 - BSH, Hamburg 6 - GEOMAR Helmholtz Centre for Ocean Research Kiel

Circulation and water mass formation in the subpolar North Atlantic is sensitive to atmospheric changes, thus it exhibits large natural variability in circulation and temperature / salinity patterns. Long-term time series of these quantities are necessary to study the fluctuations and the processes involved and to separate and detect variability caused by anthropogenic warming in the future. Shipboard and moored hydrographic observations, Argo and altimeter data are combined with the output of the high resolutinn VIKING20 model to study and quantify the exchange of the main components of the Atlantic meridional overturning circulation between the subtropical and the subpolar regime.

Sources for the upper limb of the AMOC – cold and warm water routes revisited in an eddy-resolving ocean model

Abstract ID : 605

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Siren Rühs ,sruehs@geomar.de ,(PhD candidate) ,Germany ,Kiel ,Presenting[1]

Prof. Arne Biastoch ,abiastoch@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[1]

Dr. Franziska Schwarzkopf ,fschwarzkopf@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[3]

1 - GEOMAR Helmholtz Centre for Ocean Research Kiel 2 - GEOMAR Helmholtz Centre for Ocean Research Kiel 3 - GEOMAR Helmholtz Cebtre for Ocean Research Kiel

The upper limb of the Atlantic Meridional Overturning Circulation (AMOC), providing a net northward heat transport across the equator, is recognized for its importance in modulating European as well as global climate variability. It is supplied by waters entering the South Atlantic mainly via two routes, through the Agulhas Current in form of Agulhas Leakage and through Drake Passage, traditionally referred to as the warm and cold water routes, respectively. However, there is no consensus on the relative importance of these two sources for the northward flow and heat transport in the tropical Atlantic, as well as on their possible interplay.
Previous studies addressing these issues were mostly based on the evaluation of non-eddying ocean model simulations. Here we revisit the relations between the two routes by using Lagrangian analyses of a hindcast with the global-nested ocean general circulation model INALT20, which is eddy-resolving (1/20° horizontal resolution) in the South Atlantic and respective Southern Ocean sector. Virtual fluid particles were released within the North Brazil Current, which has been identified as a choke point for the inter-hemispheric northward flow and heat transport, and traced backwards in time to the locations where they entered the South Atlantic. Conditional pathways, associated timescales, temperature and salinity characteristics at the sources, as well as their transformation during the particles transits through the South Atlantic are investigated.
Our results emphasize a substantial contribution of waters originating at Drake Passage, as well as a complex interplay between these waters and those entering the South Atlantic via the Agulhas Current, which hampers a clear distinction between cold and warm water routes. Due to extensive mixing processes, the source waters are losing their initial temperature and salinity characteristics relatively fast and become nearly indistinguishable upon reaching the North Brazil Current.

Potential for deep convection in the Arctic Basin under a warming climate and contribution to the AMOC

Abstract ID : 615

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Camille Lique ,camille.lique@ifremer.fr ,(None) ,France , ,Not Presenting[1]

Dr. Matthew Thomas ,matthew.thomas@yale.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Helen Johnson ,helen.johnson@earth.ox.ac.uk ,(Associate Professor) ,United Kingdom ,Oxford ,Not Presenting[3]

Dr. Yves Plancherel ,yves.plancherel@earth.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - IFREMER 2 - Yale University 3 - University of Oxford 4 - University of Oxford

Model studies have previously suggested a link between variations in the rate of deep water formation in the North Atlantic and variations in the strength of the Atlantic Meridional Overturning Circulation (AMOC), but the dynamical link between the two is not fully understood. Here, we investigate the potential for deep Mixed Layer Depths (MLDs) to appear in the Arctic Basin under a warming climate, and we quantify the potential contribution of deep convection in the Arctic Basin to the AMOC.
We use results from "present day" simulations of two climate models (CNRM and HiGEM) and also from simulations with a four times increase in atmospheric CO2 levels, representing a future, warmer climate. Under a warming climate, we expect (i) a reduction of the AMOC, (ii) a shoaling of the MLD in the North Atlantic and (iii) a northward retreat of the sea ice edge.
First, we document the changes affecting the MLD in the Arctic and the North Atlantic under a warming climate. There is a strong shoaling of the MLD in the present-day areas of deep convection in the North Atlantic, but also a deepening in the Arctic Ocean, where MLD can episodically reach up to ~1000m. Looking at the temporal and spatial structures of the changes affecting the ocean surface properties reveals that the Eurasian Basin undergoes a strong surface warming (linked with the sea ice retreat) and a strong salinization (due to the intensification of the Arctic surface gyres driven by stronger surface stress as the sea ice pack is thinning). Together, these changes decrease the stratification, triggering convective events in the basin.
Second, a quantitative Lagrangian diagnostic is applied to climate model output to determine where the mixed layer subduction contributes to the AMOC. For "present-day" conditions, the main contributions to the AMOC are mixed layer subduction in the Labrador, Irminger and Greenland Seas. In contrast, in the 4xCO2 simulations, the AMOC is greatly reduced and mixed layer subduction in the Arctic Basin and the subtropical gyre contribute significantly to the AMOC, the latter being likely related to a change of the stratification.

The late 2000's decrease in the Atlantic Meridional Overturning Circulation

Abstract ID : 616

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. David Smeed ,das@noc.ac.uk ,(None) ,United Kingdom ,Southampton ,Presenting[1]

Dr. Simon Josey ,simon.josey@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Claudie Beaulieu ,C.Beaulieu@soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. William Johns ,bjohns@rsmas.miami.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Ben Moat ,ben.moat@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Eleanor Frajka-Williams ,e.frajka-williams@soton.ac.uk ,(Associate Professor) ,United Kingdom ,Southampton ,Not Presenting[3]

Mr. Darren Rayner ,darren.rayner@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]

Dr. Christopher Meinen ,Christopher.Meinen@noaa.gov ,(Oceanographer) ,United States ,Miami ,Not Presenting[8]

Mr Molly Baringer ,molly.baringer@noaa.gov ,(None) ,South Africa ,None ,Not Presenting[9]

Prof. Harry Bryden ,H.Bryden@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. Gerard McCarthy ,gerard.mccarthy@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]

1 - National Oceanography Centre 2 - National Oceanography Centre 3 - University of Southampton 4 - RSMAS 5 - National Oceanography Centre 6 - University of Southampton 7 - NOC 8 - NOAA-AOML 9 - NOAA/AOML 10 - University of Southampton 11 - NOC

Variability of the Atlantic Meridional Overturning Circulation (AMOC) plays a central role in the climate of the North Atlantic. Observations in the sub-tropical North Atlantic showed that the AMOC reduced by 10% over the period from 2007 to 20111, and it has been suggested that the reduction was forced by changes in the properties of Labrador Sea deep-water. Using new data from the RAPID array at 26°N we show that the AMOC has not reduced further but now occupies a weaker circulation state relative to the first years of observations. Changes of both surface and deep waters contributed to this change. This change of AMOC state is concurrent with other changes in the North Atlantic including a more northerly path of the Gulf Stream, evidenced by a change in the currents observed by satellite altimetry, and by an altered pattern of sea-surface temperature (SST). The observed change in SST is described by a dipole that resembles the pattern of response to a declining AMOC predicted by coupled climate models3. Concurrent changes in air-sea fluxes reveal that the changes in ocean heat transport and sea-surface temperature have altered the pattern of ocean-atmosphere heat exchange over the North Atlantic. These results provide strong evidence to support the hypothesis that the AMOC is a major factor in decadal scale internal variability of North Atlantic climate.

On the buoyancy-driven theory of the Atlantic meridional overturning circulation

Abstract ID : 712

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Remi Tailleux ,R.G.J.Tailleux@reading.ac.uk ,(None) ,United Kingdom ,Reading ,Not Presenting[1]

1 - University of Reading

In the mid-late 90s, the classical buoyancy-driven view of the Atlantic meridional overturning circulation (AMOC), according to which the AMOC is set up by high-latitude cooling, was challenged by two alternative mechanically-driven views. The first one is related to the 'Drake passage' effect, according to which the AMOC responds nearly linearly to changes in zonal winds at the latitude of Drake Passage. The second-one is related to the mixing-driven view of the AMOC, according to which the upwelling branch of the AMOC is supposed to be powered by small-scale mixing occurring in response to the mechanical stirring by winds and tides. These developments were accompanied by strong attacks against Lorenz's theory of available potential energy - which had until then been the standard framework for the buoyancy-driven view of the AMOC --- ranging from completely omitting APE theory from reviews of ocean energetics to constructing an ad-hoc new definition of buoyancy power input consistent with the idea that the latter is negligible. Given the incompatible character of the buoyancy- and mechanically-driven views of the AMOC, there is no question that only one view can be correct. In this talk, I will argue that the 'ocean heat engine controversy' can be traced back to incompatible views on the energy pathways taking place in stratified turbulent mixing, specifically to the question of what the ultimate source of energy for the net increase in background gravitational potential energy (BGPE) that is generally observe to accompany a turbulent mixing event? Thus, in the mechanically-driven view of the AMOC, BGPE increases at the expense of the energy supplied by winds and tides, whereas in the buoyancy-driven view, BGPE increases at the expenses of the internal energy associated with the mean vertical density gradient created by surface buoyancy fluxes. It is easily showed, however, that only the latter is compatible with the second law of thermodynamics. Therefore, only the buoyancy-driven view can be correct. Moreover, it is also easily explained why neither the Drake passage effect nor Munk and Wunsch's views on ocean mixing contradict it.

Modelling the onset of North Atlantic Deep Water formation across the Eocene-Oligocene Transition

Abstract ID : 723

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. David Hutchinson ,david.hutchinson@geo.su.se ,(Postdoctoral Researcher) ,Sweden ,Stockholm ,Not Presenting[1]

Dr. Agatha de Boer ,agatha.deboer@geo.su.se ,(None) ,Sweden ,None ,Not Presenting[1]

Dr. Helen Coxall ,helen.coxall@geo.su.se ,(None) ,Sweden , ,Not Presenting[1]

Prof. Rodrigo Caballero ,rodrigo@misu.su.se ,(None) ,Sweden , ,Not Presenting[1]

Prof. Johan Nilsson ,nilsson@misu.su.se ,(None) ,Sweden , ,Not Presenting[1]

1 - Stockholm University 2 - Stockholm University 3 - Stockholm University 4 - Stockholm University 5 - Stockholm University

Geological evidence suggests that North Atlantic Deep Water (NADW) first formed around the Eocene-Oligocene Transition (EOT), a climate transition 34 Ma ago when semi-permanent ice sheets on Antarctica first formed. In earlier periods, deep water is thought to have formed in the Southern Ocean and possibly the North Pacific. Here we investigate possible causes of this reorganization of the deep circulation. We present, for the first time, the coupled climate model GFDL CM2.1 to simulate the EOT climate transition using late Eocene paleogeography. Using this paleogeography, we find that the North Atlantic becomes very fresh, which prevents NADW formation. Instead sinking occurs in the North Pacific and Southern Ocean in agreement with Eocene circulation proxies. We test the role of greenhouse forcing by varying the CO_2 to values of 400, 800 and 1600 ppmv. We find that under cooler conditions the high latitudes of the North Atlantic become saltier due to a weakening of the hydrological cycle, but this effect is not large enough to destabilize the strong North Atlantic halocline and induce sinking. We further test the effect of closing the Arctic-Atlantic gateway. This experiment is motivated by geological data that suggest that the Arctic Ocean became isolated at the EOT. The gateway closure shuts off freshwater export from the Arctic to the Atlantic. This change enables a strong salinification of the North Atlantic that triggers the onset of NADW production. Closing the Arctic-Atlantic gateway also alters the salt advection feedback in the Pacific basin, causing deep water formation to shut down in the North Pacific.

A Possible Cause for Recent Decadal Atlantic Meridional Overturning Circulation Decline

Abstract ID : 790

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Mojib Latif ,mlatif@geomar.de ,(Professor) ,Germany ,Kiel ,Not Presenting[1]

1 - GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel

The Atlantic Meridional Overturning Circulation (AMOC) is a major oceanic current system with widespread climate impacts. AMOC influences have been discussed among others with regard to Atlantic hurricane activity, regional sea level variability, and surface air temperature and precipitation changes on land areas adjacent to the North Atlantic Ocean. Most climate models project significant AMOC slowing during the 21st century, if atmospheric greenhouse gas concentrations continue to rise unabatedly. Recently, a marked decadal decline in AMOC strength has been observed, which was followed by strongly reduced oceanic poleward heat transport and record-low sea surface temperature in parts of the North Atlantic, which has been linked to record-low densities in the deep Labrador Sea. Here, we provide evidence from observations and ocean re-analyses that the decadal AMOC decline was due to the combined action of the North Atlantic Oscillation and the East Atlantic Pattern, the two leading modes of North Atlantic atmospheric surface pressure variability, which prior to the AMOC decline both transitioned into their negative phases. This change in atmospheric circulation diminished the oceanic heat loss over the Labrador Sea and forced ocean circulation changes lowering upper ocean salinity transport into that region. In response Labrador Sea deep convection weakened, which slowed the AMOC and reduced the associated northward heat transport. This new mechanism for decadal AMOC variability, involving both the NAO and the EAP, has implications for multiyear climate predictability and climate change detection in the North Atlantic sector.

Recent advances in observing the North Atlantic Meridional Overturning Circulation

Abstract ID : 851

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Stuart Cunningham ,Stuart.Cunningham@sams.ac.uk ,(Head of Environmental Physics & Autonomous Technology) ,United Kingdom ,Oban ,Not Presenting[1]

1 - The Scottish Association for Marine Science

Earth's climate, particularly the warm northern hemisphere, is tied to meridional heat, fresh-water and anthropogenic carbon transported by the AMOC. Ocean-atmosphere exchanges in the North Atlantic are fundamental in driving AMOC variability and trends. Climate models forecast a 50% slowing of the AMOC this century as warming and freshening inhibits convection. Observing and understanding the AMOC in our changing climate is essential for climate predictions.

What do we require from the observing system? 1. To quantify AMOC mean strength and variability at intra-annual to centennial timescales, throughout the Atlantic, in both depth and density space; 2. Determine fluxes of heat, salt and carbon; 3. Relate these to wind, buoyancy, eddy forcing and to storage changes; 4. Constrain reanalyses and models for climate prediction. The observing challenge is substantial.

Elements of an observing system are in place. Purposefully designed transatlantic, full-depth mooring arrays are established in the subtropics (RAPID at 26°N) and subpolar region (OSNAP at 57°N). Combined with Argo and altimetry data they quantify heat and fresh-water fluxes and are able to partition flows in informative coordinate frames.

AMOC components have been observed for decades by arrays measuring exchanges with the Nordic Seas and the Arctic Ocean, and are important for monitoring fresh-water transport. In the tropical Atlantic (MOVE at 16°N) monitors transport fluctuations of southward flowing North Atlantic Deep Water.

The Global Hydrographic Investigations Program defines an array of ten decadal repeat hydrographic sections in the North Atlantic. These provide climate quality observations of the ocean below and inshore of the 2 km isobath, and link physical to biogeochemistry and ecosystems.

Coastal sea-level and ocean-atmospheric modes of variability have been linked to AMOC variability using data from the Global Sea-Level Observing System.

Satellite-tracked surface drifting buoys of the Global Drifter Programme inform pathways of connectivity and support short-term seasonal to interannual climate predictions.

Increasing numbers of proxy climate records covering the Atlantic describe new evidence for the existence of Atlantic multidecadal variability and for exceptional AMOC changes in the 20thC.

This talk will review advances in the observing system and consider where more observations would be beneficial.

Subtropical-tropical pathways in the South Atlantic Ocean

Abstract ID : 877

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Anna Cabré ,cabre@icm.csic.es ,(None) ,Spain , ,Not Presenting[1]

Prof. Josep L. Pelegrí ,pelegri@icm.csic.es ,(Research Professor) ,Spain ,Barcelona ,Presenting[1]

1 - Institut de Ciències del Mar, CSIC 2 - Institut de Ciències del Mar, CSIC

The South Atlantic is the only basin with net heat transfer from the extratropics to the tropics. Despite its crucial role in the returning limb of the Atlantic meridional overturning circulation, the subtropical to tropical paths are yet poorly understood. Here we study these pathways using a climatological output of the GLORYS 2V4 simulation (0.25º resolution). Our goal is to understand what mechanisms connect the subtropical and tropical gyres, inducing predominant northward transfer. For this purpose we examine the proportion of subtropical-tropical transfer that occurs in the middle of the ocean as opposed to the western boundary, and the paths of propagation as a function of depth, density and location. We pay special attention to assess the spatial and temporal windows (starting at the time and location of the deepest surface mixed layer with positive wind-stress curl) that would allow the exchange between the subtropical and tropical gyres through obduction, as well as to the possibility of annual-mean epipycnal pumping (arising from the positive net correlation between latitudinal velocity anomalies and layer thickness). For our calculations we use the horizontal and vertical velocities for the annual-mean, monthly-mean and climatological flow fields. We show these velocity fields at different depth and density levels and along vertical latitudinal sections, and present the Eulerian and Lagrangian streamlines, the latter calculated through the forward and backward tracking of water particles starting at different latitudinal and meridional sections. We find that most of the transfer occurs in the western boundary through the North Brazil Undercurrent, which corresponds to water parcels along density layers that are obducted in the western half of the subtropical gyre. These waters come from the South Equatorial Current for upper thermocline waters, and from further south for the mid-thermocline layers.

Recent strengthening of deep convection in the North Atlantic Subpolar Gyre

Abstract ID : 940

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Marieke Femke de Jong ,femke.de.jong@nioz.nl ,(Tenure track scientist) ,Netherlands ,Den Burg ,Presenting[1]

Dr. Laura de Steur ,laura.de.steur@nioz.nl ,(None) ,Netherlands , ,Not Presenting[1]

1 - Royal Netherlands Institute for Sea Research 2 - Royal Netherlands Institute for Sea Research

The Subpolar North Atlantic plays a crucial role in the global ocean circulation. The Gulf Stream/North Atlantic Current transports heat northward in the upper layers. Strong winter cooling at high latitudes forms dense waters that creates the deep southward branch of the Atlantic Meridional Overturning Circulation. In global coupled climate models, dense water formation at high latitudes is tied to the strength of the northward heat transport. It is predicted that increasing stratification in the Subpolar Gyre, either due to increasing surface temperatures or freshwater release from Greenland, will inhibit deep water formation in a changing climate. In the models this results in a decrease of AMOC strength and local cooling over the Subpolar Gyre in the near future. Recent observations of reduced transport at the RAPID line at 26.5°N and anomalously cold surface temperatures in the Subpolar Gyre have led to some studies suggesting that this process is already at work. However, although the transport at 26.5°N is indeed reduced it is not linked to weakened convection in the high latitudes. In situ observations show that deep convection has strengthened rather than weakened during recent years. Record depth mixed layers were observed in the Irminger Sea in the winter of 2014-2015. In the same winter mixed layers in the Labrador Sea reached the deepest depths since 1994. Overall, the current hydrography of the Subpolar Gyre is reminiscent of the early 1990s, a period characterized by high North Atlantic Oscillation (NAO) index and strong atmospheric forcing. Similarly, the recent deep convection events were caused by an exceptionally long and cold winter during a high NAO. The anomalously low sea surface temperatures observed in the Subpolar Gyre appear to be the consequence of this strong local atmospheric cooling rather than transport changes in the AMOC.

The importance of deep, basinwide measurements in optimized Atlantic Meridional Overturning Circulation observing arrays

Abstract ID : 944

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Gerard McCarthy ,gerard.mccarthy@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Jennifer Mecking ,J.Mecking@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Matthew Menary ,matthew.menary@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. Ben Moat ,ben.moat@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. David Smeed ,david.smeed@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - NOC 2 - University of Southampton 3 - UK Met Office 4 - National Oceanography Centre 5 - NOC

The Atlantic Meridional Overturning Circulation (AMOC) is a key process in the global redistribution of heat. The AMOC is typically defined as the maximum of the overturning stream function, which occurs near 30°N in the North Atlantic. The RAPID mooring array has provided full-depth, basinwide, continuous estimates of this quantity since 2004. Motivated by both the need to deliver near real-time data and optimization of the array to reduce costs, we consider alternative configurations of the mooring array and the utilisation of satellite altimetry data. Results suggest that the variability observed since 2004 could be reproduced by a single tall mooring on the western boundary and a mooring to 1500 m on the eastern boundary. This timescale of variability can also be captured by satellite altimetry based estimates. We consider the potential future evolution of the AMOC in two generations of the Hadley Centre climate models and a suite of additional CMIP5 models. The modeling studies show that deep, basinwide measurements are essential to capture correctly the future decline of the AMOC. We conclude that, while a reduced array or satellite measurements could be useful for estimates of the AMOC on subseasonal to decadal time scales as part of a near real-time data delivery system, extreme caution must be applied to avoid the potential misinterpretation or absence of a climate time scale AMOC decline that is a key motivation for the maintenance of these observations.

Study of mesoscale features in the Cape Basin: Characteristics and impacts over a large range of scales

Abstract ID : 1004

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Marion Kersalé ,marion.kersale@uct.ac.za ,(Posdoctoral researcher) ,South Africa ,Cape Town ,Not Presenting[1]

Prof. Isabelle Ansorge ,Isabelle.Ansorge@uct.ac.za ,(Head of Department) ,South Africa ,None ,Not Presenting[1]

Prof. Sabrina Speich ,speich@lmd.ens.fr ,(None) ,France , ,Not Presenting[3]

Dr. Tarron Lamont ,tarron.lamont@gmail.com ,(Marine Scientist) ,South Africa ,Cape Town ,Not Presenting[4]

Mr. Marcel van den Berg ,MARCEL@OCEANAFRICA.COM ,(None) ,South Africa , ,Not Presenting[5]

Dr. Renellys Perez ,Renellys.C.Perez@noaa.gov ,(Associate Scientist) ,United States ,Miami ,Not Presenting[6]

1 - UCT 2 - UCT 3 - ENS 4 - Department of Environmental Affairs 5 - Oceans and Coasts Research, DEA 6 - UM/CIMAS and NOAA-AOML

As part of international and national programmes (SAMOC - South Atlantic Meridional Overturning Circulation; SANAP - South African National Antarctic Programme) repeat monitoring lines attached to relief voyages of South African scientific bases have been conducted. In the framework of these projects, our work focuses on the eastern part of the SAMBA array (South Atlantic MOC Bassin-wide Array) offering a ideal set of data to observe the exchanges between Indian and Atlantic oceans. The eastern side of the SAMBA array presently consists of current meter moorings and CPIES (Current and Pressure equipped Inverted Echo Sounders) that are deployed along the latitude 34.5°S crossing the Agulhas ring corridor, from the shelf to near the Walvis Ridge offshore. The analysis of the SAMBA-east moored data sets, from September 2014 to December 2015, provides some accurate information on the mesoscale features in the Cape basin and their influences on local water masses distribution. Comparison between the data sets will allow us to validate and define the substantial role of different components on the total variabilities of the velocity fields and sea surface height. Understanding the characteristics of the local dynamics associated with the Greater Agulhas Current system represents a fundamental step towards our understanding of the strength and variability of the MOC and so the climate system variability.

Fast ocean overturning response to non-local wind forcing

Abstract ID : 1027

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Eleanor Frajka-Williams ,e.frajka-williams@soton.ac.uk ,(Associate Professor) ,United Kingdom ,Southampton ,Not Presenting[1]

Dr. Felix Landerer ,Felix.W.Landerer@jpl.nasa.gov ,(None) ,United States , ,Not Presenting[2]

1 - University of Southampton 2 - Jet Propulsion Laboratory, Pasadena CA

Fast ocean overturning response to non-local wind forcing
In 2009/10 the MOC at 26°N underwent a striking reduction, including a short duration reversal. This was repeated in 2010/11 and in March 2013. During this event, the zonal winds at 26°N switched from their typical easterly orientation to strongly westerly, and the associated meridional Ekman transport reversed sign to southward. Curiously, however, the deep ocean responded simultaneously with a northward anomaly in transports below 3000 m. Separately, investigations into measuring ocean transports and the MOC in particular have shown that both altimetry and GRACE ocean bottom pressure recover some portions of the ocean circulation variability. Here we use satellite observations and reanalysis winds to elucidate the events of 2009/10, 2010/11 and March 2013. We find that the MOC reduction at 26°N is part of a basin-scale response to wind stress curl forcing over the northeast Atlantic, one symptom of which was the previously noted reversal of zonal winds at 26°N. The consequence is that using satellite observations, the local transport variations at 26°N can be placed in the context of the basin-scale Atlantic circulation.

The Atlantic-Pacific Buoyancy Dipole and the Thermodynamic Role of the Global Overturning Circulation

Abstract ID : 1222

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Emily Newsom ,enewsom@caltech.edu ,(NOAA CG&D Postdoctoral Fellow, Caltech) ,United States ,Pasadena ,Not Presenting[1]

1 - None

Models of the Meridional Overturning Circulation (MOC) traditionally focus on differences in continental geometry between the northern and southern extra-tropics, highlighting the unique zonal symmetry of the Southern Ocean system and instead emphasizing meridional asymmetry in the MOC. These studies reinforce a two-dimensional, two-celled, model of the MOC. Recent studies have cautioned that this two-celled model severely limits our understanding of a more complex Global Overturning Circulation (GOC), which in reality has important zonal structure and differs greatly between the Atlantic and Pacific Oceans. Here, we argue that this traditional two-celled model further obscures a fundamental feature of global-scale thermodynamic coupling between the ocean and atmosphere and the essential function of the Southern Ocean therein.

An analysis in a fully coupled global climate model (CCSM 4) reveals that the Indo- Pacific Oceans receive a significant surplus of buoyancy flux over their Equatorial and Northern Hemisphere surfaces; in contrast, the Atlantic constantly loses buoyancy to the atmosphere over the same latitudes. This asymmetric surface forcing is countered by an interior ocean buoyancy transport, accomplished by a global-scale "figure-of-eight" overturning circulation stucture between all ocean basins, which provides a global conduit of buoyancy from the Northern Hemisphere Indo-Pacific and into the Northern Hemisphere Atlantic and persists only through zonal asymmetries in the Southern Ocean circulation. While the global pattern of surface buoyancy flux and the structure of the GOC are deeply coupled, it is further argued that the distribution of surface buoyancy gains and losses is geometrically constrained by the significant differences in ocean basin width at each latitude. We present a new model for understanding the meridional and zonal structure of the GOC from a thermodynamic perspective: the overturning circulation is a means of redistributing broadly persistent, zonally asymmetrical features in oceanic heat and freshwater uptake over the global scale. This model provides a new context in which to consider zonal asymmetries in Southern, Pacific, and Atlantic Ocean dynamics, asymmetries which are essential in maintaining a steady global climate.

Recent daily AMOC variability estimates at 34.5°S from in situ observations

Abstract ID : 1332

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Sabrina Speich ,speich@lmd.ens.fr ,(None) ,France , ,Not Presenting[1]

Dr. Christopher Meinen ,Christopher.Meinen@noaa.gov ,(Oceanographer) ,United States ,Miami ,Not Presenting[2]

Mr Alberto Piola ,apiola@hidro.gov.ar ,(None) ,Argentina , ,Not Presenting[3]

Mr Edmo Campos ,edmo@usp.br ,(None) ,Brazil , ,Not Presenting[4]

Mr Silvia Garzoli ,Silvia.Garzoli@noaa.gov ,(None) ,United States , ,Not Presenting[5]

Prof. Isabelle Ansorge ,Isabelle.Ansorge@uct.ac.za ,(Head of Department) ,South Africa ,None ,Not Presenting[6]

Mr. Marcel van den Berg ,MARCEL@OCEANAFRICA.COM ,(None) ,South Africa , ,Not Presenting[7]

Dr. Tarron Lamont ,tarron.lamont@gmail.com ,(Marine Scientist) ,South Africa ,Cape Town ,Not Presenting[8]

Mr. Thierry Terre ,Thierry.Terre@ifremer.fr ,(None) ,France , ,Not Presenting[9]

Dr. Renellys Perez ,Renellys.C.Perez@noaa.gov ,(Associate Scientist) ,United States ,Miami ,Not Presenting[5]

Dr. Shenfu Dong ,Shenfu Dong <Shenfu.Dong@noaa.gov> ,(None) ,United States , ,Not Presenting[11]

1 - ENS 2 - NOAA-AOML 3 - Univ. Buenos Aires 4 - Univ. Sao Paulo 5 - UM/CIMAS and NOAA-AOML 6 - UCT 7 - Oceans and Coasts Research, DEA 8 - Department of Environmental Affairs 9 - Ifremer 10 - UM/CIMAS and NOAA-AOML 11 - NOAA/AOML

The meridional overturning circulation (MOC) is a part of the global ocean circulation that redistributes heat, freshwater and carbon throughout the world ocean. In the Atlantic, the MOC (AMOC) in particular carries heat northward, and variations in the AMOC strength have been connected to socially important quantities like precipitation pattern changes, sea level rise, and extreme weather changes across much of the planet. Recent numerical climate model projections have suggested that the present strength and structure of the AMOC may not continue, and variations could yield changes in the ocean anthropogenic carbon uptake, alterations to sea level patterns, or even possibly abrupt weather changes within the next few decades.

Monitoring of the AMOC is therefore key to understanding the state of climate change, and in particular to tracing the Earth's energy imbalance. The transport of properties by the AMOC, which is a three-dimensional circulation pattern, depends on the rate of overturning and the differences in property concentration between the upper and lower limbs of the overturning as well as upon the modifications of water properties along their global journey. Therefore observations of the AMOC must extend throughout the world's ocean basins to quantify changes and to determine their causes and impacts.

The South Atlantic Ocean plays a key role as a nexus for water masses formed elsewhere, and significant water mass changes occur as waters pass through the basin en-route to remote regions of the global ocean. Here, water masses are significantly altered by local air-sea interactions and diapycnal/isopycnal fluxes, particularly in regions of intense mesoscale activity and steep topography. These contributions have been shown to have a crucial role in the strength of the AMOC in paleoceanographic and modelling studies.

In this presentation we will discuss new estimates of the time-varying volume transports across 34.5°S in the South Atlantic derived from the SAMBA-SAMOC array. We will also discuss the variability of the transport due to eastern-boundary eddies (Agulhas Rings, cyclones, etc) from the analysis of 2 year CPIES data in the Cape Basin and multi-satellite sea-level data. These results will be also compared with estimates from different observing platforms and from OGCMs (both, deterministic models and reanalyses).

Adjustment of the upper and lower meridional overturning cells to high-latitude buoyancy forcing anomalies

Abstract ID : 1400

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Laura Cimoli ,laura.cimoli@physics.ox.ac.uk ,(PhD student) ,United Kingdom ,Oxford ,Not Presenting[1]

Prof. David Marshall ,david.marshall@physics.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Helen Johnson ,helen.johnson@earth.ox.ac.uk ,(Associate Professor) ,United Kingdom ,Oxford ,Not Presenting[2]

1 - None 2 - University of Oxford 3 - University of Oxford

The dynamical mechanisms driving the interaction between the upper and lower cells of the Atlantic Meridional Overturning Circulation (AMOC) are still poorly understood, despite the important role that these two cells play in our climate system in transporting heat and sequestering carbon. The upper and lower cells are associated with the formation of North Atlantic Deep Water in the North Atlantic, and Antarctic Bottom Water in the Southern Ocean, respectively. To what extent does a weaker (or stronger) upper cell influence the lower cell, and vice versa? What are the dynamical mechanisms driving this interaction and setting its time-scale?
In a series of idealized simulations with the MIT general circulation model, using a sector configuration at 1° resolution, we explore the response of the upper and lower cells to buoyancy forcing anomalies at high-latitudes. We investigate several forcing scenarios with different surface restoring conditions applied to either the model North Atlantic or the model Southern Ocean, both weakening and strengthening the upper and lower cells. The results show strong nonlinearities, with changes in the North Atlantic forcing not affecting the lower cell, while changes in the Southern Ocean forcing do affect the upper cell when the lower cell is made stronger, but not when the lower cell is made weaker. Both cells respond surprisingly quickly, on a time scale of 10-30 years, to a perturbation in their respective formation hemispheres. Interestingly, the upper cell responds quickly also to a stronger lower cell, following a rapid change in the slope of the isopycnals in the Southern Ocean, the dynamics of which will be discussed. The processes that propagate the anomaly through the ocean basin and set the time scale of the response will also be discussed. Moreover, we will discuss the implications for these results of sloping bathymetry and enhanced abyssal diapycnal mixing which lead to water sinking in the ocean interior and upwelling along boundary layers.

P05 - Advances in Monitoring, Detecting, Understanding, Hazard Assessment and Forecasting of Mean and Extreme Coastal Sea Level (IAPSO)

Drivers of the spatial and temporal variability in sea level extremes

Abstract ID : 126

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Philip Woodworth ,plw@noc.ac.uk ,(Visiting Scientist (Retired)) ,United Kingdom ,Liverpool ,Presenting[1]

Dr. Marta Marcos ,marta.marcos@uib.es ,(None) ,Spain , ,Not Presenting[2]

1 - National Oceanography Centre Liverpool 2 - IMEDEA (UIB-CSIC), Balearic Islands

Extreme sea levels present a number of major threats to the coastal environment. They can cause coastal flooding, thus impacting coastal ecosystems, infrastructure and communities. In the worst floods, there can be significant loss of life. High waters arise from the interplay of astronomical tides, storm surges and mean sea level (MSL) variations. Changing climatic and topographic conditions may alter one or more of these contributions to extreme sea levels, leading to increased or decreased coastal vulnerability. Understanding the distribution of extremes, their drivers and the associated risks is therefore an important requirement for coastal management.Observational evidence of extreme sea levels and their changes relies on high-frequency tide gauge records. Presently, the most extensive data base is the Global Extreme Sea Level Analysis (GESLA) data set, recently compiled and freely released (www.gesla.org). It contains the longest and most geographically representative sea level records at hourly, and higher, temporal sampling. In this contribution, we make use of the available tide gauge observations to illustrate the geographical coherence of the intensities and frequency of occurrence of sea level extremes. Changes in extremes at inter-annual to multi-decadal time scales are shown to be mostly, but not uniquely, driven by MSL variations. Long-term changes in the storm surge component of extremes unrelated to MSL are investigated using both non-tidal residuals and skew surges. These changes are examined globally but with a focus on relatively data-rich North Atlantic coastlines (some other examples such as the coastline of India may also be mentioned). Links between extremes and large-scale climate indicies are investigated. Any climate change aspect of extreme sea level variability may have some predictive capability if the indicies themselves are predictable. Finally, we test the assumption of stationarity of the probability of extreme occurrence and to which extent it holds when MSL changes are considered in combination with storm surges and in the context of a warming climate.

Mapping coastal sea level at high resolution with radar interferometry: the SWOT Mission

Abstract ID : 151

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Lee-Lueng Fu ,llf@jpl.nasa.gov ,(Senior Research Scientist) ,United States ,Pasadena ,Not Presenting[1]

Dr. Yi Chao ,ychao@remotesensingsolutions.com ,(None) ,United States , ,Not Presenting[2]

Dr. Imen Turki ,imen.turki@univ-rouen.fr ,(None) ,France , ,Not Presenting[3]

Dr. Benoit Laignel ,benoit.laignel@univ-rouen.fr ,(None) ,France , ,Not Presenting[3]

1 - Jet Propulsion Laboratory 2 - Remote Sensing Solutions 3 - University of Rouen 4 - University of Rouen

The spatial resolution of the present constellation of radar altimeters in mapping two-dimensional sea surface height (SSH) variability is approaching 100 km (in wavelength). At scales shorter than 100 km, the eddies and fronts are responsible for the stirring and mixing of the ocean, especially important in the various coastal processes. A mission currently in development will make high-resolution measurement of the height of water over the ocean as well as on land. It is called Surface Water and Ocean Topography (SWOT), which is a joint mission of US NASA and French CNES, with contributions from Canada and UK. SWOT will carry a pair of interferometry radars and make 2-dimensional SSH measurements over a swath of 120 km with a nadir gap of 20 km in a 21-day repeat orbit. The synthetic aperture radar of SWOT will make SSH measurement at extremely high resolution of 10-70 m. SWOT will also carry a nadir looking conventional altimeter and make 1-dimensional SSH measurements along the nadir gap. The temporal sampling varies from 2 repeats per 21 days at the equator to more than 4 repeats at mid latitudes and more than 6 at high latitudes. This new mission will allow a continuum of fine-scale observations from the open ocean to the coasts, estuaries and rivers, allowing us to investigate a number of scientific and technical questions in the coastal and estuarine domain to assess the coastal impacts of regional sea level change, such as the interaction of sea level with river flow, estuary inundation, storm surge, coastal wetlands, salt water intrusion, etc. As examples, we will illustrate the potential impact of SWOT to the studies of the San Francisco Bay Delta, and the Seine River estuary, etc. Preliminary results suggest that the SWOT Mission will provide fundamental data to map the spatial variability of water surface elevations under different hydrodynamic conditions and at different scales (local, regional and global) to improve our knowledge of the complex physical processes in the coastal and estuarine systems in response to global sea level changes.

Procedure for Probabilistic Tsunami Hazard Assessment from Incomplete and Uncertain Data

Abstract ID : 501

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Ansie Smit ,ansie.smit@up.ac.za ,(Researcher/Student) ,South Africa ,Pretoria ,Not Presenting[1]

1 - University of Pretoria Natural Hazard Centre

Tsunamis are a natural phenomenon with a low probability of occurring, but have a high impact when it does occur. Many events are known only through investigations of deposits and historical narratives. Many tsunami-threatened coastal areas therefore have long historic records available containing information of the largest and catastrophic tsunami occurrences. Traditional probabilistic tsunami hazard analysis procedures require earthquake and/or tsunami observations spanning hundreds of years, but are not always capable of accommodating these types of datasets or the associated uncertainty regarding location and intensity of individual events. During this presentation, we will introduce a new, empirical technique for probabilistic tsunami hazard assessment which permits the estimation of the key tsunami distribution parameters in the case when the tsunami catalogue consists of the historic and the most recent, instrumentally recorded ("complete") tsunami intensity (i) events. The three recurrence parameters are, according to the Soloviev frecquency-intensity relation, defined as the mean tsunami activity rate, λ, the parameter b, which describes the relation between weak and strong events, and the coastline-characteristic maximum possible tsunami intensity, i_{max}. Estimates for these three recurrence parameters are calculated by taking into consideration incompleteness of the catalogue, uncertainty in the tsunami intensity determination, as well as the uncertainty associated with the applied tsunami occurrence models. The uncertainty in the tsunami occurrence models is introduced by assuming that the mean tsunami activity rate, λ, and the parameter b are random variables, each described by the gamma distribution. This approach results in the extension of the classic frequency-intensity Soloviev-Immamura relation and the Poisson distribution of the number of tsunamis with their compounded counterparts. The proposed procedure was applied to determine the recurrence parameters needed to estimate the return periods for tsunamis in the tsunamigenic regions of Japan (JAP), Kuril-Kamchatka (K-K) and South America (SAM). The recurrence parameter λ, b and i_{max}, for each regions is respectively derived as $\boldsymbol{\theta}_{JAP}$ = (1.5, 0.4, 4.3) , $\boldsymbol{\theta}_{K\text{-}K}$ = (0.3, 0.2, 4.2) and $\boldsymbol{\theta}_{SAM}$ = (0.2, 0.5, 4.2). The proposed methodology provides a highly flexiable tool for probabilistic tsunami hazard assessment utilizing only empirical data and does not require prior seismic hazard assessment or wave propagation modelling.

Early

SMART submarine telecommunication cables to monitor sea level in the global ocean

Abstract ID : 1223

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. jerome aucan ,jerome.aucan@ird.fr ,(Research Scientist) ,New Caledonia ,Noumea ,Presenting[1]

Prof. Bruce Howe ,bhowe@hawaii.edu ,(None) ,United States , ,Not Presenting[2]

1 - IRD 2 - University of Hawaii

A Joint Task Force (JTF) sponsored by three U.N. agencies --International Telecommunication Union (ITU), the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO-- is leading an effort for integrating environmental monitoring sensors into transoceanic commercial submarine telecommunication cables. These are called SMART Cables - Science Monitoring And Reliable Communications. The initiative addresses two main issues of importance to science and society: a) the need for sustained climate-quality data from the sparsely observed deep oceans into continental slopes and b) the desire to increase the reliability, integrity, and scope of the global tsunami warning networks. The Joint Task Force of scientists, the telecommunication industry, governments, and UN agencies is initially focusing upon integrating sensors for temperature, pressure, and acceleration.
Several science workshops have recently reviewed and endorsed the SMART cable concept, specifically covering ocean climate and circulation monitoring (at CalTech and UHawaii), and tsunami and earthquake measurements (at Geosciences Research Center, Potsdam).
The pressure measurements from SMART cables, envisioned with high frequency sampling and low drift, in concert with satellite altimetry and gravity would form a powerful complementary combination to resolve sea level variations over a wide range of temporal and spatial scales
In one of the studies presented at these meetings, models showed that a few cables crossing the Pacific could reduce the time-to-detection of tsunamis by approximately 20 percent. Furthermore, the linear sensor arrays enabled by SMART cables would allow direct measurements of the tsunami wavefield. Such dense sampling would allow improved warning against tsunamis triggered by submarine landslides or other non-tectonic sources.
A request for information has been issued early 2016 for a "wet demonstration" project, which may involve testing within existing science cable systems or be installed in a relatively short communication cable.
These SMART cable systems would be a new highly reliable, long-lived component of the ocean observing system, complementing satellite, float and other in situ platforms and measurements. International participation and interest parties are welcomed. Further information is at http://www.itu.int/en/ITU-T/climatechange/task-force-sc/Pages/default.aspx

The role of the wind and magnetic field in the amplification and detection of tsunami-related internal gravity waves by airglow imaging systems

Abstract ID : 1441

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Giovanni Occhipinti ,ninto@ipgp.fr ,(Associate Professor) ,France ,Paris ,Presenting[1]

Prof. Jonathan Makela ,jmakela@illinois.edu ,(None) ,United States , ,Not Presenting[2]

Mr. Matthew Grawe ,grawe2@illinois.edu ,(None) ,United States , ,Not Presenting[2]

1 - Institut de Physique du Globe 2 - University of Illinois 3 - University of Illinois

The tremendous tsunami following the 2011 Tohoku Earthquake produced internal gravity waves (IGWs) in the neutral atmosphere and large disturbances in the overlying ionospheric plasma while propagating through the Pacific Ocean, observed, for the first time, by an airglow imaging system located in Hawaii (Makela et al., 2011). To corroborate the tsunamigenic hypothesis of these perturbations, a 3D numerical model of the ocean-atmosphere coupling has been developed and has been shown to reproduce the tsunami signature observed in the airglow by the imager (Occhipinti et al., 2011). To date, two additional tsunamigenic events have been detected by the airglow systems in Hawaii (Grawe et al., 2017): the Haida Gwaii (M: 7.7, 27 October, 2013) and Chile (M: 8.2, 16 September 2015). Here, based on modeling of all three events, we highlight the role of the wind and the magnetic field in the coupling between the IGW and the plasma, as well as the observation geometry. The agreement between data and synthetics strongly supports the interpretation of the tsunami-related-IGW and opens new perspectives for oceanic monitoring and tsunami warning systems.

References @ www.ipgp.fr/~ninto

Destructive meteorological tsunamis in the world oceans: 2012-2016

Abstract ID : 1512

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Alexander Rabinovich ,a.b.rabinovich@gmail.com ,(None) ,South Africa ,None ,Not Presenting[1]

Dr. Ivica Vilibic ,vilibic@izor.hr ,(research scientist) ,Croatia ,Split ,Presenting[2]

Mr Jadranka Sepic ,sepic@izor.hr ,(None) ,Croatia , ,Not Presenting[2]

1 - (1) P.P. Shirshov Institute of Oceanology RAS, Moscow, Russia, and (2) Institute of Ocean Sciences, Sidney, BC, V8L 4B2 Canada 2 - Institute of Oceanography and Fisheries 3 - Institute of Oceanography and Fisheries

Meteorological tsunamis (meteotsunamis) are destructive oceanic waves that have the same temporal and spatial scales as ordinary tsunami waves, but are related to atmospheric processes rather than to seismic activity or submarine landslides. Meteotsunamishave long been considered very rare and exotic phenomenon that occur only in a few specific harbours, such as Ciutadella (Balearic Islands, Spain), Vela Luka, and Stari Grad as well as in Croatia, Mazaro dell Vallo in Sicily and Nagasaki Bay in Japan. However, recent observations from around the world and the occurrences of several devastating events during 2012-2016 demonstrate meteotsunamis are much more common and worldwide than previously thought. This paper overviewssome of the strongest and most interesting recent events: (1) The 2012-2013 derecho-generated meteotsunamis on the East Coast of the USA; (2) the February 2014 flood at Cassino Beach, Brazil; (3) the March 2014 extreme event at Panama City, FL, USA; and (4) the unique chain of meteotsunami events that occurred on 23-27 June 2014 in the Mediterranean - Black Sea region that subsequently affected Spain, Croatia, Italy and the Ukraine. A number of numerical experiments and thorough data analyses show that meteotsunamis are a resonant phenomenon governed by the Froude number, *Fr*, the ratio of the atmospheric gravity wave speed to the phase speed of long ocean waves. Meteotsunamis can also be strongly amplified bytopographic convergence features and harbour resonance.

P06 - Western boundary current systems (IAPSO)

The role of the Deep Western Boundary Current in the North and South Atlantic: Relationships between the upper and lower limbs of the MOC

Abstract ID : 69

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited talk

Dr. Christopher Meinen ,Christopher.Meinen@noaa.gov ,(Oceanographer) ,United States ,Miami ,Not Presenting[1]

1 - NOAA-AOML

The Meridional Overturning Circulation (MOC) in the Atlantic consists primarily of a warm northward flow of near surface waters that travel from the Southern Ocean up to the northern North Atlantic, and a corresponding cold southward flow of deep waters that flow from the high latitude North Atlantic southward to the Southern Ocean. Much of the analysis of the MOC to date has focused on the warm upper limb, however recent work is showing that the lower limb is much more complex than had previously been thought. The bulk of the MOC lower limb is thought to be carried along the eastern seaboard of the Americas in the Deep Western Boundary Current (DWBC). Comparison of observed DWBC volume transport variations at 26.5°N and at 34.5°S to the total observed upper limb MOC variations at those latitudes indicates that the deep flows are not simply contained along the western boundary. The DWBC variability at both latitudes exceeds that of the total basin-wide MOC upper limb variability, by more than 300% at 26.5°N (16 Sv vs. 5 Sv standard deviations), and by more than 250% at 34.5°S (23 Sv vs. 9 Sv standard deviations). Clearly the flow of the DWBC must be embedded in a very dynamic recirculation/eddy environment in the deep waters that extends longitudinally across the entire basin. In this presentation, results from two multi-year field programs designed to measure the DWBC volume transport at 26.5°N and at 34.5°S will be presented and discussed.

Broadening not Strengthening of the Agulhas Current since the early 1990s

Abstract ID : 141

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. Lisa Beal ,lbeal@rsmas.miami.edu ,(Professor of Ocean Sciences) ,United States ,Miami ,Presenting[1]

Dr. Shane Elipot ,selipot@rsmas.miami.edu ,(Associate Scientist) ,United States ,Miami ,Not Presenting[1]

1 - Rosenstiel School of Marine and Atmospheric Science at the University of Miami 2 - Rosenstiel School of Marine and Atmospheric Science at the University of Miami

Western boundary currents-such as the Agulhas Current in the Indian Ocean-carry heat poleward, moderating Earth's climate and fuelling the mid-latitude storm tracks. They could exacerbate or mitigate warming and extreme weather events in the future, depending on their response to anthropogenic climate change. Climate models show an ongoing poleward expansion and intensification of the global wind systems, most robustly in the Southern Hemisphere, suggesting that western boundary currents may be intensifying and shifting poleward. Observational evidence of such changes comes from accelerated warming and air-sea heat flux rates within all western boundary currents, which are two or three times faster than global mean rates. Here we create a multi-decadal transport proxy for the Agulhas Current, using a current meter array and satellite altimeter data, to show that despite these expectations, the current has not intensified since the early 1990s. Instead, we find that it has broadened as a result of more eddy activity. Analyses of other western boundary currents-the Kuroshio and East Australia currents-hint at similar trends. These results indicate that intensifying winds may be increasing the eddy kinetic energy of boundary currents, rather than their mean flow. This could act to decrease poleward heat transport and increase cross-frontal exchanges between the coastal ocean and the deep ocean. Sustained *in situ* measurements are needed to properly understand the role of these current systems in a changing climate.

Influence of the East Australian Current on shelf dynamics and upwellings from moorings, gliders and HF radar observations

Abstract ID : 217

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Amandine Schaeffer ,a.schaeffer@unsw.edu.au ,(Postdoc) ,Australia ,SYDNEY ,Not Presenting[1]

Mr. Anthony Gramoulle ,thonyo_@hotmail.fr ,(None) ,Australia , ,Not Presenting[1]

Miss. Dana White ,dwhite93@gmail.com ,(None) ,Australia , ,Not Presenting[1]

Dr. Moninya Roughan ,mroughan@unsw.edu.au ,(None) ,Australia , ,Not Presenting[1]

Dr. Bradley Morris ,Bradley.Morris@environment.nsw.gov.au ,(None) ,Australia , ,Not Presenting[1]

Dr. Julie Wood ,julie.e.wood@gmail.com ,(None) ,Australia , ,Not Presenting[1]

1 - UNSW Sydney Australia 2 - UNSW Sydney Australia 3 - UNSW Sydney Australia 4 - UNSW Sydney Australia 5 - UNSW Sydney Australia 6 - UNSW Sydney Australia

The mesoscale circulation along the coast of southeastern Australia is dominated by the South Pacific Western Boundary Current system: the East Australian Current (EAC) and its eddy field. Due to the relatively narrow continental shelf, this fast-flowing current (> 1 m/s) strongly influences the circulation and watermass characteristics on the adjacent shelf. We use a series of multi-platform observations to investigate the impact of the EAC on the shelf dynamics, focusing on different upwelling processes. Moored in situ measurements over 2-4 years enabled to investigate the cross-shelf dynamics and dense water uplift resulting from the EAC intrusions onto the shelf. The EAC dominates the cross-shelf momentum balances and is the major driver of bottom water uplift at 30oS (upwstream) in response to a strong along-shelf bottom stress (Ekman transport).
The spatial extension of these current-driven uplifts was characterized using a comprehensive dataset from 25 ocean gliders deployed along the EAC. A high resolution hydrographic and bio-geo-chemistry climatology was generated, showing a hotspot for dense bottom water uplift with low dissolved oxygen (DO) where the shelf is narrow and the EAC intensified. Downstream, where the jet separates from the coast, the dynamic height minimum shows separation upwelling, resulting in denser watermass with higher colored dissolved organic matter and DO concentrations than the EAC water. Finally, supply of cold nutrient-rich water to the surface layers can also be driven by cyclonic eddies, resulting from the instabilities of the EAC or shear interaction with an opposed wind-driven flow. HF radar observations of surface currents reveal that cyclonic structures with Rossby numbers O(0.2f - 1.9f) occur on average every week. In particular, frontal eddies associated with EAC meanders are advected poleward along the inshore edge of the EAC with speeds of 0.3-0.4 m/s, migrating as far as Sydney, 500 km south (based on satellite imagery). Such coherent structures are a major mechanism for the transport and entrainment of nutrient rich coastal water, and together with current-driven uplifts influence both the physical and biological dynamics of the continental shelf.

A lagrangian study of the surface velocity structure of the Agulhas Current at 34° S

Abstract ID : 421

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Mr. Jethan d'Hotman ,jethandh@gmail.com ,(Masters student) ,South Africa ,Cape Town ,Not Presenting[1]

Mr. Marc de Vos ,Marc DeVos <Marc.DeVos@weathersa.co.za>, ,(None) ,South Africa , ,Not Presenting[2]

Mr. Neil Malan ,Neil Malan <neilcmalan@gmail.com> ,(None) ,South Africa , ,Not Presenting[3]

Mrs. Tamaryn Morris ,Tammy Morris <tammy@saeon.ac.za> ,(None) ,South Africa , ,Not Presenting[4]

Mr. Johan Stander ,Johan.Stander@weathersa.co.za ,(None) ,South Africa , ,Not Presenting[5]

Dr. Juliet Hermes ,juliet@saeon.ac.za ,(None) ,South Africa ,None ,Not Presenting[1]

1 - SAEON 2 - Marine Research Unit, South African Weather Services (SAWS), Cape Town, South Africa 3 - Oceanography Department, University of Cape Town, South Africa 4 - Egagasini Node, South African Environmental Observation Network (SAEON), Cape Town, South Africa 5 - NoneRegional Office (Western and Northern Cape), South African Weather Services (SAWS), Cape Town, South Africa 6 - SAEON

The distribution of the maxima of Agulhas Current surface velocity has been investigated using six hourly interpolated surface drifter data and along track altimetry. The Agulhas System Climate Array (nominal 34.5° S), which underlies the along-track altimetry transect, (altimeter track # 96) is used as the reference line across the Agulhas Current. Between January of 1992 and June of 2016, 38 individual drifters were seen to cross the ASCA transect with speeds ranging from 0.2 $m.s^{-1}$ to 2.1 $m.s^{-1}$. Geostrophic speeds were extracted from the along-track altimetry of the ASCA line in order to place each drifter's location in relation to the current's velocity maxima. A key objective of this analysis is to quantify the influence of upstream current structure on the formation of mesoscale and sub-mesoscale features downstream.
A semi-permanent, trapped cyclonic eddy on the eastern shelf edge of the Agulhas Bank (downstream of ASCA), which further impacts the dynamics of the Agulhas Current and thus the surface drifter trajectories, was investigated using the drifters. Three of the five drifters deployed as part of an ASCA maintenance cruise in 2016 became entrained in this feature, prompting an effort to quantify the frequency with which the cyclone is present and its influence on the general circulation. Using an eddy tracking scheme, preliminary results show that, during the 24 year study period (1992-2016), this same eddy appeared 36 times for a total period of 320 days. While this is a lower frequency than anticipated, the eddy is certainly a recurring feature.

The East Australian Current System - An observational description

Abstract ID : 445

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited Speaker

Mr. Ken Ridgway ,ken.ridgway@csiro.au ,(Retirement Fellow) ,Australia ,Hobart ,Not Presenting[1]

1 - CSIRO Oceans & Atmosphere

The East Australian Current (EAC) is one of the major western boundary currents of the global ocean. It provides a complex and highly energetic poleward termination of the Subtropical Gyre flow in the South Pacific Basin and is the dominant mechanism for the redistribution of heat between the ocean and atmosphere in the Australian region by transporting heat from the tropical Pacific Ocean to the mid-latitude ocean and atmosphere. Here we consider the EAC as a complete western boundary system including inputs and outputs, the influence of topography, the bifurcation of westward flow, the complex structure of eddies, jets and boundary currents. Much of our current understanding of the EAC has been developed from in situ observations collected over many decades. However, these data are irregularly distributed in both space and time and are not generally suitable for resolving changes in the EAC circulation over time periods ranging from interannual to decadal or longer time scales. A wealth of observations have been obtained since 1990, and some major national and international programs have focused on the region. These data allow a far more detailed picture of this EAC system to be constructed. We describe results from satellite altimetry, broadscale Argo coverage, long-term coastal stations, and eddy-resolving XBT lines. More recently, a series of north Queensland glider deployments and a multi-year current meter array off Brisbane provide comprehensive measurements of the boundary currents. In fact, some of these data are the first direct observations of the boundary systems. Finally, this enhanced seasonal, interannual, and decadal observational picture of the EAC system is compared with recent model results.

The role of forcing variability in eddy shedding and the southward extent of the East Australian Current's extension

Abstract ID : 566

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Mr. Christopher Bull ,christopher.ys.bull@gmail.com ,(PhD Candidate) ,Australia ,Kensington ,Not Presenting[1]
Mr. Andrew E. Kiss ,a.kiss@adfa.edu.au ,(None) ,Australia , ,Not Presenting[2]

Dr. Nicolas C. Jourdain ,nicolas.jourdain@univ-grenoble-alpes.fr ,(None) ,France , ,Not Presenting[3]

Prof. Matthew England ,M.England@unsw.edu.au ,(None) , , ,Not Presenting[4]

Dr. Erik van Sebille ,e.van-sebille@imperial.ac.uk ,(None) ,Netherlands , ,Not Presenting[5]

1 - None 2 - School of Physical, Environmental and Mathematical Sciences, University of New South Wales Canberra at the Australian Defence Force Academy, Canberra , Australia. 3 - Univ. Grenoble Alpes, CNRS, IRD, IGE, F-38000 Grenoble, France. 4 - UNSW 5 - Institute for Marine and Atmospheric Research, Utrecht University, Netherlands

The East Australian Current (EAC) in the western Pacific Ocean is Australia's strongest and most important boundary current, supporting Australia's temperate coastlines by transporting heat poleward. The large variability of the latitude at which the EAC separates has an important impact on local climate and cross-shelf marine ecosystems. For example, in the summer of 2015, south-east Australian waters observed record temperatures as compared to the previous two decades; this event is (mostly) attributed to an increase in the southward penetration of the EAC. Thus, understanding the non-linear mechanisms that control the variability in the EAC extension is important for improving future climate projections.
Here, using eddy-permitting NEMO ocean model simulations, we present a suite of simulations forced by the same time-mean but with different atmospheric and ocean variability. These simulations show an EAC with high intrinsic variability and stochastic eddy shedding. We further show that local atmospheric variability leads to increases in eddy shedding rates and southward eddy propagation, and this leads to an increased extent of the EAC extension. We employ an energetics framework to show that an increase in offshore, upstream eddy variance leads to the described enhancement of the EAC extension. The eddy-permitting results presented are useful for understanding the EAC separation dynamics in the context of future extreme temperature warming attribution studies.

Impact of a fully resolved mesoscale on the dynamics in the Agulhas Current system

Abstract ID : 585

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Franziska Schwarzkopf ,fschwarzkopf@geomar.de ,(None) ,Germany ,Kiel ,Presenting[1]
Prof. Arne Biastoch ,abiastoch@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[2]

Dr. Jan Harlaß ,jharlass@geomar.de ,(None) ,Germany , ,Not Presenting[2]

Mr. René Schubert ,rschubert@geomar.de ,(None) ,Germany , ,Not Presenting[2]

1 - GEOMAR Helmholtz Cebtre for Ocean Research Kiel 2 - GEOMAR Helmholtz Centre for Ocean Research Kiel 3 - GEOMAR Helmholtz Centre for Ocean Research Kiel 4 - GEOMAR Helmholtz Centre for Ocean Research Kiel

The Agulhas Current (AC), the western boundary current of the South Indian Ocean, has been shown to play an important role in the connectivity between the Indian and Atlantic oceans. The greater AC system is highly dominated by mesoscale processes. To investigate their influence onto the regional and global circulation, a family of high-resolution ocean general circulation model configurations based on the current NEMO code has been developed. The high resolution is achieved by embedding "nests" covering the South Atlantic and the western Indian Ocean at 1/10° (INALT10) and 1/20° (INALT20) resolution in global model configurations with five times coarser host grids. Nests and hosts are connected through two-way interaction, allowing the nests not only to receive boundary conditions from their respective host, but also to transmit the mesoscale impact into the global ocean. A secondary nest at 1/60° resolution, embedded in a version of INALT20 with spatially reduced nest extent, is facilitated to gain insights into the sub-mesoscale processes in the AC system.
Large-scale features like the Drake Passage transport and the Atlantic meridional overturning circulation strength turn out to be rather robust, whereas the dynamics of the AC system strongly depend on the representation of mesoscale processes. Transport through the Mozambique Channel decreases with increasing resolution, in agreement with observations. Both, southward flowing AC and northward flowing Agulhas Undercurrent (AUC) increase with increasing resolution towards more realistic values, documenting the importance of improving mesoscale dynamics as well as bathymetric slopes along this narrow western boundary current regime. Most of the increased AC transport retroflects back into the Indian Ocean, leaving the portion of flow into the South Atlantic, Agulhas leakage, even at smaller transports.
By systematically comparing the different model configurations, the impact of a fully resolved mesoscale is documented.

The impact of large Agulhas Current meanders on Shelf Waters

Abstract ID : 589

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Mr. Neil Malan ,neilcmalan@gmail.com ,(PhD Candidate) ,South Africa ,Cape Town ,Presenting[1]

Prof. Chris Reason ,chris.reason@uct.ac.za ,(None) ,South Africa , ,Not Presenting[1]

Dr. Juliet Hermes ,juliet@saeon.ac.za ,(None) ,South Africa ,None ,Not Presenting[3]

Dr. Bjorn Backeberg ,BBackeberg@csir.co.za ,(Principal Researcher) ,South Africa ,Cape Town ,Presenting[4]

1 - University of Cape Town 2 - University of Cape Town 3 - SAEON 4 - CSIR

Large solitary meanders are arguably the dominant mode of variability in the Agulhas Current. Observational studies have shown these large meanders are associated with strong upwelling velocities and affect the shelf circulation for over 100 days per year on average. Here, 10-year time series from two ocean models, INALT01 and AGU-HYCOM, are used to create a composite picture of the Agulhas Current and its interactions with the shelf circulation in meandering and non-meandering modes. Both models show good agreement with the size, propagation speed and frequency of observed meanders. These composite meanders are then used to examine the response of shelf waters to the onset of large meanders, with the use of model output enabling the dynamics at depth to be explored. Results show a mean warming of up to 3°C of depth-averaged temperature along the shelf edge, associated with convergences driven by an intensification of the flow along the leading edge of large meanders. However, this intensification of flow results in cooling of bottom waters, driving cold anomalies at the shelf break to the order of 5°C at 100m. Thus the intensification of the current jet associated with large meander events appears to drive strong up and downwelling events across the Agulhas Current's inshore front, facilitating shelf-slope exchange. These processes are important, although little understood, as the Agulhas Current advectively controls the thermocline over the Agulhas Bank, a coastal area of important fishing and spawning activity.

Modulation of Western Boundary Currents by Oceanic Current Interactions with the Atmosphere

Abstract ID : 591

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Mr. Lionel Renault ,lrenault@ucla.edu ,(Researcher) ,United States ,Los Angeles ,Not Presenting[1]
Prof. James C. McWilliams ,jcm@ucla.edu ,(None) ,United States , ,Not Presenting[2]

Prof. Jonathan Gula ,jonathan.gula@univ-brest.fr ,(None) ,France , ,Not Presenting[3]

Dr. Masson Sebastien ,Sebastien.Masson@locean-ipsl.upmc.fr ,(None) ,United States , ,Not Presenting[2]

Dr. Molemaker Jeroen ,nmolem@ucla.edu ,(None) ,United States , ,Not Presenting[2]

Prof. Pierrick Penven ,pierrick.penven@ird.fr ,(None) ,France , ,Not Presenting[6]

1 - None 2 - UCLA 3 - LOPS 4 - UCLA 5 - UCLA 6 - IRD

The Gulf Stream (GS) and the Agulhas Current are known to have a strong influence on the climate and on transports of heat.
Numerical oceanic models have persistent biases to represent realistically their mean characteristics as the GS separation near Cape Hatteras or the mean Agulhas retroflection position. In this presentation, we investigate a source of sensitivity of those WBC that results from the current feedback to the atmosphere. Using a set of regional coupled and uncoupled ocean-atmosphere simulations over Gulf Stream and the Agulhas Current, we will address to what extent this ocean-atmosphere mechanical coupling can improve the realism of the oceanic simulations. We show the current feedback to the atmosphere strongly modulates the exchange of energy between the ocean and the atmosphere, and, in particular induces, through the oceanic mesoscale eddies, large sink of energy from the ocean to the atmosphere, slowing down the full gyres and dampening the mesoscale activity. As a results, it stabilizes the GS separation and post separation and, by reducing a too large mesoscale activity near Port Elizabeth, reduces the occurence of the Agulhas Current Upstream Retroflection mode, allowing a more realistic Agulhas separation. The atmospheric response to the current feedback is further discussed.

Observed eddy dissipation in the Agulhas Current

Abstract ID : 601

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Miss. Laura Braby ,laurabraby@gmail.com ,(PhD Student) ,South Africa ,Cape Town ,Not Presenting[1]

Dr. Bjorn Backeberg ,BBackeberg@csir.co.za ,(Principal Researcher) ,South Africa ,Cape Town ,Not Presenting[2]

Prof. Isabelle Ansorge ,Isabelle.Ansorge@uct.ac.za ,(Head of Department) ,South Africa ,None ,Not Presenting[3]

Dr. Michael Roberts ,Mike.Roberts@nmmu.ac.za ,(None) ,South Africa , ,Not Presenting[4]

Dr. Marjolaine Krug ,mkrug@csir.co.za ,(Dr.) ,South Africa ,Cape Town ,Not Presenting[5]

Prof. Chris Reason ,chris.reason@uct.ac.za ,(None) ,South Africa , ,Not Presenting[6]

1 - Department of Oceanography, University of Cape Town 2 - CSIR 3 - UCT 4 - Nelson Mandela Metropolitan Unviersity 5 - Council for Scientific and Industrial Research 6 - University of Cape Town

Analyzing eddy characteristics from a global data set of automatically tracked eddies for the Agulhas Current in combination with surface drifters as well as geostrophic currents from satellite altimeters, it is shown that eddies from the Mozambique Channel and south of Madagascar dissipate as they approach the Agulhas Current. By tracking the offshore position of the current core and its velocity at 30°S in relation to eddies, it is demonstrated that eddy dissipation occurs through a transfer of momentum, where anticyclones consistently induce positive velocity anomalies, and cyclones reduce the velocities and cause offshore meanders. Composite analyses of the anticyclonic (cyclonic) eddy-current interaction events demonstrate that the positive (negative) velocity anomalies propagate downstream in the Agulhas Current at 44 km/d (23 km/d). Many models are unable to represent these eddy dissipation processes, affecting our understanding of the Agulhas Current.

Challenges in Western Boundary Currents Modeling

Abstract ID : 724

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Prof. Pierrick Penven ,pierrick.penven@ird.fr ,(None) ,France , ,Not Presenting[1]

Mr. Eric Chassignet ,echassignet@fsu.edu ,(None) ,United States , ,Not Presenting[2]

Prof. Jonathan Gula ,jonathan.gula@univ-brest.fr ,(None) ,France , ,Not Presenting[3]

Dr. Lionel Renault ,lrenault@atmos.ucla.edu ,(None) ,United States ,None ,Not Presenting[4]

1 - IRD 2 - Florida State University 3 - LOPS 4 - University of California Los Angeles

Subtropical western boundary currents are intense narrow currents closing the oceanic gyres. With typical transports of several tens of Sverdrups, they are contributing to the bulk of oceanic meridional heat transport, participating in the global heat redistribution and the thermohaline circulation. The heat and humidity air-sea exchanges associated with western boundary currents influence the climate at local and global scales. Subtropical western boundary currents are important region of heat loss from the oceans and have been the subject of recent accelerated warming. Such swift currents are prone to instabilities and host an intense oceanic turbulence with levels of eddy kinetic energy among the highest in the world oceans. Meanwhile, western boundary currents act also as graveyards for western propagating ocean eddies. These current responds to non local forcing and are highly sensitive to local interactions with topography. This results into spectacular peculiarities of the western boundary currents such as the Brazil Malvinas confluence, the retroflections of the Agulhas current, the North Brazil current or the East Australian Current, the Great Whirl of the Somali current or the bi-modal flow pattern of the Kuroshio current. Such currents, with high levels of energy, large inertia, prevalent current topography interactions, and sharp gradients in oceanic properties have been a challenge for ocean modelers for the past 40 years. Classic misrepresentations range from failed detachment of the Gulf Stream to a total destabilisation of the Agulhas Current. In this presentation we review several difficulties encountered by the modelers with western boundary currents and the different methods applied to address these problems.

Meridional heat transport of the Indian Ocean across 34°S based on high resolution Agulhas Current hydrography, satellite, and Argo data

Abstract ID : 755

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Ms. Kayleen McMonigal ,kmcmonigal@rsmas.miami.edu ,(Graduate Student) ,United States ,Miami, FL ,Not Presenting[1]

Prof. Lisa Beal ,lbeal@rsmas.miami.edu ,(Professor of Ocean Sciences) ,United States ,Miami ,Not Presenting[2]

1 - 2 - Rosenstiel School of Marine and Atmospheric Science at the University of Miami

Oceanic meridional heat transport (MHT) modulates global climate and may be particularly important in the Indian Ocean, where Agulhas Leakage is a choke point of the global thermohaline circulation. However, MHT across 32°S in the Indian Ocean has been directly measured only a handful of times, each time using one of three hydrographic crossings of the basin with an inverse model technique to conserve mass. These estimates range from -0.6 to -1.6 PW. It is unknown how much seasonal and shorter time scale variability may contribute to differences between the estimates. To begin to address the seasonal range of MHT, we use high resolution hydrography of the Agulhas Current available at 34°S at 4 points in time to give western boundary temperature transport. This is connected to the interior basin temperature transport derived from Argo float displacements and profiles, combined with satellite SSH data, utilizing a method which was previously used in a similar calculation of MHT in the North Atlantic. There are approximately 1000 float profiles per 3 month period across the basin between 29°S and 39°S from 2008-2016, compared to approximately 200 profiles in a typical hydrographic crossing. This combined Argo/SSH method successfully reproduces the large scale temperature and salinity fields as compared to the 2009 Indian Ocean hydrographic crossing, with root mean square errors of 0.27°C and 0.03 PSU and biases of -0.04°C and -0.003 PSU. These are reasonable errors considering that the method is designed to reproduce the large scale temperature and salinity fields with mesoscale variability removed. Together with Ekman temperature transports constructed from wind stress products and Argo temperature data, these components construct the first estimate of MHT of the South Indian Ocean in austral winter, and more than double the number of independent direct estimates of MHT of the basin. In the future, we will use this method with temperature and velocity time series of the Agulhas Current from the Agulhas System Climate Array (ASCA) moorings to estimate the seasonal variability of basin wide MHT.

Field experiments in the Brazil-Malvinas Confluence during early austral fall

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Additional Information : None

Prof. Josep L. Pelegrí ,pelegri@icm.csic.es ,(Research Professor) ,Spain ,Barcelona ,Presenting[1]

Mrs. Dorleta Orúe-Echevarría ,dorleta@icm.csic.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Paola Castellanos ,castellanos@icm.csic.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Mikhail Emelianov ,mikhail@icm.csic.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Antonio García-Olivares ,agolivares@icm.csic.es ,(None) ,Spain , ,Not Presenting[1]

Mr. Marc Gasser ,gasser@icm.csic.es ,(None) ,Spain , ,Not Presenting[1]

Prof. Alonso Hernández-Guerra ,alonso.hernandez@ulpgc.es ,(Director) ,Spain ,Las Palmas de Gran Canaria ,Not Presenting[7]

Dr. Jordi Isern-Fontanet ,jisern@icm.csic.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Francisco Machín ,francisco.machin@ulpgc.es ,(None) ,Spain , ,Not Presenting[9]

Mrs. Marta Masdeu-Navarro ,marta.masdeu2@gmail.com ,(None) ,Spain , ,Not Presenting[1]

Dr. Jesús Peña-Izquierdo ,susopeiz@gmail.com ,(None) ,Spain , ,Not Presenting[1]

Mr. Sergio Ramírez-Garrido ,sramirez@icm.csic.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Miquel Rosell-Fieschi ,miquel.rofi@gmail.com ,(None) ,Spain , ,Not Presenting[1]

Mr. Jordi Salat ,salat@icm.csic.es ,(None) ,Spain , ,Not Presenting[1]

Mr. Joaquín Salvador ,jsalvador@icm.csic.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Martin Saraceno ,saraceno@cima.fcen.uba.ar ,(Researcher) ,Argentina ,Buenos Aires ,Not Presenting[16]

Mr. Ignasi Vallès-Casanova ,ignasi.valles@gmail.com ,(None) ,Spain , ,Not Presenting[1]

Dr. Álvaro Viúdez ,aviudez@icm.csic.es ,(None) ,Spain , ,Not Presenting[1]

1 - Institut de Ciències del Mar, CSIC 2 - Institut de Ciències del Mar, CSIC 3 - Institut de Ciències del Mar, CSIC 4 - Institut de Ciències del Mar, CSIC 5 - Institut de Ciències del Mar, CSIC 6 - Institut de Ciències del Mar, CSIC 7 - Instituto de Oceanografía y Cambio Global, ULPGC 8 - Institut de Ciències del Mar, CSIC 9 - Universidad de Las Palmas de Gran Canaria 10 - Institut de Ciències del Mar, CSIC 11 - Institut de Ciències del Mar, CSIC 12 - Institut de Ciències del Mar, CSIC 13 - Institut de Ciències del Mar, CSIC 14 - Institut de Ciències del Mar, CSIC 15 - Institut de Ciències del Mar, CSIC 16 - CONICET-UBA 17 - Institut de Ciències del Mar, CSIC 18 - Institut de Ciències del Mar, CSIC

We present the results of two field experiments carried in early austral fall over the Brazil-Malvinas Confluence (BMC) onboard the R/V Hespérides, each approximately lasting two weeks. The first experiment (March 2015) began encircling the BMC with hydrographic stations (lowered ADCP, CTD and water samples) along a perimeter of about 1200 km, in order to identify the water masses and fluxes reaching the BMC, and then sampled the collision region with six 100-km long and 400-m deep cross-frontal hydrographic sections. Data was also obtained from the vessel ADCP (velocities down to about 600 m), eight subsurface drifters and nine Argo floats. Here we describe the fluxes and structure of the BMC at three different scales: *frontal*, *confluence* and *regional*. The *frontal* sampling, approximately comprising a 200 km x 100 km region, shows intense cross-frontal property gradients (e.g. up to 20°C in about 10 km at 50 m depth), numerous thermohaline intrusions (10-100 m thick, 10 km wide and 10-50 km long) and a very shallow (5-20 m) and fast (velocities close to 1.8 m/s) eastward surface brackish (salinities of 29-33 g/kg) filament on the warm side of the front (narrowing from some 100 km over the slope to only a few kilometers in the outer stations). The *confluence* sampling followed the border of a 400 km x 200 km rectangle that encompassed the entire collision of the two impinging currents, characterized by large water recirculation in adjacent vortices (two anticyclones and one cyclone at distances less than 500 km from the collision point) before the eastward flushing along the frontal system. Finally, we used the ARMOR3D fields (Guinehut et al., 2012, Ocean Sci. 8, 845-857) to characterize the *regional* flow patterns and water masses, from 31°S to 45°S and from 38°W to the continental platform. The second experiment (April 2017) will focus on the temporal and latitudinal evolution of the frontal system. It will include hydrographic and microstructure stations, the deployment of drifters and floats, and a towed vehicle to sample the uppermost 400 m of the water column.

Seasonality of the Agulhas Current with respect to near- and far-field winds

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Additional Information : None

Ms. Katherine Hutchinson ,kath.hutchinson@gmail.com ,(PhD student) ,South Africa ,Cape Town ,Presenting[1]

Prof. Lisa Beal ,lbeal@rsmas.miami.edu ,(Professor of Ocean Sciences) ,United States ,Miami ,Not Presenting[2]

Dr. Juliet Hermes ,juliet@saeon.ac.za ,(None) ,South Africa ,None ,Not Presenting[3]

Prof. Pierrick Penven ,pierrick.penven@ird.fr ,(None) ,France , ,Not Presenting[4]

Prof. Isabelle Ansorge ,Isabelle.Ansorge@uct.ac.za ,(Head of Department) ,South Africa ,None ,Not Presenting[5]

1 - University of Cape Town 2 - Rosenstiel School of Marine and Atmospheric Science at the University of Miami 3 - SAEON 4 - IRD 5 - UCT

The drivers of Agulhas Current seasonality remain poorly understood. Model studies predict a winter-spring maximum in transport, whilst observations reveal a summertime February-March maximum. Here, we investigate the role of winds on Agulhas seasonality using shallow water models, satellite measurements, and a 22-year transport proxy based on observations. We show that a first order baroclinic model can successfully reproduce the seasonal phasing of the Agulhas Current. This seasonality is found to be highly sensitive to the propagation speed of Rossby waves, which determines the areas of destructive interference by overlying wind forcing. By matching Rossby wave speeds to those observed with altimetry, we simulate an Agulhas Current with a maximum flow in January-February and a minimum flow in July, agreeing well with observations. We find that near-field winds, to the west of 35E, dominate this seasonality, as signals from more remote wind forcing die out while crossing the basin. Local winds driving coastal upwelling/downwelling directly over the Agulhas cannot, alone, explain the observed seasonal phasing, as they force a November maximum and June minimum in flow. We also investigate the seasonal response to Indian Ocean winds using a barotropic model with realistic topography, as theory suggests the barotropic response dominates at seasonal timescales. The barotropic model is, however, unable to correctly capture the seasonal cycle of the Agulhas, predicting a wintertime maximum in transport. The results from the barotropic simulation are similar to previous model studies, showing seasonality dominated by a southward propagation of signals via the Mozambique Channel, and suggest these models are too barotopic in their response to the winds. Findings from this study elucidate the role of near-fields winds and baroclinic processes in determining the seasonality of the Agulhas. Furthermore, the sensitivity of the seasonal cycle to Rossby wave propagation speeds leads to the interesting hypothesis that modifications in ocean stratification due to climate change may lead to a shift in phase of Agulhas seasonality.

Signature of the Agulhas Current in ASAR derived wind fields

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Additional Information : None

Dr. Marjolaine Krug ,mkrug@csir.co.za ,(Dr.) ,South Africa ,Cape Town ,Not Presenting[1]

Mr. Daniel Schilperoort, ,danielschilperoort@ostenergy.com ,(None) ,South Africa , ,Not Presenting[2]

Prof. Mathieu Rouault ,Mathieu.Rouault@uct.ac.za ,(Professor) ,South Africa ,Cape Town ,Not Presenting[3]

Dr. Fabrice Collard ,dr.fab@oceandatalab.com ,(None) ,France , ,Not Presenting[4]

Dr. Morten Hansen ,morten.hansen@nersc.no ,(None) ,Norway , ,Not Presenting[5]

1 - Council for Scientific and Industrial Research 2 - Nansen-Tutu Centre for Marine Environmental Research 3 - University of Cape town 4 - OceanDataLab 5 - Nansen Environmental and Remote Sensing Center

A 5-year archive of Advanced Synthetic Aperture Radar (ASAR) wide swath images is used to investigate SAR derived wind variations over the Agulhas Current, near 34^{o}S. These wind fields are extracted at a 1 km spatial resolution from the ASAR Normalized radar cross-sections using the CMOD5.n GMF and wind directions from the hourly Climate Forecast System Reanalysis (CFSR) reanalysis product. The derived wind speeds are compared to those analysed in the CFSR dataset. The magnitude of the Agulhas Current at the time of the ASAR acquisition are estimated using the Globcurrent product.
Comparisons between the CFSR winds and winds measured by the Advanced *Scatterometer* (*ASCAT* METOP-A) show that the wind directions in the CFSR and ASCAT products are in good agreement. Winds over the Agulhas Current are generally aligned along a north-east / south-west axis, in line with the mean direction of the Agulhas Current. In an upwind configuration , marked differences exist between the ASAR and CFSR wind speeds. On average, the ASAR wind speeds over the Agulhas Current exceed those estimated in the CFSR product by about 5 m/sec. The differences in wind speeds between the ASAR and CFSR product are greatest at the northern wall of the Agulhas Current, where the largest gradient of SST are observed. In a downwind configuration, the differences between the ASAR and CFSR wind speeds still remain large, with differences in wind speeds in the 2-4 m.sec range. The large discrepancies between the ASAR and CFSR winds in an upwind configuration is questioning the validity of the CMOD5.n GMF in western boundary current regions. In a downwind configuration, the CFSR product tends to under-estimate wind speeds increases over the Agulhas current which we attribute to the unstable marine boundary layer over the warm Agulhas Current.

Gulf Stream North Wall variations in the context of decadal and multidecadal Atlantic variability

Abstract ID : 942

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Additional Information : None

Dr. Gerard McCarthy ,gerard.mccarthy@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Terrence Joyce ,tjoyce@whoi.edu ,(None) ,United States , ,Not Presenting[2]

1 - NOC 2 - Woods Hole Oceanographic Institute

The Gulf Stream North Wall (GSNW) is a rare example of a long timeseries indicative of ocean circulation, with versions existing since the 1950s. Here we look at the timeseries of the GSNW to assess the role of this western boundary current variation in Atlantic multidecadal climate. It is widely hypothesised that ocean circulation-especially the Atlantic Meridional Overturning Circulation (AMOC)-governs the phases of the Atlantic Multidecadal Variability (AMV). However, direct observations of ocean circulation that would prove this link do not exist. This has lead to robust and prominent recent challenges to the paradigm that ocean circulation controls the phases of the AMV. Here, the contemporary GSNW is identified in satellite velocity and ship-of-opportunity ADCP measurements to identify the spatial pattern of velocity associated with the long GSNW timeseries. We examine the relationship between a weakened AMOC as observed by the RAPID array and a northward shift in the GSNW.
We examine the consistency of this relationship through time by examining the GSNW timeseries with timeseries of the North Atlantic Oscillation (NAO) and AMV. Different relationships between the NAO, GSNW and AMV are found when decadal and multidecadal modes of variability are extracted from the timeseries. This changing relationship is consistent with a switch from atmospheric to oceanic control of sea surface temperatures on timescales longer than decadal.

Topographically challenged coastal sea level along a western boundary system

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Additional Information : None

Mr. Anthony Wise ,awise@liv.ac.uk ,(PhD Student) ,United Kingdom ,Liverpool ,Not Presenting[1]

Prof. Chris W. Hughes ,cwh@liv.ac.uk ,(None) ,United Kingdom , ,Presenting[1]

1 - University of Liverpool / National Oceanography Centre 2 - University of Liverpool / National Oceanography Centre

Recent studies of mean sea level along the North American east coast have suggested an upward tilt toward the south. The origins of sea level gradients along this coast are debated, but idealized models have suggested that continental slopes prevent deep ocean pressure gradients from affecting coastal sea levels over alongshore distances less than thousands of kilometers. On the other hand, models looking at wind-driven ocean circulation and western continental slopes suggest that the decreasing effect of the Earth's ambient rotation at low latitudes has an important effect on transmission from ocean to coast. Here we consider the dependence of the coastal sea surface height's (SSH) response to wind-driven ocean circulation on bottom topography, when the Coriolis parameter is dependent on latitude. The steady linear equations governing depth-integrated flow including bottom friction, beta-approximation Coriolis parameter and non-constant bottom topography are used with a rectangular domain. It is found that a SSH imposed at the ocean boundary of this domain, idealizing the western boundary of a double gyre interior, is capable of penetrating onto the shelf and producing an upward tilt towards the south. The coastal SSH response to topography has two distinct regimes dependent on the magnitude of bottom friction and the length scales of the domain across-shore and vertically. Where the bottom friction parameter is large or the length-scales small, wide shallow shelves maximize ocean to coast penetration of the SSH signal and coastal-wall type topographies maximize insulation. When the frictional parameter is small or the length-scales large, the dependence reverses. An exact solution shows explicitly how processes analogous to diffusion and advection alter the coastal response for different topographies and how Rossby waves due to a latitude dependent Coriolis parameter decrease the insulation provided by steep bottom topographies. The results give a more detailed linear picture of how bottom topography can affect coastal sea level in western boundary systems.

On interannual variability of the Natal Pulse

Abstract ID : 1017

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Additional Information : None

Mr. Yoko Yamagami ,yamagami@eps.s.u-tokyo.ac.jp ,(None) ,Japan ,Tokyo ,Presenting[1]

Dr. Tomoki Tozuka ,tozuka@eps.s.u-tokyo.ac.jp ,(None) ,Japan , ,Not Presenting[1]

Prof. Bo Qiu ,bo@soest.hawaii.edu ,(None) ,United States , ,Not Presenting[3]

1 - The University of Tokyo 2 - The University of Tokyo 3 - University of Hawaii at Manoa

The Agulhas Current sporadically undergoes offshore meander events, known as the Natal Pulse, which may influence the pinch off of the Agulhas Rings in the Agulhas retroflection region. Since the Agulhas Rings may play an important role in the global climate system by modulating inter-ocean water mass exchange between Indian and Atlantic Oceans, it is crucial to understand the dynamical mechanisms of variations in the Natal Pulse. In this study, the sources of the Natal Pulse and interannual variability in the occurrence of Natal Pulse events are investigated using satellite altimeter data and outputs from the Ocean general circulation model For the Earth Simulator (OFES).
Based on composite analyses and an automatic eddy tracking method, it is found that almost all the Natal Pulse events are triggered by anticyclonic eddies propagating from the upstream region, most of which originates from the Southeast Madagascar Current (SEMC), but some eddies are from the Mozambique Channel. This is further supported by a lag correlation between interannual variations of the Natal Pulse occurrence and eddy kinetic energy off the southern coast of Madagascar. An EKE budget analysis using the OFES outputs indicates relative importance of barotropic conversion not only in the Natal Bight but also in the SEMC region. Therefore, this study suggests an intriguing energy path from the basin-scale wind field to the Natal Pulse through the SEMC intensification and eddy propagation.

Dynamics of Brazil Current transport variability observed at 34.5°S on intraseasonal to interannual time scales

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Additional Information : None

Dr. Maria Paz Chidichimo ,mariapaz.chidichimo@gmail.com ,(Researcher) ,Argentina ,Ciudad Autónoma de Buenos Aires ,Not Presenting[1]

Mr Alberto Piola ,apiola@hidro.gov.ar ,(None) ,Argentina , ,Not Presenting[2]

Dr. Christopher Meinen ,Christopher.Meinen@noaa.gov ,(Oceanographer) ,United States ,Miami ,Not Presenting[3]

Mr Silvia Garzoli ,Silvia.Garzoli@noaa.gov ,(None) ,United States , ,Not Presenting[4]

Mr Edmo Campos ,edmo@usp.br ,(None) ,Brazil , ,Not Presenting[5]

Dr. Renellys Perez ,Renellys.C.Perez@noaa.gov ,(Associate Scientist) ,United States ,Miami ,Not Presenting[4]

Prof. Sabrina Speich ,speich@lmd.ens.fr ,(None) ,France , ,Not Presenting[7]

Mr Shenfu Dong ,Shenfu.Dong@noaa.gov ,(None) ,United States , ,Not Presenting[3]

1 - Argentine Research Council (CONICET) / Hydrographic Service 2 - Univ. Buenos Aires 3 - NOAA-AOML 4 - UM/CIMAS and NOAA-AOML 5 - Univ. Sao Paulo 6 - UM/CIMAS and NOAA-AOML 7 - ENS 8 - NOAA-AOML

The Brazil Current (BC) closes the subtropical gyre in the western South Atlantic, carrying relatively warm and salty along the continental margin of South America between approximately 15ºS to 38ºS. As it flows southward the BC contributes to the Meridional Overturning Circulation (MOC) variability in the South Atlantic and the associated meridional heat transport. Variations in the BC cause significant anomalies in the regional sea surface temperature, which have an impact on the regional climate and marine ecosystems. Previous studies using satellite data have shown that in the last few decades the BC penetrated further south, but the associated impacts of this displacement are not yet well understood. Here, the BC transport variability is analyzed from data collected along a line in the western South Atlantic at 34.5ºS with four pressure-equipped inverted echo sounders (PIES) from May 2009 to present. In 2012, two current-and-pressure-equipped inverted echo sounders (CPIES) were deployed midway between three of the existing sites to augment the horizontal resolution of the array. The combination of the data from the PIES/CPIES and regional hydrographic surveys yields daily estimates of full-depth vertical profiles of temperature, salinity, density, and the meridional component of the absolute geostrophic velocity. Daily time series of absolute BC transport are estimated by vertically integrating the geostrophic velocities (baroclinic referenced to the bottom plus barotropic) across the array. Continental shelf flows are estimated using high-resolution hydrographic transects, direct velocity measurements from an ADCP mooring, and numerical models. The estimated time-mean absolute southward BC transport at 34.5ºS is -13.5 ± 0.8 Sv with a standard deviation of 5.0 Sv. Fluctuations with periods shorter than 100 days account for 60% of the variance. The variability of the baroclinic component accounts for the largest fraction of the absolute transport variability (80%). The baroclinic and barotropic transports are uncorrelated, highlighting the need of

measuring both transport components independently. Local and basin-wide drivers of BC variability on intraseasonal to interannual time scales as well as the linkage between BC and MOC variability observed at 34.5ºS will be presented and discussed.

Crossroads of the Agulhas System

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Additional Information : None

Dr. Jeffrey Book ,jeff.book@nrlssc.navy.mil ,(None) , , ,Not Presenting[1]

Prof. Isabelle Ansorge ,Isabelle.Ansorge@uct.ac.za ,(Head of Department) ,South Africa ,None ,Not Presenting[2]

Dr. Tarron Lamont ,tarron.lamont@gmail.com ,(Marine Scientist) ,South Africa ,Cape Town ,Not Presenting[3]

Mr. Marcel van den Berg ,MARCEL@OCEANAFRICA.COM ,(None) ,South Africa , ,Not Presenting[4]

Dr. Ana Rice ,Ana.Rice@nrlssc.navy.mil ,(None) ,United States , ,Not Presenting[5]

1 - US Naval Research Laboratory 2 - UCT 3 - Department of Environmental Affairs 4 - Oceans and Coasts Research, DEA 5 - U.S. Naval Research Laboratory

The Agulhas Current System, uniquely among Western Boundary Currents, turns back upon itself in a tight loop forming the Agulhas Retroflection. The shedding of Agulhas Rings at the retroflection provides a pathway of exchange between the Atlantic and Indian Oceans with important implications for the meridional overturning circulation. After the retroflection, the Agulhas Return Current (ARC) meanders northward around the Agulhas Plateau before returning to its easterly pathway. At its most northerly point, the ARC passes within 300 km of the oppositely flowing Agulhas Current (AC), and an altimetry track line crosses through both currents. Annual measurement of The AC and ARC along this "Crossroads" Line has been conducted for five years, starting with a cruise to study the ARC in 2012 and then by cruises returning from Marion Island from 2013 through 2017. Absolute geostrophic volume and temperature transports were calculated for both these major currents using CTD and XBT hydrographic measurements referenced to shipboard ADCP currents. We will present the results of these Crossroads Line studies with respect to the dynamics and snapshot transports of the AC, ARC, and several major mesoscale eddies that also crossed the transect line during the crossings.

Wind Increase above Agulhas Eddies

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Additional Information : None

Prof. Mathieu Rouault ,Mathieu.Rouault@uct.ac.za ,(Professor) ,South Africa ,Cape Town ,Not Presenting[1]

1 - University of Cape town

Sea surface temperature (SST) estimated from the Advanced Microwave Scanning Radiometer E onboard the Aqua satellite and altimetry derived sea level anomalies are used south of the Agulhas Current to identify warm-core mesoscale eddies presenting a distinct SST perturbation superior to 1^{o}C to the surrounding ocean. The analysis of twice daily instantaneous charts of equivalent stability neutral wind speed estimates from the SeaWinds scatterometer onboard the QuikScat satellite collocated with SST during the lifespan of for those six identified eddies show stronger wind speed above those warm eddies than surrounding water at all wind directions as was found in previous studies. However, only half of the case show higher wind above the eddies at the instantaneous scale. 20 % of the cases had incomplete data due to partial global coverage of the scatterometer for one path. For cases where the wind is stronger above warm eddies, there is no relationship between the increase in surface wind speed and the SST perturbation but we do find a linear relationship between the decrease in wind speed from the center to the eddy border downstream and the SST perturbation. SST perturbations range from 1^{o}C to 6^{o}C for a mean eddy SST of 15.9^{o}C and mean SST perturbation of 2.65^{o}C. Diameter of eddies range from 100 to 250 km. Mean background wind speed is about 12 m.s^{-1} mostly southwesterly to northwesterly and ranging mainly from 4 m/s to 16 m/s. Mean wind increase is about 15 % at 1.8 m.s^{-1}. Wind speed increase of 4 to 7 m.s^{-1} above warm eddies is not uncommon. Cases where the wind did not increase above the eddies or did not decrease downstream had higher wind speeds and happen during cold front associated with intense cyclonic low pressure systems suggesting certain synoptic conditions need to be met to allow for the development of wind speed anomalies over warm core ocean eddies In many cases, change in wind speed above eddies was masked by a large-scale synoptic wind speed deceleration/acceleration affecting part of the eddies.

Disentangling the link between transport and eddies in the Mozambique Channel

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Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Stéphane Pous ,pous@mnhn.fr ,(associate Professor) ,France ,Paris ,Not Presenting[1]

Dr. Julie Deshayes ,Julie.Deshayes@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[2]

Prof. Pierrick Penven ,pierrick.penven@ird.fr ,(None) ,France , ,Not Presenting[3]

Dr. Bjorn Backeberg ,BBackeberg@csir.co.za ,(Principal Researcher) ,South Africa ,Cape Town ,Not Presenting[4]

Dr. Issufo Halo ,haloi@cput.ac.za ,(None) ,South Africa , ,Not Presenting[5]

Prof. Chris Reason ,chris.reason@uct.ac.za ,(None) ,South Africa , ,Not Presenting[6]

1 - MNHN 2 - CNRS 3 - IRD 4 - CSIR 5 - Cape Peninsula University of Technology 6 - University of Cape Town

Circulation in the Mozambique Channel is dominated by the southward migration of eddies, particularly large anticyclonic features, as observed through LOCO section. Previous studies based on high resolution ocean hindcast suggest that these eddies are generated to the north of the Channel by barotropic and baroclinic instabilities. On the other hand, the net transport through the Channel has been linked to large-scale modes of variability in the South West Indian Ocean. Notwithstanding, the link between the eddies and the net transport through the Channel remains unclear. This is the question that we address, using a multi-model comparison approach.
Regional high resolution ocean hindcasts using NEMO, HYCOM and ROMS all succeed in reproducing eddies in the Mozambique Channel. They also produce a net transport through LOCO section with quite realistic mean value and variability. Yet, by investigating in details the processes of variability, a number of substantial differences amongst hindcasts are highlighted. Unfortunately, all simulations have biases and none is reproducing observations perfectly well. As a consequence, and in absence of longer observations along LOCO section, we look for features in the mechanisms of variability common to most hindcasts and hypothesize that those reflect the real ocean.
In this presentation, we will present and discuss some results from this methodology for the link between transport and eddies in the Mozambique Channel: at sub-annual frequency, changes in the net transport seem to result from anomalies in the upper ocean currents, due to both passing eddies and boundary currents, while at low frequency, our analysis suggests that changes in the net transport are rather linked to anomalies in the deep undercurrent located along the western side of the Channel.

Modelling the cyclonic Durban Eddy south of the KwaZulu-Natal Bight, east coast of South Africa

Abstract ID : 1360

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Ms. Lisa Guastella ,lisa.guastella@alumni.uct.ac.za ,(Research Scientist) ,South Africa ,Durban ,Presenting[1]

Dr. Serena ILLIG ,serena.illig@ird.fr ,( ) ,France ,Toulouse ,Not Presenting[2]

Dr. Michael Roberts ,Mike.Roberts@nmmu.ac.za ,(None) ,South Africa , ,Not Presenting[3]

1 - BCRE 2 - IRD 3 - Nelson Mandela Metropolitan Unviersity

The Durban Eddy is a semi-permanent mesoscale cyclonic lee eddy that exists south of the KwaZulu-Natal Bight (KZNB), along the east coast of South Africa. The eddy spins up south of Durban, inshore of the southward flowing Agulhas Current and in the lee of the Bight. After a few days, it detaches from this position, migrates southward and flattens inshore of the Current, eventually dissipating ~100 km to the south. It is postulated that the Eddy is topographically induced (Pearce, 1977; Gill & Schumann, 1979) and that it may be one of the suppliers of nutrients to the KZNB through northward advection of upwelled eddy water inshore (Meyer et al., 2002), although there was little material evidence for this. Using surface drifter buoys and ADCP current measurements, Guastella & Roberts (2016) was inconclusive of this, due to limited sampling in space and time, although they suggested it was possible that a portion of water could advect northward. To overcome the limitation in data availability, our approach is to test these theories based on experimentation with the Regional Ocean Modelling System (ROMS). While the Natal Pulse (a larger feature associated with meanders in the Agulhas Current) has been the subject of previous oceanographic modelling studies (e.g. Tsugawa & Hasumi, 2010), no known dedicated oceanographic modelling has thus far been done on the smaller, mesoscale Durban Eddy. Therefore, this study represents a benchmark to further investigate this feature. A parent configuration with a spatial resolution of 1/8° simulates the circulation off eastern South Africa, while a first online zoom at 1/24° details the dynamics of the KZNB and a second embedded zoom at 1/72° focuses on the Durban Eddy. Results show that the model replicates the circulation of the KZNB well in the child domain and reproduces the Durban Eddy spatio-temporal dynamics in the grandchild domain. The destination of eddy water was investigated with Lagrangian floats trajectory analysis, disseminated at various positions/levels in the model. Initial results indicate that it is possible for Durban Eddy water to advect northward at depth, lending support to the theory by Meyer et al. (2002).

Impacts of Agulhas Leakage on the western boundary systems of the Tropical Atlantic Ocean

Abstract ID : 1366

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Content Motivation : None
Additional Information : None

Dr. Paola Castellanos ,castellanos@icm.csic.es ,(None) ,Spain , ,Presenting[1]

Mr Edmo Campos ,edmo@usp.br ,(None) ,Brazil , ,Not Presenting[2]

Dr. Jaume Piera ,piera@icm.csic.es ,(None) ,Spain , ,Not Presenting[1]

Mr Olga Sato ,olga.sato@usp.br ,(None) ,Brazil , ,Not Presenting[2]

1 - Institut de Ciències del Mar, CSIC 2 - Univ. Sao Paulo 3 - Institut de Ciències del Mar, CSIC 4 - Univ. Sao Paulo

The potential effects of changes in the Agulhas Leakage on the mean ocean circulation and anomalies in the South and Tropical Atlantic are studied with an eddy-resolving numerical experiment with the Hybrid Coordinate Ocean Model (HYCOM). Results show an increase in the leakage from 1970 to 2010. This increase in the leakage has an impact on the meridional oceanic volume and heat transports in the Atlantic Ocean. Significant linear trends found in the integrated transport at 20ºS, 15ºS, and 5ºS correlate well with decadal fluctuations of the Agulhas leakage. The augmented transport seems to be related to an increase in the latent heat flux observed along the NE Brazil coastline since 2003. Our study shows that the precipitation in the Brazilian coast has been increasing since 2005, at the same location and with the same regime shift observed for the latent heat flux and the volume transport. This strongly suggests that the increase of the Agulhas transport affects the western boundary system of the Tropical Atlantic Ocean, which is directly related to an increase in the precipitation and latent heat flux along the western coast.

The use of downscaling technique to investigate the physical processes related to the Brazil Current in the Southwest Atlantic - Preliminary Results

Abstract ID : 1425

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Miss. Leilane Passos ,leilanepassos@gmail.com ,(Research Project Scholarship) ,Brazil ,Sao Jose dos Campos ,Presenting[1]

Dr. Luciano Pezzi ,luciano@dsr.inpe.br ,(None) ,Brazil , ,Presenting[2]

1 - INPE 2 - National Institute for Space Research

Regional effects of climate change on the Brazil Current have not been investigated properly. For instance, recent studies based on a Coupled Global Climate Models (CGCM) pointed to a warming trend of the western boundary currents in the next decades. However, these studies have applied the CGCMs in a coarse horizontal resolution (~100 km) so that the mesoescale oceanic processes related to western boundaries cannot completely be solved. The downscaling technique has widely been used in the regional modeling in order to generate the climate information in higher resolution and to understand more accurately the local and regional response of the ocean to the climate change. In this work, downscaling experiments were performed using the results of the CGCM named Community Climate System Model version 4 (CCSM4) in simulations with the Regional Ocean Modeling System (ROMS). The regional downscaling employed a horizontal resolution of ~9 km in the Southwest Atlantic to reproduce the CCSM4 in three scenarios: (i) historic, (ii) RCP4.5 and (iii) RCP8.5. The results of historical scenario compared to the Optimum Interpolation Sea Surface Temperature (OISST) showed that the ROMS simulation reached the area-averaged root mean square deviation (RMSD) for sea surface temperature (SST) of 1.98°C, while the original CCSM4 exhibited 1.65°C. It was important to note that ROMS simulation presented low RMSDs in most of the numeric domain, excepting the area around the Subantarctic front and in the Brazil-Malvinas Confluence (BMC) region. These higher errors can be attributed to the ROMS use of a bulk formulation to calculate the input of heat, moist and stress fluxes on ocean surface what might influence negatively its SST representation. Unlike, CCSM4 is an earth system model and the ocean, land, ice, and atmosphere components are coupled by allowing a more appropriate input these fluxes in the ocean-atmosphere interface. Furthermore, these results are preliminary and new experiments have been performing to improve the downscaling results, mainly in the BMC region. Finally, experiments have been planned to reproduce the RCP4.5 and RCP8.5 scenarios under different atmospheric CO_2 concentrations.

P07 - Upwelling systems and ocean economy (IAPSO)

Agulhas Leakage and the intermediate water masses in the Benguela Upwelling system

Abstract ID : 71

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Nele Tim ,nele.tim@uni-hamburg.de ,(PostDoc) ,Germany ,Hamburg ,Not Presenting[1]

Mr Kay-Christian Emeis ,kay.emeis@uni-hamburg.de ,(None) ,Germany , ,Not Presenting[2]

Mr Eduardo Zorita ,eduardo.zorita@hzg.de ,(None) ,Germany , ,Not Presenting[3]

1 - University of Hamburg 2 - Helmholtz-Zentrum Geesthacht, University of Hamburg 3 - Helmholtz-Zentrum Geesthacht

We analysed the origin and age of intermediate waters that well up in the Benguela Upwelling System (BUS) located off Angola, Namibia and South Africa, one of the four large Eastern Boundary Upwelling Systems (EBUS). EBUS's very high primary production is supported by upwelling of cold sub-thermocline and nutrient-rich water masses in response to trade-wind induced offshore Ekman transport. Upwelling in the BUS is fed by two distinct intermediate water masses that cause differences in the nutrient, CO2 and oxygen states of the northern and southern sub-systems, and the relative predominance of these water masses has significant effects on the ecosystem. We analyse a simulation with an ocean model INALT20 (GEOMAR Kiel, Germany), a global ocean simulation with the 1/4 degree and a nested 1/20 degree resolution over the South Atlantic Ocean, for the time period 1958-2009. Our focus lies on the impact of the Agulhas Leakage on the South Atlantic water masses at intermediate depths. To investigate the pathways and ages of the two upwelling water masses before they reach the Namibian shelf, we used the Lagrange software ARIANE for tracking water parcel trajectories in the ocean simulation. Both intermediate water masses contain Agulhas Leakage water and differ in transport history and age. As a second part, the Agulhas Leakage response to wind stress variations and the possible impact of the El Niño-Southern Oscillation was analysed. The position and intensity of the westerly belt and the easterly trades north of it appear to modulate the amount of water of the Agulhas Current reaching the South Atlantic.

Equilibrium Dynamics of the Benguela System

Abstract ID : 623

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Jennifer Veitch ,veitch.jennifer@gmail.com ,(None) ,South Africa , ,Presenting[1]

Prof. Pierrick Penven ,pierrick.penven@ird.fr ,(None) ,France , ,Not Presenting[2]

Dr. Juliet Hermes ,juliet@saeon.ac.za ,(None) ,South Africa ,None ,Not Presenting[1]

Dr. Tarron Lamont ,Tlamont@environment.gov.za ,(None) ,South Africa , ,Not Presenting[4]

Prof. Frank Shillington ,frank.shillington@uct.ac.za ,(None) ,South Africa , ,Not Presenting[5]

1 - SAEON 2 - IRD 3 - SAEON 4 - Oceans & Coasts Research Branch, Department of Environmental Affairs 5 - UCT

As one of the world's four highly-productive eastern boundary upwelling systems, the Benguela is unique in that both its northern and southern boundaries are associated with warm water tropical regimes: the former via signals propagating from the tropical Atlantic and the latter with turbulent interactions associated with Agulhas leakage. Broadly speaking, the Benguela upwelling system can be divided into northern and southern regimes, separated by the perennially intense Lüderitz upwelling cell at 27°S where offshore volume fluxes are extremely large. Upwelling is most intense during austral spring and summer months in the southern Benguela where the seasonal signal is large, whereas in the northern Benguela the signal is very much reduced and most intense upwelling occurs during autumn and winter months. This phase shift of upwelling in the Benguela system is connected with the seasonally shifting South Atlantic Anticyclone and the intensification of the southeasterly, upwelling favourable wind by the land-sea thermal gradient. Model results show that while indexes based on 2D upwelling theory reproduce the seasonal signal and large-scale upwelling features satisfactorily, they underestimate (overestimate) upwelling rates in the southern (northern) Benguela due to local enhancement (inhibition) by geostrophic currents. The enhancement of upwelling in the southern Benguela is related to the Good Hope jet current that is driven by the cross-shore density front that intensifies seasonally during active upwelling periods and also throughout the year by warm offshore waters associated with Agulhas leakage. The success of the Benguela marine ecosystem and the west coast fishing industry therefore depends not only on wind-driven coastal upwelling dynamics and nearshore retention processes that ensure successful recruitment, but also on larger-scale dynamics that can influence the health of the ecosystem by, for example, nearshore geostrophic convergence, the transport of fish eggs and larvae (into nursery areas and cross-shelf losses) and the transport of low-oxygen water (notably in the north).

seasonality of coastal upwelling off south of Madagascar: temporal and spatial variability

Abstract ID : 633

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Mr. Juliano Dani RAMANANTSOA ,oceanman1@live.fr ,(PhD Candidate) ,South Africa ,Cape Town ,Not Presenting[1]

Dr. Marjolaine Krug ,mkrug@csir.co.za ,(Dr.) ,South Africa ,Cape Town ,Not Presenting[2]

Prof. Mathieu Rouault ,Mathieu.Rouault@uct.ac.za ,(Professor) ,South Africa ,Cape Town ,Not Presenting[3]

Prof. Pierrick Penven ,pierrick.penven@ird.fr ,(None) ,France , ,Not Presenting[4]

Prof. Jonathan Gula ,jonathan.gula@univ-brest.fr ,(None) ,France , ,Not Presenting[5]

1 - UCT 2 - Council for Scientific and Industrial Research 3 - University of Cape town 4 - IRD 5 - LOPS

High biological productivity in Madagascar's southern coastal marine zone is attributed to coastal upwelling which supports a wide range of marine ecosystems, including fisheries. Changes in the upwelling system may have a direct impact on biological and societal functions provided by the system. This paper provides new insights on the variability of upwelling in the coastal regions of South of Madagascar. Satellites-derived are used to characterise the spatial extent and strength of the coastal upwelling cells. A front detection algorithm and an upwelling index are applied to thirteen years of Multi-scale Ultra-high Resolution Sea Surface Temperatures (SST). The influence of the winds and ocean currents as drivers of the upwelling are investigated using satellite and in-situ observations as well as numerical models.

Results reveal the presence of two well-defined upwelling cells. The first cell (core 1) is located in the south-east, while the second cell (core 2) occurs at the southern tip of Madagascar. These two cores are characterised by different seasonal occurrences, different intensities, different upwelled water mass origins, as well as different forcing mechanisms.

Findings also indicate that the wind contributes to the coastal upwelling south of Madagascar; although it is not the main driver. On the other hand, the East Madagascar Current (EMC) is significantly linked to the upwelling index in core 1 only. Findings also reveal that core 1 and core 2 are influenced by two different coastal flows which follow respectively eastern pathways, from EMC water, and western pathways, from the Mozambique channel water.

The upwelling mechanism investigation revealed that the eastern part of core 1 is more topographically induced upwelling by the EMC while the southernmost part is more wind-driven cross chore Ekman transport. The origin of the high seasonality of the upwelling in core 2 comes from a concurrent contribution primarily from the coastal circulation, as well as wind-driven upwelling. Core 2 is also more influenced by the intrusion of warm water from the western pathways.

Towards a coastal modelling system for South Africa: A St Helena Bay case study

Abstract ID : 649

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Charine Collins ,charinecollins@gmail.com ,(Post-Doctoral Research Fellow) ,South Africa ,Cape Town ,Presenting[1]

Dr. Tarron Lamont ,tarron.lamont@gmail.com ,(Marine Scientist) ,South Africa ,Cape Town ,Not Presenting[2]

Dr. Bjorn Backeberg ,BBackeberg@csir.co.za ,(Principal Researcher) ,South Africa ,Cape Town ,Not Presenting[3]

Dr. Jennifer Veitch ,veitch.jennifer@gmail.com ,(None) ,South Africa , ,Not Presenting[4]

Dr. Juliet Hermes ,juliet@saeon.ac.za ,(None) ,South Africa ,None ,Not Presenting[4]

1 - South African Environmental Observation Network 2 - Department of Environmental Affairs 3 - CSIR 4 - SAEON 5 - SAEON

St. Helena Bay, forming part of the southern Benguela ecosystem, is the largest bay on the west coast of South Africa. It is a well-known retention area and one of the most productive embayments of the Benguela ecosystem. To date, only a few infrequent studies have focused on variations in the bay scale circulation. Climatologies of the vertical structure of temperature and salinity, constructed from monthly sampling along the St Helena Bay Monitoring Line (SHBML) over an 11-year period, have revealed clear vertical and cross-shelf variations at the seasonal timescale. Even though ocean modelling efforts in and around South Africa have increased in recent years, high-resolution bay scale modelling is still in its infancy. The observational data set in the St Helena Bay region, the only long-term, cross-shelf, full water column dataset for South Africa, makes this area the perfect location to test the appropriateness of existing regional simulations for further downscaling at the bay scale. The aim of this study is to assess and understand the relative strengths and limitations of a number of regional three-dimensional hydrodynamic models, all of which have been used in the past to study various aspects of the Benguela ecosystem. Quantitative model-data comparisons using multiple univariate skill metrics are used to reveal the advantages and potential limitations of the different model simulations. Taylor and target diagrams are used to visually summarise the model skill in reproducing both the temporal and spatial variability along the SHBML. The models under consideration exhibit varying degrees of skill in reproducing the observed variability along the SHBML. Overall, the models demonstrate limited skill in reproducing the temporal and spatial variability of temperature and salinity. All the models demonstrate greater skill in reproducing the observed seasonal variability in the surface and at depth than at intermediate levels. Furthermore, the models also demonstrate greater skill in reproducing the offshore variability compared to the inshore variability.

Decade-scale trends in plankton of the Benguela upwelling system

Abstract ID : 708

Conflict Declaration : None
Content Motivation : None
Additional Information : None

Dr. Hans Verheye ,hans.verheye@gmail.com ,(Specialist Scientist) ,South Africa ,Cape Town ,Presenting[1]

Dr. Tarron Lamont ,tarron.lamont@gmail.com ,(Marine Scientist) ,South Africa ,Cape Town ,Not Presenting[1]

Dr. Jenny Huggett ,jenny.huggett@gmail.com ,(Marine Scientist) ,South Africa ,Cape Town ,Not Presenting[1]

Dr. Anja Kreiner ,Anja.Kreiner@mfmr.gov.na ,(None) ,Namibia , ,Not Presenting[4]

Mr. Richard Horaeb ,Richard.Horaeb@mfmr.gov.na ,(None) ,Namibia , ,Not Presenting[5]

Mr. Ian Hampton ,ihampton@fishsurveys.co.za ,(None) ,South Africa , ,Not Presenting[6]

1 - Department of Environmental Affairs 2 - Department of Environmental Affairs 3 - Department of Environmental Affairs 4 - Ministry of Fisheries and Marine Resources 5 - None 6 - Fisheries Resource Surveys cc.

Environmental drivers causing changes in phytoplankton biomass and production include surface warming, increased wind stress and upwelling, extension of low-oxygen zones, changes in nutrient distribution and increased stratification. While variations in phytoplankton at seasonal and interannual time scales have been documented in the Benguela, there is no strong evidence of decade-scale changes or the expected ecosystem-wide increase/decrease in production in response to projected increases/decreases in upwelling-favourable winds. During the past seven decades trends in abundance, biomass, production and species and size composition of neritic zooplankton communities have changed substantially on the west and south coasts of southern Africa. On the West Coast, copepod abundance increased from the 1950s onward in both the northern and southern Benguela subsystems, until a turning point around the mid-1990s in the south and a decade later in the north, after which abundance declined. There was also a shift from large to smaller species dominating the copepod communities. Such changes in copepod abundance and community structure may be linked to an ecological regime shift, likely induced by environmental changes but exacerbated by a shift in prey size-based predation pressure by pelagic fish. On the South Coast, total copepod abundance has declined since the late 1980s, and while upwelling has increased, phytoplankton biomass and size composition showed no significant trends. Copepod species composition indicated a gradual decline in the proportion of *Calanus agulhensis*, the dominant large copepod on the South Coast, with a corresponding increase in the proportion of small copepods. These major changes reflect patterns of spatial, temporal and size-based heterogeneity in the Benguela upwelling region and are thought to be mediated locally and differentially through bottom-up and top-down forcing mechanisms. While the relative importance of these control mechanisms remains uncertain, changes in the plankton observed in the Benguela have fundamental effects on biogeochemical processes, food web structure and ecosystem functioning, as well as on the ecosystem services supported by the plankton. Because plankton are ideal indicators of ecosystem change, continued systematic

monitoring of their communities in the region is essential to understanding the long-term impacts of these changes.

POPULATION DISTRIBUTION AND BIOMASS VARIABILITY OF SARDINE AND ANCHOVY IN THE CANARY CURRENT SYSTEM AS SIMULATED BY AN END-TO-END CUOPLED MODEL

Abstract ID : 960

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. José Carlos Sánchez Garrido ,jcsanchez@ctima.uma.es ,(Postdoc researcher) ,Spain ,Malaga ,Not Presenting[1]

Dr. Francisco Werner ,cisco.werner@noaa.gov ,(None) ,United States , ,Not Presenting[2]

Dr. Antonio J. Ramos González ,antonio.ramos@ulpgc.es ,(None) ,Spain , ,Not Presenting[3]

Dr. Jerome Fiechter ,fiechter@ucsc.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Curchitser Enrique ,curchitser@gmail.com ,(None) ,United States , ,Not Presenting[5]

Dr. Jesús García Lafuente ,glafuente@ctima.uma.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Javier Arístegui ,javier.aristegui@ulpgc.es ,(None) ,Spain , ,Not Presenting[7]

Dr. Santiago Hernández León ,shernandezleon@ulpgc.es ,(None) ,Spain , ,Not Presenting[8]

Dr. Angel Rodríguez Santana ,angel.santana@ulpgc.es ,(None) ,Spain , ,Not Presenting[8]

1 - University of Malaga 2 - NOAA 3 - Universidad del Las Palmas de Gran Canarias 4 - University of California Santa Cruz 5 - Rutgers University 6 - University of Malaga 7 - Universidad de las Palmas de Gran Canarias 8 - Universidad de Las Palmas de Gran Canarias 9 - Universidad de Las Palmas de Gran Canarias

Small pelagic fishes as sardine and anchovy account for as much as 20-25% of the world fisheries catch. They are particularly abundant in the four major eastern boundary upwelling ecosystems, where high levels of biological productivity are sustained by the supply of nutrient-rich water from beneath the photic zone. An intrinsic and puzzling feature of small pelagic fish is the large fluctuations of their population, typically occurring at decadal scales. The causes for such fluctuations have been extensively analyzed and discussed in the literature, yet our understanding of the mechanism involved is very limited. End-to-end models are emerging tools useful to test hypothesis for such fish population variability or to gain new insights into the problem. This comprehensive and complex model approach is now becoming possible largely thanks to the present-day computer power.
This contribution focuses on the population dynamics of sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) in the Canary Current Upwelling Ecosystem. We describe and present the results of an end-to-end coupled model simulation including these two small pelagic species. The end-to-end application includes three model components: the ROMS circulation sub-model, the lower

trophic ecosystem sub-model NEMURO, and a recently developed individual-based model for the fish (Rose et al. 2015; Fiechter et al. 2015). The computational grid for the three models covers NW Africa and the Western Iberian Peninsula at a spatial resolution of 12 km. This resolution is sufficient for certain eddy variability to occur in ROMS. Different biological traits were prescribed for anchovy and sardine: temperature optimum, diet preferences, and the onset and duration of the spawning season, among others. A hind-cast simulation of the period 1958-2007 was carried out.
Model results reveal a fairly different behavior of sardine and anchovy. Anchovies gather off the northern part of Morocco and the Gulf of Cadiz, whereas sardines appear more scattered across the domain, further offshore, and further south, where upwelling favorable conditions take place year round. Both species exhibit decadal-scale fluctuations in both the location of the center of mass of the population and their biomass abundance; the latter being reasonably correlated with historical landing records.

Subseasonal Coastal Trapped Waves propagation in the Southeastern Pacific and Atlantic oceans

Abstract ID : 1253

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Serena ILLIG ,serena.illig@ird.fr ,( ) ,France ,Toulouse ,Presenting[1]

Miss. Emeline Cadier ,emeline.cadier@gmail.com ,(None) ,France , ,Not Presenting[1]

Mrs. Marie-Lou Bachelery ,bachelery.marielou@gmail.com ,(Post doctoral fellow) ,South Africa ,Cape Town ,Not Presenting[3]

Dr. Boris Dewitte ,boris.dewitte@ird.fr ,(None) ,France , ,Not Presenting[1]

1 - IRD 2 - IRD 3 - Department of Oceanography, MARE Institute, LMI ICEMASA, University of Cape Town 4 - IRD

The objective of this study is to describe the Coastal Trapped Wave variability along the southwestern American and African continents at subseasonal timescales (<120 days). We aim at determining to which extent the alongshore current and sea level coastal variability can be accounted for by equatorially remote-forced or locally wind-forced CTW response. The methodology is based on the experimentation with twin regional model configurations of the South Eastern Pacific and the Southeastern Atlantic oceans. The estimation of free CTW modal structures and associated contribution to coastal variability allows to infer and compare the characteristics (magnitude, dissipation, scattering) of each CTW mode in the two systems, in order to explain their similarities and differences at subseasonal time scales as observed from altimetry. The modal structures of the four first free CTW modes are first derived from model mean stratification and topography, at all cross-shore sections along the Southwestern African and American continents. In the Humboldt Current system, the CTW structures are significantly more baroclinic than in the Benguela, due to steeper and deeper topographic slope along the Peruvian and Chilean coasts. We then developed a new methodology to estimate the CTW contributions to model pressure and alongshore currents. In both systems, the extracted modes of variability are shown to propagate at velocities close to the appropriate theoretical phase speeds. The summed-up contribution of the first three CTW modes account for ~60% of the subseasonal variance in along-shelf currents on the shelf and slope and ~80% of the coastal sea level variability. In the Atlantic southeastern basin, mode 2 carries a greater fraction of CTW energy than mode 1, while in the Pacific counterpart it is the inverse. Mode 1 and mode 2 contributions are not coherent in time and exhibits particular space-time characteristics. Numerical sensitivity experiments allow to quantify the respective contributions of the local atmospheric forcing versus the remote equatorial forcing to the subseasonal CTW propagations in both systems.

Effects of environmental variability on small pelagic fish in the southern Benguela ecosystem

Abstract ID : 1503

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Carl van der Lingen ,carl.vanderlingen@gmail.com ,(None) ,South Africa , ,Not Presenting[1]

1 - Department of Agriculture, Foresty, and Fisheries

Small pelagic fish are important in upwelling ecosystems as they are typically important forage species and provide a critical trophic link between the high primary and secondary productivity of these systems and a suite of predators including other fishes, marine mammals and seabirds. Small pelagic fish also support large commercial fisheries in upwelling and other systems and account for around 25% of present total global marine catch. In the southern Benguela, combined annual catches of sardine (*Sardinops sagax*), anchovy (*Engraulis encrasicolus*) and West Coast round herring (*Etrumeus whiteheadi*) have averaged around 300 000t for the past five decades. Their planktivorous diet, short life span and reliance on transport to or retention within suitable nursery areas of their pelagic eggs and larvae makes these species highly responsive to environmental forcing. As a consequence they are characterized by substantial inter-annual variability in recruitment success and show both annual and decadal scale fluctuations in population size. The effects of environmental variability on the dynamics of small pelagic fish in the southern Benguela are illustrated through descriptions of four modelling and observational studies that examined this. These include (i) coupled 3D hydrodynamic - individual based models that examined the influence of spatial and temporal variability in sardine and anchovy spawning patterns on transport to and retention within suitable nursery grounds, with a brief discussion of the management implications of such studies for the sardine fishery; (ii) investigations into whether the abrupt eastward shift in relative anchovy spawner biomass from predominantly west of Cape Agulhas to predominantly east of Cape Agulhas that occurred in the mid-1990s was linked to increased cross-shelf SST gradients on the Central and Eastern Agulhas Bank, and whether sardine and round herring are also shifting eastwards; (iii) observations of how recent harmful algal blooms on the South Coast negatively impact sardine but not anchovy, and what physical drivers might be responsible for such blooms; and (iv) investigations of how anchovy recruitment variability is influenced by coastal upwelling along the West Coast. Conjectures on how future variability in the southern Benguela arising from global climate change might impact these species are also given.

M01 - Atmospheric Chemistry and Physics for the 21st Century (IAMAS)

Contamination of Air, Dust and Sediment with Polycyclic Aromatic Hydrocarbons

Abstract ID : 79

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Khageshwar Singh Patel ,patelsingh1951@gmail.com ,(Emeritus Professor) ,India ,Raipur-492010, CG ,Not Presenting[1]

Dr. Harald Saathoff ,harald.saathoff@kit.edu ,(None) ,Germany , ,Not Presenting[2]

Dr. Yogita Nayak ,nayakyogita@gmail.com ,(None) ,India , ,Not Presenting[3]

Dr. J. Lintelmann ,lintelmann@gsf.de ,(None) ,Germany , ,Not Presenting[4]

1 - Pt. Ravishankar Shukla University 2 - Institute for Meteorology and Climate Research, Research Centre, Karlsruhe, Germany 3 - School of Studies in Chemistry, Pt. RavishankarShukla University, Raipur-492010, India 4 - GSF-Forschungszentrum für Umwelt und Gesundheit, Institut für Ökologische Chemie, Neuherberg, Germany

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous environmental pollutants and are emitted from both natural and anthropogenic sources. The chemical species i.e. black carbon (BC) and polycyclic aromatic hydrocarbons (PAHs) are emitted out with particulate matters (PM) during the combustion processes of biomass, coal, gasoline, etc. They pose a real health-hazard to inhabitants of heavily dusted regions. In this work, the distribution and sources of BC and polycyclic aromatic hydrocarbons (PAHs in the ambient respirable particulate matter (PM10), road dust and pond sediment of Raipur city during year 2007-08 are described. Twelve toxic PAHs i.e. phenanthrene (Phe), anthracene (Ant), fluoranthene (Fla), pyrene (Pyr), benz[a]anthracene (Baa), chrysene (Cry), benzo[b]fluoranthene (Bbf), benzo[k]fluoranthene (Bkf), benzo[a]pyrene (Bap), dibenz[a,h]anthracene (Dba), benzo[ghi]perylene (Bgh) and indeno[1,2,3-cd]pyrene (Ind) were selected for investigation in the proposed work. The PM10 concentration in the ambient air (n = 24) was ranged from 116 - 523 µg m-3 with mean value of 283±55 µg m-3. The BC and SPAHs contents were ranged from 8.8 - 65.5 and 0.04 - 0.17 µg m-3 with mean value of 28.8±6.8 and 0.09±0.02 µg m-3, respectively. The concentration of SPAHs in the PM10, road dust and pond sediment was found to be 342, 12.7 and 9.7 mg kg-1, respectively. The variation and sources of BC and PAHs in the PM, dust and sediment are discussed.

Origin of the seasonal cycle of columnar methane observed by GOSAT over South Asia

Abstract ID : 184

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Sachiko Hayashida ,sachiko@ics.nara-wu.ac.jp ,(Professor) ,Japan ,Nara ,Not Presenting[1]

Dr. Naveen Chandra ,nav.phy09@gmail.com ,(None) ,Japan , ,Not Presenting[1]

Dr. Prabir K. Patra ,prabir@jamstec.go.jp ,(None) ,Japan , ,Not Presenting[3]

Dr. Tazu Saeki ,tazu.saeki@jamstec.go.jp ,(None) ,Japan , ,Not Presenting[3]

1 - Nara Women's University 2 - Nara Women's University 3 - Department of Environmental Geochemical Cycle Research, JAMSTEC 4 - Department of Environmental Geochemical Cycle Research, JAMSTEC

To reduce the uncertainty in CH4 emissions on a regional scale, we need to examine changes in the geographical distribution of CH4 in more detail, including the seasonal and year-to-year variability, and compare these findings with the factors that control CH4 emissions. Though satellite observations have the advantage of providing continuous monitoring over a wide spatial range, the information obtained from passive nadir-sensors that use solar radiation from the Short-Wavelength Infrared (SWIR) spectral region, is limited to the column amount of CH4 (XCH4), which involves the CH4 densities at all altitudes along the solar light path. The connection of XCH4 with emissions from the surface, thus, is not straightforward. In this presentation, we report the seasonal variation of XCH4 over some regions over India, which were measured by the Greenhouse Gases Observation Satellite (GOSAT). To break down the contribution of CH4 at different altitudes to XCH4, we utilize an atmospheric chemistry-transport model (ACTM). We found that, over the Indo-Gangetic Plain (IGP), the seasonal variation of XCH4 corresponds to the emission variation, with the maximum occurring in the southwest (SW) monsoon season (July-September). This fact appears to suggest that the seasonality of XCH4 could be attributable to the emission variation. However, comparisons with model simulations revealed that only half of the seasonal enhancement in the observed XCH4 can be attributable to emissions from the surface, as only 50% of CH4 is available in the lower troposphere below 600 hPa. In fact, 30% of the CH4 was in the uplifted air mass in the upper troposphere above 400 hPa. Over semi-arid western India, 70% of CH4 resides above 600 hPa, due to the characteristic transport mechanisms over India, such as the large-scale deep convection coupled with the anticyclonic wind during the SW monsoon. We will discuss the roles of transport and chemical mechanisms that control XCH4 distributions.

Evolution of air quality in Santiago, Chile: a 30 years perspective

Abstract ID : 280

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Laura Gallardo ,lgallard@u.uchile.cl ,(Associate Professor, Geophysics Director Center for Climate and Resilience Research University of Chile) ,Chile ,Santiago ,Not Presenting[1]

1 - Center for Climate and Resilience Research, University of Chile

Air quality monitoring has taken place in Santiago rather continuously since 1988, and in a standardized manner since 1997 when the first attainment plan was implemented. These data show significantly declining trends in particles, sulfur dioxide and carbon monoxide. Nitrogen oxides, on the other hand, show trends that are either insignificant or increasing, which contrasts somewhat with the substantial upward trend derived from remotely sensed data, and the two-fold increase in number of vehicles between the late 1990's and 2015. Ozone shows an either flat or slightly declining trend that would be consistent with titration by increasing NO emissions. For all species and stations, maximum values have declined more than average or median values. In this work we present an analysis of these trends in light of the curbing measures adopted so far, which are largely technology based. We argue that Santiago has reached a point that requires of more behavioral than technological measures.

(AC)³ : A German initiative to study Arctic Amplification

Abstract ID : 319

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Manfred Wendisch ,m.wendisch@uni-leipzig.de ,(Univ.-Prof.) ,Germany ,Leipzig ,Presenting[1]

Mr. Justus Notholt ,jnotholt@iup.physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[2]

Mr. Marlen Brueckner ,mbrueck@rz.uni-leipzig.de ,(None) ,Germany , ,Not Presenting[3]

Mr. Annette Rinke ,Annette.Rinke@awi.de ,(None) ,Germany , ,Not Presenting[4]

Mr. Susanne Crewell ,crewell@meteo.uni-koeln.de ,(None) ,Germany , ,Not Presenting[5]

Mr. Christof Luepkes ,christof.luepkes@awi.de ,(None) ,Germany , ,Not Presenting[6]

Mr. Andreas Macke ,macke@tropos.de ,(None) ,Germany , ,Not Presenting[7]

1 - Uni Leipzig 2 - University of Bremen 3 - University of Leipzig 4 - AWI Potsdam 5 - University of Cologne 6 - AWI Bremerhaven 7 - TROPOS

Within the last 25 years a remarkable increase of the Arctic near-surface air temperature exceeding the global warming by a factor of two has been observed. This phenomenon is commonly referred to as Arctic Amplification. The warming results in rather dramatic changes of a variety of climate parameters. For example, the Arctic sea ice has declined significantly. This ice retreat has been well identified by satellite measurements. However, coupled regional and global climate models still fail to reproduce it adequately; they tend to systematically underestimate the observed sea ice decline. It is, therefore, of utmost importance to improve our knowledge of the origins of the observed Arctic climate changes. This is required to improve the accuracy of its projections. To achieve this aim we combine the scientific expertise and competency of three German universities and two non-university research institutes in the framework of the Transregional Collaborative Research Centre TR 172. Observations from instrumentation on satellites, aircraft, tethered balloons, research vessels, and a selected set of ground-based sites are integrated in dedicated campaigns, as well as being combined with long-term measurements. The field studies are conducted in different seasons and meteorological conditions, covering a suitably wide range of spatial and temporal scales. They are performed in an international context and in close collaboration with modelling activities. The latter utilize a hierarchy of process, meso-scale, regional, and global models to bridge the spatio-temporal scales from local individual processes to appropriate climate signals. The models serve to guide the campaigns, to analyse the measurements and sensitivities, to facilitate the attribution of the origins of observed Arctic climate changes, and to test the ability of the models to reproduce observations. Result achieved in the first year of the project will be reported.

Diagnosing changes in free tropospheric ozone over Europe: A model study

Abstract ID : 378

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Fiona Tummon ,fiona.tummon@env.ethz.ch ,(Post-doc) ,Switzerland ,Zurich ,Not Presenting[1]

Dr. Andrea Stenke ,andrea.stenke@env.ethz.ch ,(None) ,Switzerland , ,Not Presenting[2]

Prof. Johannes Staehelin ,johannes.staehelin@env.ethz.ch ,(None) ,Switzerland , ,Not Presenting[2]

Dr. Laura Revell ,laura@bodekerscientific.com ,(None) ,New Zealand , ,Not Presenting[4]

Prof. Thomas Peter ,thomas.peter@env.ethz.ch ,(None) ,Switzerland , ,Not Presenting[5]

1 - None 2 - ETH Zurich 3 - ETH Zurich 4 - Bodeker Scientific 5 - ETH

In recent decades, the negative impacts of tropospheric ozone on human and ecosystem health have led to policy changes aimed at reducing emissions of ozone precursor gases such as nitrogen oxides (NO_x) and volatile organic compounds (VOCs). Although emissions of these species have significantly decreased in Europe and North America since the early 1990s, observational data indicate that free tropospheric ozone over Europe has not decreased as expected. Uncertainty remains as to how much of a role the transport of stratospheric ozone or tropospheric ozone from remote source regions has played in recent trends, as well as how this will evolve in a changing climate.
The global chemistry-climate model SOCOL (SOlar Climate Ozone Links) is used to investigate tropospheric ozone over Europe from 1980 to 2015. To fully disentangle the effects of both long-range transport and input from the stratosphere, simulations are run with ozone tracers from 29 different atmospheric regions. Results show that the largest contributions to European tropospheric ozone originate from in situ ozone production in the free troposphere, as well as input from the stratosphere. The stratospheric input during the 1990s was significantly lower than during the 1980s, indicating that this source region does not appear to have played a role in the higher than expected free tropospheric ozone levels over Europe. Instead, changes in in situ chemistry as well as increased transport from long-range source regions including Asia and the tropics play a more important role, increasing from the late 1990s into the 2000s. These results are of great significance in terms of European air quality policies and how they target high ozone levels.

The Stratosphere-troposphere Processes And their Role in Climate (SPARC) Project

Abstract ID : 381

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Fiona Tummon ,fiona.tummon@env.ethz.ch ,(Post-doc) ,Switzerland ,Zurich ,Presenting[1]

Dr. Judith Perlwitz ,Judith.Perlwitz@noaa.gov ,(None) ,United States , ,Not Presenting[1]

Prof. Neil Harris ,neil.harris@cranfield.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - None 2 - None 3 - Cranfield University

Stratosphere-troposphere Processes And their Role in Climate (SPARC) is a core project of the World Climate Research Programme (WCRP). Founded in 1992, SPARC has coordinated high-level research activities related to understanding Earth system processes for over two decades. More specifically, SPARC promotes and facilitates cutting-edge international research activities on how chemical and physical processes in the atmosphere interact with climate and climate change.
SPARC activities are organised under three overarching themes and result from an integration of process studies, observations, and modelling. Research is largely bottom-up driven and contributes significantly to international assessments, such as the assessments of ozone depletion by the World Meteorological Organisation (WMO) and United Nations Environmental Programme (UNEP), as well as the climate assessments of the Intergovernmental Panel on Climate Change (IPCC). SPARC products include scientific assessment reports, journal publications, newsletters, and datasets.
Much of the science SPARC is coordinating relates to the WCRP Grand Challenges (GC), particularly the GCs on Clouds, Circulation and Climate Sensitivity, Near-term Climate Prediction, Climate Extremes, and Carbon Feedbacks in the Climate System. Grand Challenges are both highly specific and highly focused, identifying specific barriers preventing progress in a critical area of climate science. They enable the development of targeted research efforts with the likelihood of significant progress over 5 to 10 years.
This presentation will focus on recent advancements made in SPARC research topics as well as SPARC's key objectives for the coming years.

Quantitative analysis of airborne remote sensing and in-situ observations of complex CH4 (and CO2) sources

Abstract ID : 450

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Sven Krautwurst ,krautwurst@iup.physik.uni-bremen.de ,(Doctoral Student) ,Germany ,Bremen ,Presenting[1]

Dr. Thomas Krings ,thomas.krings@iup.physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Mr. John P. Burrows ,burrows@iup.physik.uni-bremen.de ,(None) ,Germany ,None ,Not Presenting[1]

Mr. Jakob Borchardt ,bjakob@iup.physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Michael Buchwitz ,Michael.Buchwitz@iup.physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Heinrich Bovensmann ,heinrich.bovensmann@iup.physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Konstantin Gerilowski ,gerilows@iup.physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

1 - Institute of Environmental Physics, University of Bremen 2 - Institute of Environmental Physics, University of Bremen 3 - Institute of Environmental Physics, University of Bremen 4 - Institute of Environmental Physics, University of Bremen 5 - Institute of Environmental Physics, University of Bremen 6 - Institute of Environmental Physics, University of Bremen 7 - Institute of Environmental Physics, University of Bremen

Methane (CH_4) is the second most important anthropogenic greenhouse gas beside carbon dioxide (CO_2). The methane (and also CO_2) budget is well constraint on a global scale. However, localised emissions from point sources such as power plants and coal mine ventilation shafts or fugitive emissions from fossil fuel exploitation and extraction sites, and landfills are often not readily assessed by current measurement systems and networks. Especially aircraft measurements can be used to enhance our knowledge of these anthropogenic emitters, particularly when ground access is limited. A sensor developed to accomplish this task is the optical remote sensing instrument MAMAP (Methane Airborne MAPper). It delivers column-averaged dry air mole fractions of CH_4 (or CO_2) based on absorption spectroscopic measurements in the short-wave infrared region. A precision of about 0.4% allows determining emissions of point sources or fugitive emissions under study. During the last years, measurement and data analysis techniques have been refined and the method has successfully been applied to determine emissions from power plants, coal mines, landfills and oil production sites. Recently, the MAMAP remote sensing measurements were accompanied and supplemented by airborne in-situ measurements of CH_4 and CO_2. The in-situ data has been used for an independent emission rate estimate and to validate the remote sensing data. This presentation will give an overview of recent campaign activities with a focus on fugitive emissions from fossil fuel extraction sites and landfills.

Past, Present and Future of Tropospheric Ozone in Asia

Abstract ID : 458

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Hiroshi Tanimoto ,tanimoto@nies.go.jp ,(Head of Global Atmospheric Chemistry Section) ,Japan ,Ibaraki ,Presenting[1]

Dr. Kohei Ikeda ,ikeda.kohei@nies.go.jp ,(None) ,Japan , ,Not Presenting[1]

Dr. Sachiko Okamoto ,okamoto.sachiko@nies.go.jp ,(None) ,Japan , ,Not Presenting[1]

Dr. Hajime Akimoto ,akimoto.hajime@nies.go.jp ,(None) ,Japan , ,Not Presenting[1]

1 - National Institute for Environmental Studies 2 - National Institute for Environmental Studies 3 - National Institute for Environmental Studies 4 - National Institute for Environmental Studies

Evolution of tropospheric ozone is of central interest in the understanding of oxidizing capacity, radiative forcing, and impacts on ecosystem. Although much attention has been paid to reconcile long-term trends of tropospheric ozone, in particular, at the surface level, the current state-of-science models still cannot reproduce the temporal changes in the northern hemisphere in a quantitative manner. In Asia, changes during the last decades are drastic in particular in the lower free troposphere, presumably associated with intercontinental influences. Current changes, however, cannot be sufficiently evaluated due to lack of updated inventories of anthropogenic emissions. In this study we review past and current changes in ozone in the whole troposphere. We integrated ozonesonde, surface, and aircraft observations to obtain robust trends of ozone in the free troposphere in the last decade with particular emphasis on recent years. We found that the changes are slowing down after 2010 in the lower free troposphere, while still monotonically increasing in the middle and upper troposphere, implying the combined effects of the decreasing hemispheric background levels, slow down of the regional emissions of ozone precursors, and the enhancement of the stratosphere-troposphere exchange. We also discuss possible changes in near future, in response to ongoing changes in climate and socioeconomic activities in Asia.

Achievements of the EMRP project ATMOZ “Traceability for atmospheric total column ozone”

Abstract ID : 493

Conflict Declaration : None

Content Motivation : None

Additional Information : The authorship includes the partners from the EMRP-ENV59 JRP consortium

Dr. Luca Egli ,luca.egli@pmodwrc.ch ,(Scientist) ,Switzerland ,Davos-Dorf ,Presenting[1]

Dr. Julian Gröbner ,julian.groebner@pmodwrc.ch ,(None) ,Switzerland , ,Not Presenting[1]

1 - PMOD/WRC 2 - PMOD/WRC

The European Metrology Research Project "Traceability for atmospheric total column ozone" aims to significantly enhance the reliability of total ozone column determination at the Earth surface. The joint research project is a collaboration between European National Metrology Institutes (NMIs), the research community, national or international agencies and industry.
The project consortium has developed new devices, techniques, methods and software tools and has characterized the most important ozone network instruments such as Dobson and Brewer reference instruments in order to provide traceable ozone column measurements.
The conference paper presents an overview of the project and focuses on scientific highlights achieved by the end of the 3-year project. The results of following milestones of the project will be presented and discussed:

1. Characterization of Dobson and Brewer reference instruments with new devices and techniques
2. Array spectroradiometer for multispectral ozone retrieval
3. New ozone absorption cross section in the UV band
4. New high resolution solar reference extraterrestrial spectrum
5. Comprehensive uncertainty budgets for ground-based total column ozone retrieval from Dobson, Brewer and array spectroradiometer measurements

The developed methods and devices were applied and tested during two project field campaigns at the Izaña Atmospheric Research Center of the Spanish Meteorological Agency, Tenerife, Spain and at the regional Brewer calibration center Europe (RBCC-E) intercomparison in Huelva Spain. The field campaigns resulted in a comprehensive evaluation of state-of-the art ozone monitoring systems towards a homogenization of ozone networks within 1% uncertainty.

Finding the right seeding aerosol for Arctic winter cirrus cloud thinning

Abstract ID : 497

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Isabelle Steinke ,isabelle.steinke@kit.edu ,(Postdoctoral fellow) ,Germany ,Karlsruhe ,Not Presenting[1]

Mr. Tobias Schorr ,tobias.schorr@kit.edu ,(None) ,Germany , ,Not Presenting[1]

Prof. Thomas Leisner ,thomas.leisner@kit.edu ,(None) ,Germany , ,Not Presenting[1]

1 - Karlsruhe Institute of Technology 2 - Karlsruhe Institute of Technology 3 - Karlsruhe Institute of Technology

Arctic winter cirrus cloud thinning could contribute significantly to a global decrease in surface temperatures (Storelvmo and Herger, 2014). With the net warming effect of cirrus clouds strongly depending on the ice crystal number concentration and crystal sizes, efficient cloud seeding could lead to a suppression of homogeneous freezing and thus a reduced number of small ice crystals. However, there are still gaps with regard to the understanding of microphysical cirrus cloud processes, e.g. the competition between homogeneous freezing of droplets and heterogeneous ice nucleation induced by background aerosol. In this study, we present results for AIDA cloud chamber studies investigating the competition between deposition nucleation of dust aerosol and freezing of sulfuric acid droplets at temperatures between 200 and 230 K. We also present first hypotheses regarding the ice nucleation properties of efficient seeding aerosols.

References

Storelvmo, T. and Herger, N., 2014. Cirrus cloud susceptibility to the injection of ice nuclei in the upper troposphere. Journal of Geophysical Research-Atmospheres, 119(5): 2375-2389.

Ocean ventilation changes and impact on oxygen and anthropogenic carbon distributions in the North Atlantic

Abstract ID : 509

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Rhein Monika ,mrhein@physik.uni-bremen.de ,(None) ,Germany ,Bremen ,Not Presenting[1]

Dr. Steinfeldt Reiner ,rsteinf@physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Kieke Dagmar ,dkieke@uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

1 - IUP-MARUM, Uni Bremen 2 - IUP-MARUM, Uni Bremen 3 - IUP-MARUM, Uni Bremen

Ventilation of about 30 percent of the subpolar North Atlantic occurs in a relatively small region in the central Labrador Sea. Here, atmospheric climate signals as well as trace gases are transfered from the surface into the ocean interior and subsequently follow the main circulation pathways. The variability of the ventilation receives a lot of attention because of the impact on the large - scale oxygen and anthropogenic carbon distribution. Moreover, in climate models as well as in high resolution ocean - sea ice models, the ventilation variability in the Labrador Sea has a major influence on the climate relevant Atlantic meridional overturning circulation (AMOC). Here we will present the most recent estimates of ventilation changes and discuss the impact on the distribution of oxygen and anthropogenic carbon.

Atmospheric Chemistry Research and International Collaborations: Challenges facing the International Global Atmospheric Chemistry (IGAC) Project

Abstract ID : 554

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Megan Melamed ,megan@igacproject.org ,(IGAC Executive Officer) ,United States ,Boulder, CO ,Not Presenting[1]

Dr. Mark Lawrence ,mark.lawrence@iass-potsdam.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Hiroshi Tanimoto ,tanimoto@nies.go.jp ,(Head of Global Atmospheric Chemistry Section) ,Japan ,Ibaraki ,Presenting[3]

1 - International Global Atmospheric Chemistry (IGAC) Project, University of Colorado/CIRES 2 - Institute for Advanced Sustainability Studies 3 - National Institute for Environmental Studies

The atmosphere is an integrator connecting the components of the Earth system. Human emissions of pollutants and long-lived greenhouse gases into the atmosphere have caused dramatic transformations of the planet, altering air quality, climate, the cryosphere, elemental cycles and nearly every ecosystem worldwide. Understanding the global atmosphere requires an international network of scientists providing intellectual leadership in areas of atmospheric chemistry that need to be addressed, promoted and would benefit from research across disciplines and/or geographical boundaries. Acknowledgement of this need led to the formation of the International Global Atmospheric Chemistry (IGAC) Project in 1990. Since 1990, IGAC has fostered a community of several thousand students, scientists, policy makers, and stakeholders that actively collaborate across geographical boundaries and disciplines in order to contribute to addressing the most pressing global environmental change and stainability issues through scientific research. However, fulfilling IGAC's mission to facilitate atmospheric chemistry research towards a sustainable world is not without its challenges. Currently, one of the most pressing issues of our time is air quality. The World Health Organization recently stated that over 9 out of 10 people breath unhealthy air and that air quality is the top environmental cause of premature deaths in the world. Due to this attention, the issue of air quality is becoming so prominent, and in many cases so political, that conducting sound fundamental scientific research on air quality is being threatened by the increased emphasis on applied or solution oriented research. This emphasis leaves little room for curiosity-driven, exploratory science, which in the past has resulted in the discovery of some of the most pressing global environmental change issues, with the ozone hole being a very prominent example. The recent growth of post-truth and nationalist sentiments are further challenges to fundamental scientific research and international collaborations. We seek to explore the challenges facing IGAC and discuss ways in which they may be overcome so that IGAC can continue to foster an international community that aims to address the known and unknown global environmental change and sustainability issues of our time through scientific research.

Photosensitized chemistry at the air/sea interface: biology vs chemistry

Abstract ID : 583

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Christian George ,christian.george@ircelyon.univ-lyon1.fr ,(CNRS Senior Scientist) ,France ,Villeurbanne ,Not Presenting[1]

1 - CNRS-IRCELYON

The sea-surface microlayer (SML) chemical composition, driven by biogeochemical and physical processes in the ocean, influences not only the organic fraction of marine aerosol produced by sea spray processes but also controls trace gas deposition to the ocean and may be involved in secondary organic aerosol formation in the marine boundary layer. Hence, a better chemical characterization and understanding of the oceanic microlayer and its processes is highly desirable. The SML, covering up to 70% of the ocean's surface has different physical, chemical and biological properties compared to the subsurface water, with an enrichment of organic matter i.e., dissolved organic matter including UV absorbing humic substances, fatty acids, amino acids, proteins, lipids, phenolic compounds, as well as trace metals, particulate matter and microorganisms. Here we present new experimental evidences that when exposed to sunlight, these compounds can initiate photosensitized reactions at the air/sea interface leading to the production of significant amount of unsaturated products, such as isoprene which was up to now supposed to be produced in the marine boundary layer (MBL) via biological activities. The isoprene fluxes derived from our experiments do compare very favourably to actual fluxes measured in the marine boundary layer. The existence of organic films on the ocean surface due to biological activities therefore influences air/sea exchanges in an unexpected significant manner, as interfacial photosensitized chemistry is significant source of isoprene, in the absence of any biological source, in the marine boundary layer. This interfacial chemistry simply involves fatty acids as surfactants and dissolved organic matter as photosentitizers which are ubiquitous in the marine environment.

Measurement and Modeling of Aerosols in Taiwan

Abstract ID : 594

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Charles Chou ,ckchou@rcec.sinica.edu.tw ,(Research Fellow) ,Taiwan ,Taipei ,Presenting[1]

Dr. Chuan-Yao Lin ,yao435@rcec.sinica.edu.tw ,(None) ,Taiwan , ,Not Presenting[1]

Dr. Wei-Nai Chen ,wnchen@rcec.sinica.edu.tw ,(None) ,Taiwan , ,Not Presenting[1]

1 - Academia Sinica 2 - Academia Sinica 3 - Academia Sinica

Taiwan is located in a unique geographic area that facilitates the in situ study of a variety of aerosols on the island. In particular, strong sea spray fluctuation in coastal areas during winter monsoon seasons, the photochemical production of secondary aerosols during the summer, and substantial air pollutant emission in urban areas create complex aerosol features over the island. Moreover, Taiwan is located on the lee side of the East Asian winter monsoon region and thus receives air pollutants and dust particles transported with Asian outflows. During the last 10 years, a number of field investigations on concentration and physicochemical properties of aerosol particles have been conducted in specific areas and cities in Taiwan. Moreover, numerical modeling has also been developed and deployed to study the formation and transport of aerosols in the East Asia, particularly with implications for radiative forcing and air quality in the area. This presentation is going to summarize the results from the measurement and modeling studies on aerosols in Taiwan during the last couple years. The features in the temporal and spatial variations of aerosols will be analyzed, and the implications for changes in regional atmospheric composition will be discussed.

How well do we know surface emissions of atmospheric pollutants

Abstract ID : 627

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Claire Granier ,claire.granier@aero.obs-mip.fr ,(None) ,France ,Toulouse ,Not Presenting[1]

Dr. Thierno Doumbia ,thiernodoumbia@yahoo.fr ,(None) ,France , ,Not Presenting[2]

Dr. Katerina Sindelarova ,katerina.sindelarova@latmos.ipsl.fr ,(None) ,Czech Republic , ,Not Presenting[3]

Ms. Louise Granier ,louise.granier.lg@gmail.com ,(None) ,France , ,Not Presenting[4]

Dr. Gregory Frost ,gregory.j.frost@noaa.gov ,(None) ,United States , ,Not Presenting[5]

Dr. Catherine Liousse ,Cathy.Liousse@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[1]

Ms. Sabine Darras ,sabine.darras@obs-mip.fr ,(None) ,France , ,Not Presenting[7]

1 - CNRS 2 - Meteo-France 3 - Charles University 4 - LATMOS 5 - NOAA ESRL/CSD 6 - CNRS 7 - Observatoire Midi-Pyrenees

In order to understand and quantify the current composition of the atmosphere and its past evolution, information on surface emissions on an accurate, timely and accessible basis is critical. During the past few years, national and international projects have led to a better knowledge of surface emissions: inventories providing the spatial and temporal distributions of surface emissions for different periods and regions have been developed. These inventories provide either emissions on a national basis for different countries, or gridded emissions at the global or regional scale.
We will present a review of the datasets providing anthropogenic emissions for the past four decades, for different gaseous and particulate compounds, i.e. carbon monoxide, nitrogen oxides, volatile organic compounds, sulfur dioxide, ammonia, black and organic carbon, and particulate matter (PM10 and PM2.5).
The quality of the different emission datasets is difficult to assess. The methodology, input data, assumptions and proxies vary strongly in space and time among the inventories. We will discuss the consistency between global and regional inventories, as well as between the different chemical compounds, for different world regions. Emissions optimized through inverse modeling techniques will also be included in the discussion. This work will help quantifying the uncertainties on anthropogenic emissions in the different regions.

Precipitation chemistry and wet deposition in the interior of South Africa

Abstract ID : 654

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Pieter van Zyl ,pieter.vanzyl@nwu.ac.za ,(Senior Lecturer) ,South Africa ,Potchefstroom ,Not Presenting[1]

1 - North-West University

South Africa is the economical hub of southern Africa and is regarded as an important source region of atmospheric pollutants. A nitrogen dioxide (NO_2) hotspot is clearly visible from space over the South African Mpumalanga Highveld, while South Africa is also regarded as the 9th largest anthropogenic sulphur (S) emitting country. Notwithstanding the importance of South Africa with regard to N and S emissions, very limited data has been published on the chemical composition of rainwater for this region. In this paper, the ionic content and wet deposition determined for rain samples collected from 2009 to 2014 at four South African IDAF (IGAC DEBITS Africa) sites are presented. These sites are considered to be regionally representative of the north-eastern interior. The results show that the total ionic concentrations and wet deposition fluxes were much higher at the two sites closer to anthropogenic emissions, while the pH of wet deposition at these two sites were lower compared to that of the two sites that were less impacted by anthropogenic emissions. The major source groups identified were marine, terrigenous (crustal), anthropogenic and biomass burning. Significant contributions from the anthropogenic source group was determined for the two sites in close proximity of anthropogenic source regions. Back trajectory analysis, however, did indicate that the two remote sites are also impacted by air masses passing over the source region through anti-cyclonic recirculation. The largest contributions at the two sites distant from the anthropogenic source regions were marine source groups, while the impact of biomass burning were also more significant at the remote sites. Comparison to previous rainwater measurements at the South African IDAF sites indicated increases in the wet deposition of S and N, while pH distributions indicated more rain events with lower pH values at all four sites. This could be ascribed to a significant increase in anthropogenic activities and population growth in this part of South Africa with an associated increase in energy demand.

Spatial, temporal and source contribution assessments of BC over the northern interior of South Africa

Abstract ID : 667

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Johan Paul Beukes ,paul.beukes@nwu.ac.za ,(None) ,South Africa ,Potchefstroom ,Presenting[1]

Mrs. Kgaugelo Euphinia Chiloane ,kgaoubisi@gmail.com ,(None) ,South Africa , ,Not Presenting[2]

Dr. Pieter van Zyl ,pieter.vanzyl@nwu.ac.za ,(Senior Lecturer) ,South Africa ,Potchefstroom ,Not Presenting[1]

Miss. Petra Maritz ,20229143@nwu.ac.za ,(None) ,South Africa , ,Not Presenting[1]

Dr. Ville Vakkari ,ville.vakkari@fmi.fi ,(None) ,Finland , ,Not Presenting[5]

Dr. Miroslav Josipovic ,Micky.Josipovic@nwu.ac.za ,(None) ,South Africa , ,Not Presenting[1]

Dr. Andrew D. Venter ,Andrew.Venter@nwu.ac.za ,(None) ,South Africa ,Potchefstroom ,Not Presenting[1]

Dr. Kerneels Jaars ,20162750@nwu.ac.za ,(Postdoctoral Research Fellow) ,South Africa ,Potchefstroom ,Not Presenting[1]

Dr. Petri Tiitta ,petri.tiitta@uef.fi ,(None) ,Finland , ,Not Presenting[9]

Prof. Markku Kulmala ,markku.kulmala@helsinki.fi ,(None) ,Finland , ,Not Presenting[10]

Prof. Alfred Wiedensohler ,ali@tropos.de ,(None) ,Germany , ,Not Presenting[11]

Dr. Catherine Liousse ,Catherine.Liousse@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[12]

Mrs. Gabisile Vuyisile Mkhatshwa ,Gabi.Mkhatshwa@eskom.co.za ,(None) ,South Africa , ,Not Presenting[13]

Mr. Avishkar Ramandh ,Avishkar.Ramandh@sasol.com ,(None) ,South Africa , ,Not Presenting[14]

Prof. Lauri Laakso ,lauri.laakso@fmi.fi ,(None) ,Finland , ,Not Presenting[5]

1 - North-West University 2 - None 3 - North-West University 4 - North-West University 5 - Finnish Meteorological Institute 6 - North-West University 7 - North-West University 8 - North-West University 9 - Univ. of Eastern Finland 10 - University of Helsinki 11 - Leibniz Institute for Tropospheric Research 12 - Laboratoire d'Aérologie 13 - Eskom 14 - Sasol 15 - Finnish Meteorological Institute

Aerosol black carbon (BC) is considered to be the second most important contributor to global warming. Africa is regarded as the largest source region of atmospheric BC. To date, little BC mass concentration data have been presented for South Africa in the peer-reviewed public domain. This work presents equivalent black carbon (eBC) (optical absorption method) data collected from three sites, where continuous measurements were conducted, i.e. Elandsfontein (EL), Welgegund (WG) and Marikana (MA), as well elemental carbon (EC) (evolved carbon method) at five sites where

samples were collected once a month and analysed off-line, i.e. Louis Trichardt (LT), Skukuza (SK), Vaal Triangle (VT), Amersfoort (AM) and Botsalano (BS).
Concentration patterns across the eight sites indicate that the eBC or EC mass concentrations in the South African interior are in general higher than what has been reported for the developed world and that different sources influence the different sites. The mean eBC or EC mass concentrations for the background sites (WG, LT, SK, BS) and sites influenced by industrial activities and/or nearby settlements (EL, MA, VT and AM) ranged between 0.7 and 1.1, and 1.3 and 1.4 $\mu g/m^3$, respectively. Similar seasonal patterns were observed at all three sites where continuous measurement data were collected, with the highest eBC mass concentrations measured during June to October, indicating contributions from household combustion in the winter months (June-August), as well as savannah and grassland fires during the dry season (May to mid-October). Diurnal patterns indicated that for MA and WG, household combustion, and savannah and grassland fires were the most significant sources, respectively.
Possible contributing sources were explored in greater detail for EL, with five main sources being identified as coal-fired power stations, pyrometallurgical smelters, traffic, household combustion, as well as savannah and grassland fires. A comparison of source strengths indicated that household combustion, and savannah and grassland fires were the most significant sources of eBC during winter and spring months, while coal-fired power stations, pyro-metallurgical smelters and traffic contribute to eBC mass concentration levels year round.

Spectral snow albedo measurements at a high Alpine experimental site in Davos Switzerland

Abstract ID : 697

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Luca Egli ,luca.egli@pmodwrc.ch ,(Scientist) ,Switzerland ,Davos-Dorf ,Presenting[1]

Mr. Ralf Zuber ,r.zuber@gigahertz-optik.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Julian Gröbner ,julian.groebner@pmodwrc.ch ,(None) ,Switzerland , ,Not Presenting[1]

Dr. Gregor Hülsen ,gregor.huelsen@pmodwrc.ch ,(None) ,Switzerland , ,Not Presenting[1]

Mr. Jürg Trachsel ,juerg.trachsel@slf.ch ,(None) ,Switzerland , ,Not Presenting[5]

Dr. Anja Eichler ,anja.eichler@psi.ch ,(None) ,Switzerland , ,Not Presenting[6]

Mr. Michael Schwarzmann ,michael.schwarzmann@i-med.ac.at ,(None) ,Switzerland , ,Not Presenting[7]

Mr. Matthias Jaggi ,jaggi@slf.ch ,(None) ,Switzerland , ,Not Presenting[5]

Prof. Mario Blumthaler ,mario.blumthaler@i-med.ac.at ,(None) ,Austria , ,Not Presenting[7]

1 - PMOD/WRC 2 - Gigahertz Optik GmbH 3 - PMOD/WRC 4 - PMOD/WRC 5 - WSL - Institute for Snow and Avalanche Research SLF 6 - Paul Scherrer Institute 7 - Medical University of Innsbruck 8 - WSL - Institute for Snow and Avalanche Research SLF 9 - Medical University of Innsbruck

The quantification of albedo of snow is important for global energy budgets in the cryosphere such as melt energy in snow hydrology or the evolution of snow cover properties such as weak layer formation in avalanche forecasting.
In winter 2016/2017 the WSL - Institute for Snow and Avalanche Research, SLF starts a thorough measurement campaign at the Alpine experimental site at Weissfluchjoch 2450 m a.s.l in Davos Switzerland, measuring turbulent and latent heat fluxes, snow transport, stable water isotopes exchange, density, micro computer tomography measurements and snow impurities. In conjunction with this measurement campaign, the University of Innsbruck and the World Radiation Center (PMOD/WRC) provided spectral snow albedo measurements. The instrumentation used for the entire campaign (USB4000 CCD array spectrometer from Ocean Optics) was developed and thoroughly characterized, calibrated, optimized and tested during the EMRP project ENV03 taking advantages of the characterizations and calibrations expertise of the World Calibration Center and the corresponding laboratory facilities. At some specific days a commercially available weatherproofed new generation of array spectroradiometer instrument (BTS2048-VL-TEC-WP, from Gigahertz Optik GmbH) was tested and compared with the main instrument.
During the campaign snow albedo spectral data in the wavelength range between 320 nm and 870 nm were measured accounting for effects observed in the laboratory such as cosine error and azimuth biases. On site effects such as different height of the entrance optics above snow cover and orientation of the optics were measured to evaluate an overall uncertainty of snow albedo

measurements. In addition, impurities and specific surface area of the snow cover were measured and compared with the albedo measurements.
The results reveal that absolute snow albedo can be measured with uncertainties (measurement and field uncertainties) of about +/- 3 %. The results agree with snow albedo measurements from UVA broadband radiometers operated at the experimental site by PMOD/WRC.
The study is a first step towards a comprehensive assessment of the performance of instruments for spectral snow albedo measurements and quantification of the corresponding uncertainties.

Air Pollution: A Global Environmental Problem with Important Health Consequences

Abstract ID : 783

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Guy Brasseur ,guy.brasseur@mpimet.mpg.de ,(Senior Scientist) ,Germany ,Hamburg ,Not Presenting[1]

Dr. Rajesh Kumar ,rkumar@ucar.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Idir Bouarar ,idir.bouarar@mpimet.mpg.de ,(None) ,Germany , ,Not Presenting[3]

Dr. Claire Granier ,claire.granier@aero.obs-mip.fr ,(None) ,France ,Toulouse ,Presenting[4]

Dr. Ronald van der A ,avander@knmi.nl ,(None) ,Netherlands , ,Not Presenting[5]

1 - MPI-M 2 - National Center for Atmospheric Research 3 - Max Planck Institute for Meteorology 4 - CNRS 5 - KNMI

Every year, more than 3 millions people die prematurely from breathing air pollutants, which, according to the World Health Organization, trigger heart failures, strokes, pulmonary diseases and lung cancers. Children are particularly vulnerable to dirty air. Air pollution (back ground concentrations and acute episodes) has therefore become a global environmental problem that needs to be urgently addressed.

In order to better predict, and hence to avoid the occurrence of high levels of particulate matter (PM), ozone, and other pollutants, a multi-model analysis and prediction system has been developed by combining the results provided by seven global and regional chemical transport models. The system has been applied in China as part of the European Panda and MarcoPolo Projects.

The paper will describe the system, which is now operational. It will present some illustrative examples of air quality forecasts in eastern Asia and discuss ways to downscale results to a city block scale in urban areas (statistical methods).

Perspectives for applying such systems in other parts of the world will be provided. A new international initiative, called "Monitoring, Analysis and Prediction of Air Quality (MAP-AQ)" will be presented and discussed.

OSIRIS: Ozone, stratospheric aerosol and nitrogen dioxide profiles since the autumn of 2001

Abstract ID : 819

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Doug Degenstein ,doug.degenstein@usask.ca ,(None) ,Canada , ,Not Presenting[1]

1 - University of Saskatchewan, Institute of Space and Atmospheric Studies

The Canadian built Optical Spectrograph and InfraRed Imaging System (OSIRIS) has been in full operation onboard the Swedish built Odin spacecraft since the autumn of 2001. The 16 years of vertically resolved profile measurements of ozone, nitrogen dioxide and stratospheric aerosol make up the longest data record produced from observations made by any existing space based instrument. The OSIRIS ozone data record is featured within the ozone_cci merged time series as well as stand alone data records used for trend analysis including the 33 year (SAGE II/OSIRIS/OMPS-LP USask 2D) data record currently under evaluation by the SPARC Initiative, LOTUS. This presentation will feature highlights of the OSIRIS ozone data record including its use for the study of the Asian Monsoon. The OSIRIS stratospheric aerosol data record has been used to continue the SAGE II aerosol extinction time series and provide the CMIP-6 scientists with a high fidelity data record to study the climate impact of sulphate aerosol in the stratosphere. This presentation will highlight progress made using the OSIRIS aerosol data set including the climatic impact of volcanic activity. Finally, the OSIRIS nitrogen dioxide data record has been used within many studies including the production of a tropospheric NO_2 data product derived using vertical column measurements made by OMI. This presentation will provide detail associated with this valuable 16 year data record. OSIRIS has been in operation for over 16 years and there is no evidence that its data production will end any time soon.

Sensitivity study of synergetic retrieval of tropospheric ozone profile using ultraviolet, infrared and microwave measurements from space

Abstract ID : 825

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Tomohiro Sato ,tosato@nict.go.jp ,(Researcher) ,Japan ,Tokyo ,Presenting[1]

Dr. T. M. Sato ,takao@stp.isas.jaxa.jp ,(None) ,Japan , ,Not Presenting[2]

Prof. Hideo Sagawa ,sagawa@cc.kyoto-su.ac.jp ,(None) ,Japan , ,Not Presenting[3]

Dr. Katsuyuki Noguchi ,nogu@ics.nara-wu.ac.jp ,(Assistant Professor) ,Japan ,Nara ,Not Presenting[4]

Prof. Naoko Saitoh ,nsaitoh@faculty.chiba-u.jp ,(None) ,Japan , ,Not Presenting[5]

Prof. Hitoshi Irie ,hitoshi.irie@chiba-u.jp ,(None) ,Japan , ,Not Presenting[5]

Prof. Kazuyuki Kita ,kazuyuki.kita.iu@vc.ibaraki.ac.jp ,(None) ,Japan , ,Not Presenting[7]

Dr. Koji Zettsu ,zettsu@nict.go.jp ,(None) ,Japan , ,Not Presenting[1]

Ms. Mona Mahani ,mona.mahani@gmail.com ,(None) ,Iran , ,Not Presenting[1]

Prof. Ryoichi Imasu ,imasu@aori.u-tokyo.ac.jp ,(None) ,Japan , ,Not Presenting[10]

Prof. Sachiko Hayashida ,sachiko@ics.nara-wu.ac.jp ,(Professor) ,Japan ,Nara ,Not Presenting[4]

Mr. Yasuko Kasai ,ykasai@nict.go.jp ,(None) ,Japan , ,Not Presenting[1]

1 - National Institute of Information and Communications Technology 2 - Japan Aerospace Exploration Agency 3 - Kyoto Sangyo University 4 - Nara Women's University 5 - Center for Environmental Remote Sensing, Chiba University 6 - Center for Environmental Remote Sensing, Chiba University 7 - Ibaraki University 8 - National Institute of Information and Communications Technology 9 - National Institute of Information and Communications Technology 10 - Atmospheric and Ocean Research Institute, The University of Tokyo 11 - Nara Women's University 12 - National Institute of Information and Communications Technology

The World Health Organization (WHO) estimated approximately seven million people died because of effects of air pollution in 2012. Ozone in the troposphere, especially in the lowermost troposphere (LMT), is one of the most harmful pollutants and has been increasing globally at a rate of 0.3~1.0 ppb/year over few decades in the northern hemisphere [Dentener et al., 2010]. Global monitoring of tropospheric ozone profile is required for understanding of the current air pollution and for the future prediction. An advanced synergetic retrieval using several wavelength ranges has been applied to space-based nadir observations in ultraviolet (UV) and thermal infrared (TIR) spectral ranges (Aura/OMI and TES [Fu et al., 2013] and MetOp/GOME-2 and IASI [Cuesta et al., 2013]). In this presentation, we show that a sensitivity to derive the ozone amount in the LMT can be improved by adding limb observation in the microwave (MW) range to nadir observations in UV and TIR ranges. We performed a feasibility study of a synergetic retrieval of tropospheric ozone profile. We assumed twenty atmospheric scenarios in East Asia in summer and winter seasons. The sensitivities of

retrieved ozone in the upper troposphere (UT), middle troposphere (MT) and LMT were evaluated using a degree of freedom for signal (DFS), error in ozone partial column and averaging kernel based on the optimal estimation method. The weighting functions were calculated using the SCIATRAN, LBLRTM and AMATERASU radiative transfer models for the UV, TIR and MW spectral ranges, respectively. The DFS value was increased by about 200% and 40% by adding the MW measurements to the combination of UV and TIR measurements in the UT and LMT regions, respectively. The MW measurement increased the DFS value, nevertheless, there was no sensitivity of the LMT ozone in the MW measurement itself. Our calculation showed that the combination of UV, TIR and MW measurements was able to retrieve the ozone abundance in the LMT with a DFS value larger than unity, when the LMT ozone amount was enhanced (as large as approximately 5×10^{21} m^{-2}).

Air Pollution in Megacity Beijing and North China Plain

Abstract ID : 846

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Tong Zhu ,tzhu@pku.edu.cn ,(Professor) ,China ,Bejing ,Not Presenting[1]

1 - Peking University

Megacities Beijing is located in North China Plain, which is the region with the highest level of air pollution on the earth. Many studies have been conducted in this region to characterize the air pollutants at local and regional scales, to understand the transport and transformation processes of atmospheric pollution, and to evaluate the impacts of aerosol on climate and cloud formation. Due to its vast area and intensive air pollution, when the fresh emitted air pollutants interact with the aged air pollution plume, it is interest to further explore many scientific questions, such as:

1. Mechanisms for the producing, cycling, and sinks of HOx radicals;
2. Mechanisms of ozone, new particle, and secondary aerosol particles formation;
3. Oxidative capacity and the multiphase reaction on the surface of fine particles;
4. Optical and hygroscopic properties of aerosol and their implication in climate impacts;
5. Health effects of primary and secondary aerosol particles.

Understanding these scientific questions is essential to formulate sound air pollution policy and to carry out regional coordinate air pollution control. To address these scientific questions, a field campaign, CAREBEIJING-NCP (Campaigns of Air Pollution Research in Megacity Beijing and North China Plain) has been conducted in the summer of 2013/2014, as a follow up of CAREBEIJING 2006, 2007, and 2008, but the study region is larger and covers the North China Plain. The study design, results of CAREBEIJING-NCP 2013/2014 will be presented.

Biomass burning and multi-scale transport over Southeast Asia and Southern China: mixing of the biomass and urban plumes

Abstract ID : 901

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jason Cohen ,jasonbc@alum.mit.edu ,(Professor) ,China ,Guangzhou ,Not Presenting[1]

1 - Sun Yat-Sen University, School of Atmospheric Sciences

This work presents a multi-scale modeling approach, based on measurement-constrained emissions of biomass burning and urban emissions over Southeast Asia and Southern China. This work aims to compute the contributions of these two factors together, which are both important for contributing to the total aerosol loadings impacting hundreds of millions of people in Southeast Asia and Southern Greater China. Annually there are large-scale biomass burning plumes that originate in Myanmar, Thailand, Laos, Vietnam, and rural Southwestern China, and due to lofting and a strong Monsoon wind, are transported thousands of kilometers from their source, eventually mixing with urban plumes. The large amounts of heat from the biomass burning require high resolution models to properly compute their vertical lofting, while detailed chemistry is required to compute the ultimate aerosol loadings, size, and mixing properties in the highly humid air, as well as their distribution between the boundary layer and the lower free troposphere.

However, due to the high-speed Monsoon winds, a mesoscale and GCM are them used to compute the transport of these substances thousands of kilometers downwind where they then impact the loadings over urban regions. This work will focus on the development of the fire parameterization and how it is integrated into the mesoscale and GCM models. Further, the combination of the minimum necessary representations of aerosol physics, chemistry, mixing state, and aerosol/radiation interactions are examined to reproduce the measured effects.

The biomass burning and its long-range transported plume are based on newly inverted emissions observed over this record. These measurements are based on multiple satellites including AOD and trace gasses from MODIS, CALIOP, OMI, and others, gathered over the past 11 years (2006-2016). It is expected that these new results will help to characterize the impacts of: the time-invariant urban signal, the rapidly time-varying biomass burning signal, and the moderately time-varying atmospheric chemical and physical factors. The resulting characterization in space, time, and quantity is analyzed and compared against AERONET, NOAA, and other ground networks, with the results comparing similarly to or better than present approaches of separately combining urban and biomass burning products.

Long-term changes of regional ozone in China: implications for health and ecosystem impacts

Abstract ID : 1015

Conflict Declaration : None

Content Motivation : None

Additional Information : Subsession: Air quality, health and ecosystem impacts

Prof. Xiaobin Xu ,xuxb@camscma.cn ,(Scientist) ,China ,Beijing ,Presenting[1]

Dr. Weili Lin ,linwl@camscma.cn ,(None) ,China , ,Not Presenting[2]

Dr. Wanyun Xu ,xuwy@camscma.cn ,(None) ,China , ,Not Presenting[1]

1 - Chinese Academy of Meteorological Sciences 2 - Meteorological Observation Center, China Meteorological Administration 3 - Chinese Academy of Meteorological Sciences

Surface ozone is one of the major air pollutants in many parts of the world. High levels of ozone can exert profound impacts on human and ecosystem health. To be able to assess these impacts, it is crucial to know the spatiotemporal variations of surface ozone. So far, there have been only sporadic reports on long-term measurements of surface ozone in East Asia. It this work, we present long-term measurements of surface ozone from eight sites in China, including six Global Atmosphere Watch (GAW) sites (i.e., Waliguan, Shangdianzi, Linan, Longfengshan, Xianggelila and Akedala) established and operated by China Meteorological Administration (CMA), a rural site (Gucheng) in the North China Plain, and an urban site in Beijing (CMA campus). The sites are distributed in highly polluted regions (the North China Plain and the Yangtze River Delta), the underdeveloped region (the Northeast Plain), and the remote regions (Northwest and Southwest China). The time series of hourly average ozone prior to the end of 2015 were analyzed, with the longest and shortest dating back to 1994 (Waliguan) and 2009 (Akedala), respectively. The hourly ozone data were used to calculate a set of ozone exposure metrics, which can be used for assessing human health and vegetation impacts. We will show the diurnal, seasonal and long-term variations of ozone in different regions and discuss them in terms of emissions, geography and meteorology. Furthermore, we present some of the calculated exposure metrics, such as annual maximum 1-h and 8-h averages, SOMO35, W126, AOT40, etc. The average levels and trends of these metrics will be compared among regions and among urban, rural, and background sites. Results from this study will provide better understanding of long-term changes and regional differences of ozone in China and the potential health and ecosystem impacts.

Source apportionment of air pollutants at multiple Highveld Townships in South Africa – Implications for air quality management and human health

Abstract ID : 1088

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Stuart Piketh ,stuart.piketh@nwu.ac.za ,(Director) ,South Africa ,Potchefstroom ,Presenting[1]

Mrs. Nicola Walton ,nicolamwalton@gmail.com ,(None) ,South Africa , ,Not Presenting[1]

Miss. Brigitte Language ,bl23034149@gmail.com ,(Student) ,South Africa ,Potchefstroom ,Not Presenting[3]

Dr. Paola Formenti ,paola.formenti@lisa.u-pec.fr ,(None) ,France , ,Not Presenting[4]

Dr. Roelof Burger ,roelof.burger@nwu.ac.za ,(Senior Lecturer) ,South Africa ,Potchefstroom ,Not Presenting[1]

1 - NWU 2 - NWU 3 - North-West University 4 - Laboratoire Interuniversitaire des Systèmes Atmosphériques 5 - NWU

South African air quality legislation passed in 2004 shifted the focus from source to ambient based management principles. Fundamental to this approach, is good quality ambient air quality data. Significant progress has been made in the country in quantifying the state air quality through installation of ambient air quality monitoring stations. Air quality management plans, a requirement for all local governments, have, however, not delivered the large improvements in air quality in many regions of South Africa. In addition, as part of the new legislation a new set of minimum Emissions Standards were passed into law. Many major industries currently do not meet the minimum standards and have had to apply for postponements' of their implementation. The primary objective of the legislation is to safe guard human health and the natural environment. In order to minimise the impacts of air quality on human health, a decision was made to attach emissions offset condition to postponement licences for industries within air pollution priority areas. Industries are required to improve air quality in areas such as townships (areas with high air quality health impacts) until such time that they can meet their minimum emissions standards. In order to prioritise sources contributing the most to poor air quality in these townships source apportionment studies have been conducted in five townships. Coarse and fine fraction samples were collected for twelve hours during winter (worse-case air pollution season) and summer (best -case air pollution season). Samples were analysed for soluble ions as well as elemental composition. During winter domestic coal combustion dominates the ambient particulate load in townships in which solid fuel combustion is a primary energy source. Reduced demand for solid fuel combustion during summer reduces the relative contribution of this source. Re-suspended dust is also significant source of particulate matter in both seasons. Each township has a slightly different mix of sources during the two seasons. The sources apportionment results will be presented and implications for air quality management discussed.

Atmospheric deposition of Sulphur and Nitrogen over the Eastern portion of South Africa

Abstract ID : 1097

Conflict Declaration : None

Content Motivation : None

Additional Information : Authors MK Mompati1, SJ Piketh1, C Curtis2, JP Beukes1, P Van Zyl1 and JJ Pienaar1 1Unit for Environmental Science and Management, North-West University, Potchefstroom 2University of the Witwatersrand, Johannesburg

Mr. Mpho Mompati ,Mphomompati9@gmail.com ,(None) , , ,Not Presenting[1]

1 - North-West University (Potchefstroom)

South Africa has an abundance of mineral resources, which has led to rapid industrial development. Of particular concern is the increasing emissions of principal acid-forming pollutants into the atmosphere because of anthropogenic sources and the adverse effects of acid deposition on soil, water resources and ecosystems. Studies in industrialised and background sites over eastern South Africa have reported that deposition of acidic species does not pose an immediate threat to regional ecosystems. With this knowledge, direct measurements of selected acid-forming gaseous species and rain chemistry of water-soluble aerosols were made to confirm if ecosystems in remote and industrial sites under study are not at risk since emission rates have continuously increased over the years. This paper reports on wet deposition (Jun 2015 - Apr 2016) and dry deposition (Dec 2010 - Aug 2016) at selected background sites (Knysna, Cathedral peak) and industrial sites (Lephalale, Vaalwater, Elandsfontein) over the eastern portion of South Africa. DIONEX ICS 3000 ion chromatograph was used to analyse the chemical composition and the water-soluble ions in rainwater i.e., $CH_3COO^{?}$, $HCOO^{?}$, $C_3H_5O_2^{?}$, $C_2O_4^{2?}$, Carbonates, H^+, $NO_3^{?}$, $SO_4^{2?}$, Na^+, $Cl^?$, $F^?$, NH_4^+, K^+, Mg^{2+} and Ca^{2+} whereas dry deposition was analysed for SO_2, NO_2 and O_3. The formation of secondary particulate material through scavenging of atmospheric gaseous pollutants directly affects the pH and composition of the rainwater. Of all the alkaline cations, Ca^{2+} (1.01 µeq.L^{-1}) and NH_4^+ (1.35 µeq.L^{-1}) were the major buffering agents for rainwater acidity. The pA (potential acidity in µeq.L^{-1}) was estimated to be 69.72, 77.40, 139.18 and 21.81 for Vaalwater, Cathedral peak, Elandsfontein and Knysna, respectively. These values correspond to pH values that are lower than the measured pH values of 4.62 for Vaalwater, 4.62 for Cathedral Peak, 4.33 for Elandsfontein and 5.36 for Knysna. This signifies that 66%, 69%, 66% and 80% of rainwater acidity at Vaalwater, Cathedral Peak, Elandsfontein and Knysna is neutralised by alkaline ions. Ionic and conductivity balance was used for data quality assessment according to the WMO recommended limits.
Keywords: Rainwater chemistry; Acid-forming pollutants; pH; Acid rain; Sulphur; Nitrogen; Long-range transport; Deposition

Detection of biomass burning plume for aerosol remote sensing: potential application to the Arctic regions

Abstract ID : 1109

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Soheila Jafariserajehlou ,jafari@iup.physik.uni-bremen.de ,(None) ,Germany ,Bremen ,Not Presenting[1]

Dr. Linlu Mei ,mei@iup.physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Marco Vountas ,vountas@iup.physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Vladimir Rozanov ,rozanov@iup.physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Luca Lelli ,luca@iup.physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Mr. John P. Burrows ,burrows@iup.physik.uni-bremen.de ,(None) ,Germany ,None ,Not Presenting[6]

1 - University of Bremen 2 - University of Bremen 3 - University of Bremen 4 - University of Bremen 5 - University of Bremen 6 - Institute of Environmental Physics, University of Bremen

Biomass burning aerosol transported from North America and Russia into the Arctic circle is suspected to have significant short and long-term impact on Arctic Amplification (AA). Retrieval of biomass burning aerosol optical thickness (AOT) from passive remote sensing is one focus in the recent DFG (German Research Foundation) funded project $(AC)^3$ "ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes and Feedback Mechanisms". Misclassification of clouds and biomass burning aerosols leads to either overestimation of AOT or loss retrieval coverage. Therefore, an accurate cloud detection enabling a precise separation of cloud (especially thin cloud) and biomass burning is a crucial prerequisite for aerosol retrieval over the Arctic regions. In this study, a method based on a time-series technique is developed and used to distinguish biomass burning plumes from clouds by utilizing Advanced Along-Track Scanning Radiometer (AATSR), one payload on the European Environmental Satellite (Envisat). This method includes two steps. The first step is to separate the ground scenarios into cloud and cloud-free conditions. The main assumption for this step is that clouds have larger spatial variability and less stability compared to cloud free conditions. The spatial variability is characterized by the standard deviation while the stability has been analyzed by the covariance values between the target image and a "reference image". After building up the reference image, cloudy pixels are distinguished from biomass burning aerosol by applying covariance analysis over the channel which is less affected by soot particles, found mainly in biomass burning plumes, whereas the Top Of Atmosphere (TOA) reflectance is affected by clouds. The second step is to separate the biomass burning plume from other aerosol sources. This has been performed by Radiative Transfer (RT) simulations using the RT model SCIATRAN. Additionally, selecting the proper wavelength regions to apply covariance analysis is studied through different channels. The results of applying this idea to case studies and the validation by AERONET dataset will be presented. Moreover, the potential application of this method will be evaluated for the Arctic region in future work. Since, biomass burning is one of the main contributions to the pollution transported towards high latitudes.

Trace atmospheric gases, retrieved from the measurements of GOME, SCIAMACHY and GOME-2

Abstract ID : 1140

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. John P. Burrows ,burrows@iup.physik.uni-bremen.de ,(None) ,Germany ,None ,Not Presenting[1]

1 - Institute of Environmental Physics, University of Bremen

SCIAMACHY (SCanning Imaging Absorption spectrometer for Atmospheric CHartographY) was proposed in 1988. It was selected as a national contribution to the European Space Agency earth observation flagship, Envisat, launched on the 28th February 2012, see figure 1. Envisat flew in a sun synchronous polar orbit in descending node, having an equator crossing time of 10:00 am local time. SCIAMACHY, a passive remote sensing double monochrometer, measures the up welling radiation from the top of the atmosphere in 8 spectral channels, contiguously between 214 and 1750 nm and between 1940 and 2040 nm and also 2265 and 2380 nm. SCIAMACHY, which is shown in figure 2, made measurements in alternate limb and nadir viewing as well as solar occultation in the northern hemisphere and lunar occultation in the southern hemisphere. ESA lost contact with Envisat on the 8th April 2012. GOME is a smaller version of SCIAMACHY, which flew on ESA ERS-2 from 1995 to 2011. GOME-2 is a somewhat improved version of GOME, which is one the operational meteorological sensors, aboard the ESA/EUMESAT series of platforms called Metop.SCIAMACHY, GOME, and GOME-2 are best known for their retrievals of trace gases in the troposphere and the stratosphere, where measurements of the total and tropospheric columns of the trace gases O_3, NO_2, HCHO, CHO.CHO, BrO, IO, H_2O, as well ocean colour, cloud and aerosol optical properties. In addition SCIAMACHY observations yield dry column mixing ratios of CO, CH_4 and CO_2. In this presentation the focus on the decade of measurements retrieved from the nadir and limb observations of SCIAMACHY and the changes and trends.

Aircraft observations of sulfur dioxide transport to the UTLS from major source regions

Abstract ID : 1193

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Hans Schlager ,hans.schlager@dlr.de ,(None) ,Germany ,82234 Wessling ,Not Presenting[1]

1 - DLR

Sulfur dioxide (SO_2) is a key aerosol precursor gas, however, only during recent years high-precision in-situ data could be obtained for the upper troposphere and lower stratosphere (UTLS) using airborne chemical ionization mass spectrometry. Data composites of SO_2 for the UTLS will be presented from a large number of field campaigns performed with the research aircraft Falcon and HALO during the years 2005 to 2015 covering a geographical region from 83°N to 65°S and 105°W to 135°E and altitudes up to 15 km. The summaries provide information on the SO_2 distribution at mid-latitudes, tropical and polar regions. Median SO_2 background mixing ratios in the UTLS range between 10-25 ppt, however, also areas with strongly enhanced SO_2 mixing ratios in the UTLS were observed, associated with events of new particle formation. For selected cases, the transport pathways to the UTLS from major SO_2 source regions in south-east Asia and southern Africa will be discussed.

Quantifying source contribution to indoor particulate matter in low-income settlement in South Africa

Abstract ID : 1237

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Brigitte Language ,bl23034149@gmail.com ,(Student) ,South Africa ,Potchefstroom ,Not Presenting[1]

Prof. Stuart Piketh ,stuart.piketh@nwu.ac.za ,(Director) ,South Africa ,Potchefstroom ,Not Presenting[2]

Dr. Roelof Burger ,roelof.burger@nwu.ac.za ,(Senior Lecturer) ,South Africa ,Potchefstroom ,Not Presenting[2]

1 - North-West University 2 - NWU 3 - NWU

Ambient and indoor concentrations of small particulate matter is of concern on a global level as it impacts adversely on human health and results in premature deaths. This is especially true for developing countries where solid fuel burning for cooking and heating purposes are prevalent. Activities from which the particles result define the physical and chemical characteristics thereof. Quantifying the levels and contribution of ambient and indoor particulate matter can inform strategies to regulate and mitigate the contributing sources. Source apportionment of particles suggests possible sources to which the particles could be attributed. Identified sources can originate from either the indoor- or ambient environment due to factors such as ventilation and infiltration. In order to understand the impacts associated with particulate matter, it is vital to identify its chemical composition. Indoor particulate samples were collected in a variety of low-income settlements in South Africa. The settlements include a rural indoor coal burning settlement (KwaZamokuhle, Mpumalanga); a rural outdoor wood burning settlement (Agincourt, Mpumalanga); and an urban low income settlement (Jouberton, North-West). The particles were collect on a 37mm mixed cellulose ester filters by using a gravimetric sampling method. Sampling occurred in intervals of 12-hr in KwaZamokuhle and 24-hr in both Agincourt and Jouberton. The samples were analysed using an Axiox^{mAX} wavelength dispersive x-ray fluorescence spectrometer. A helium medium was selected as it provides the ability to analyse extremely vulnerable samples such as filters. The spectrometer was calibrated using MICROMATTER^{TM} calibration standards (NITS traceable reference materials). The elements included in the analysis were Li, Na, Mg, Al, Si, P, S, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Y, Zr, Nb, Mo, Pd, Ag, Cd, In, Sn, Sb, I, Ba, W, Pt, Au, Hg, Tl, Pb, Bi, Ce. Principal component analysis (PCA) was implemented. Results indicate that windblown dust contributes significantly to the indoor air quality. There is also a clear indication of residential combustion within the data. Source apportionment results will be discussed in further detail.

Influence of stratospheric ozone in the troposphere of southern Africa: Wavelet Approach

Abstract ID : 1239

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Nkanyiso Mbatha ,nkanyisombatha5@gmail.com ,(Researcher and Lecturer) ,South Africa ,Empangeni ,Presenting[1]

Prof. Sivakumar Venkataraman ,Venkataramans@ukzn.ac.za ,(None) ,South Africa , ,Not Presenting[2]

Mrs. Thumeka Mkololo ,Thumeka.Mkololo@weathersa.co.za ,(None) ,South Africa , ,Not Presenting[3]

Prof. Hassan Bencherif ,hassan.bencherif@univ-reunion.fr ,(None) ,Reunion , ,Not Presenting[4]

1 - University of Zululand 2 - School of Physics, University of KwaZulu-Natal 3 - South African Weather Service 4 - Laboratoire de l’Atmosphère et des Cyclones, Université de La Réunion, Saint-Denis, La Réunion

Stratosphere-troposphere exchange (STE) plays an important role in atmospheric chemistry as it changes the oxidative capacity of the troposphere and potentially also affects the climate system because ozone and water vapour are potent greenhouse gases. Moreover, the exchange of particles between the stratosphere and the troposphere could lead to an increase of "bad" ozone (tropospheric ozone) and changes in concentrations of "good" ozone (stratospheric ozone). In this study we use the ERA-Interim reanalysis data set from the European Centre for Medium-Range Weather Forecasts (ECMWF) and a refined version of a previously developed Lagrangian methodology to investigate the influence of ozone of stratospheric origin in the troposphere. The variability in time series of tropospheric ozone as measured by Atmospheric Infrared Sounder (AIRS) aboard the aqua satellite is examined within the context of the contribution by fluxes of ozone originating from the stratosphere using wavelet approach. In this work, we use methods of assessing statistical significance and confidence intervals of cross-wavelets phase and wavelet coherence to investigate the influence of stratospheric ozone in the tropospheric ozone content as a results of STE exchange. In general, this study indicates that there is seasonality of the STE in the southern Africa region in conjunction with seasonal cycle of ozone concentration at the tropopause, as well as the trends of the occurrence of the STE events over the years.

Contribution of marine aerosols to the total columnar aerosol loading over Ascension Island

Abstract ID : 1267

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Joseph Adesina ,joseph.adesina@nwu.ac.za ,(Dr/ Research Officer) ,South Africa ,Potchefstroom ,Not Presenting[1]

Prof. Stuart Piketh ,stuart.piketh@nwu.ac.za ,(Director) ,South Africa ,Potchefstroom ,Not Presenting[2]

Mr. Brent N. Holben ,brent.n.holben@nasa.gov ,(None) ,United States , ,Not Presenting[3]

1 - North West University South Africa 2 - NWU 3 - Laboratory for Terrestrial Physics, NASA Goddard Space Flight Center, Greenbelt, MD

The properties of columnar aerosol loading over Ascension Island (7.97o S, 14.4o W, 30 asl) retrieved from Sunphotometer located on the Island from Aerosol Robotic Network (AERONET) during February 2015 to January 2016 was studied to know the contribution of marine aerosols to the total atmospheric column. Identification of the aerosol type was based on the relationship between aerosol optical depth (AOD500 nm) and Angstrom exponent (α440-870). Annual average of AOD500 was 0.18±0.12, while seasonal averages were 0.17±0.10, 0.13±0.06, 0.24±0.18, 0.19±0.10 for summer, autumn, winter and spring respectively. Likewise the annual mean for the Angstrom exponent was 0.84±0.34, while the seasonal averages were 0.82±0.22, 0.66±0.32, 0.91±0.38 and 1.17±0.29 respectively. The autumn was dominated by coarse particles while spring was dominated by fine particles. Marine continental average aerosol contributions were 45.1%, 67.6%, 43.3% and 18.1% for these seasons respectively. The NOAA NCEP/NCAR re-analysis data showed a minimum and maximum temperature of 17.9o C in October and 20.1o C in March, and relative humidity of 20.0% in November and 68.2% in December respectively. TRMM precipitation data from NASA GIOVANNI interactive surface indicated minimum and maximum of 0.46 cm in June and 142.6 cm in November. Long range transport of aerosols over the location using HYSPLIT transport and dispersion model for 7 days backward trajectory indicated that aerosols come from over Angola during high loading in August and over the ocean during low loading in April.

Identification of emission and climatological factors shaping Hong Kong's PM10 levels during 1998-2015

Abstract ID : 1282

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Zibig Yuan ,zibing@scut.edu.cn ,(None) ,China ,Guangzhou ,Not Presenting[1]

1 - South China University of Technology

Both emissions and meteorology impacts the ambient pollution levels, and accurate quantification of their relative impacts is important to formulate effective pollution control measures. This study examines the long-term trends of source contributions to ambient PM10 in Hong Kong from 1998 to 2015 and the relative impacts from emission and climatological changes to the contributions from different sources and to the ambient PM10 loadings. Source contributions were estimated by applying the Positive Matrix Factorization (PMF) source apportionment model on a rich speciated PM10 dataset collected simultaneously at seven sites in Hong Kong over these eighteen years. Over 50 species including chemical elements, water-soluble ions, and elemental carbon and organic carbon were characterized for all samples. Nine sources were identified by PMF, and their relative and absolute contributions to the ambient PM10 were calculated. It was obviously found that local contributions from Hong Kong were consistently decreasing over these eighteen years, while non-local contributions, mostly from Mainland China, showed an initially increasing followed by a decreasing trend with a peak around 2011-2012. The impacts on source contributions from emissions and meteorological variations were identified by combining Kolmogorov-Zurbenko (KZ) filter and Principal Component Analysis (PCA) techniques. Results showed that the impacts from local emissions were consistently decreasing while those from non-local emissions showed maximum around 2011-2012. The impact from climatological factors was generally unfavorable for pollutant dispersion. With the continuous monitoring of PM10 compositions in Hong Kong, this study highlights the effectiveness of control measures in Hong Kong in the past decades and in Mainland China in the past several years, and shed light on future directions to make Hong Kong's particulate levels in line with WHO's air quality guidelines.

A Low Tech Approach to Carbon Sequestration

Abstract ID : 1284

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. David Eichler ,eichler.david@gmail.com ,(Prof) ,Israel ,Beer Sheva ,Not Presenting[1]

1 - Ben Gurion University

A simple method to reduce CO2 emission is proposed: preserving biomass with salt. The reduction of CO2 emission that could be accomplished with a given amount of solar energy is greater if the solar energy is used for salt production than if it is used directly as energy. The process is clearly cheaper than converting biomass to ethanol. As geoengineering proposals go, this method is safe and easily verifiable on an ongoing basis.

Long-Term, Episodic and Quasi-periodic Carbon Monoxide Pollution Events from the MOPITT Dataset

Abstract ID : 1315

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. James Drummond ,james.drummond@dal.ca ,(Professor of Physics) ,Canada ,Halifax ,Not Presenting[1]

1 - Dalhousie University

Launched in 1999, just at the start of the 21st century, the Measurements Of Pollution In The Troposphere (MOPITT) instrument has been continuously measuring carbon monoxide (CO) for over 17 years. This dataset shows many long-term trends and short-term events in the atmosphere. Since much CO production is associated with uncontrolled burning, there are many "events" across the planet and across the years and the approximate 4-week lifetime of CO in the atmosphere allows the mapping of transport of the pollution from these events across the globe.

Some of these events are "one off" events that are not repeated in the datasets but many are periodic - or at least quasi-periodic - responding to atmospheric circulation changes, especially those that lead to changes in rainfall. Examples of these are the burning in Indonesia in response to both agricultural practices and El Nino events, and the fires in the Amazon forest. Superimposed on this are longer term trends which have some anthropogenic component and large-scale transport. The long term consistency of the MOPITT dataset allows us to begin to build up a catalogue of these events that can be used in modelling and prediction of future trends.

MOPITT was built in Canada by COMDEV of Cambridge, ON and the instrument and operations are funded by the Canadian Space Agency. The instrument is carried on the NASA Terra satellite.

Chemistry and Physics of the Atmosphere over Eastern US: Air Quality Success Stories

Abstract ID : 1351

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Russell Dickerson ,rrd@umd.edu ,(None) ,United States ,College Park ,Not Presenting[1]

1 - University of Maryland

The eastern US, especially the Baltimore/Washington area, suffers high concentrations of ground-level ozone, excessive nitrogen deposition, and is a major source of greenhouse gases. Using a combination of ground based and aircraft *in situ* measurements along with remote sensing we evaluate models to forecast air quality for the State Implementation Plan. Most recently we have added measurements of CO_2 and CH_4 in an effort to better understand the flux of GHG's. Recent implementation of scrubbers on power plants and catalytic converters on vehicles has let to an order of magnitude improvement in air quality. This success has had unforeseen consequences such as increases in the gas-phase ammonia (NH_3) concentration as detected by AIRS. I will address major unanswered questions in emissions, small scale circulations, and photochemical smog production including a discussion of overestimates in NOx emissions from vehicles, HO_X chemistry, the Bay breeze, arrays of low-cost sensors and the efficacy of past and planned emissions control strategies. The Baltimore/Washington air quality story shows the power of policy relevant science.

Human driven changes in the marine atmosphere and in the nutrient deposition to the global ocean. A tribute to R. von Glasow

Abstract ID : 1365

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. MARIA KANAKIDOU ,MARIAK@UOC.GR ,(Professor) ,Greece ,Heraklion ,Not Presenting[1]

1 - UNIVERSITY OF CRETE/Department of Chemistry

The dramatic increase in world's population the past decades has been associated with significant increase in the number of megacities globally. Several among these large agglomerations are located at coastal regions where land meets with ocean. The emissions of pollutants to the atmosphere from these regions via atmospheric transport, transformation and subsequent deposition affect the oceanic ecosystems. Chemical interactions between anthropogenic and natural emissions occur in the atmosphere during transport of air masses. These interactions affect both the chemical composition of the atmosphere and of the deposited fluxes to the land and ocean ecosystems. Atmospheric deposition of trace constituents, both of natural and anthropogenic origin, can act as a nutrient source into the open ocean and affect marine ecosystem functioning and subsequently the exchange of CO_2 between the atmosphere and the global ocean. In the present study we review such interactions and present recent global modelling results on human-driven atmospheric composition changes and on the impact of human-driven atmospheric acidity on nutrient solubility. The model results have been evaluated by extensive comparison with available observations. The results are presented and implications of the findings are discussed.

Phytotoxic assessment of sulfur dioxide and ozone on four major crops in Mpumalanga, South Africa

Abstract ID : 1408

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Rebecca Garland ,rgarland@csir.co.za ,(Principal Researcher) ,South Africa ,Pretoria ,Presenting[1]

Ms. Ayanda Ntsele ,u13106742@tuks.co.za ,(None) ,South Africa , ,Not Presenting[2]

Dr. Rebecca Garland ,rgarland@csir.co.za ,(Principal Researcher) ,South Africa ,Pretoria ,Presenting[1]

1 - CSIR 2 - University of Pretoria 3 - CSIR

The Mpumalanga Highveld Priority Area in eastern South Africa is is regarded as one of the largest industrialised areas in Africa, and the province heavily relies on agriculture as a source of revenue. Monitoring data collected over the past seven years shows elevated concentrations of known phytotoxic pollutants (ozone (O_3) and and sulfur dioxide (SO_2)), especially during the growing season. This is the first study in South Africa to quantify the effects of ambient O_3 and SO_2 on four crops (wheat, maize, sorghum and soybean) in Mpumalanga. The AOT40 values, which are the thresholds used in the European Union to estimate crop yield loss from O_3, were calculated from multiple years of ambient O_3 data. The AOT40 thresholds consider O_3 concentrations for daytime hours (06:00 AM to 06:00 PM) during the three-month growing season.These AOT40 values were then used to calculated yield and revenue losses in different magisterial districts within the province. Results suggest that the most affected crop is wheat (multi-year average yield loss (AYL) of 14.21% and multi-year average total annual loss (TAL) of $2.39 million in the region), followed by maize (AYL of 11.42% and TAL of $49.9 million in the region), sorghum (AYL of 0.55% and TAL of $0.08 million in the region) and soybean (AYL of 0.12% and TAL of $0.32 million in the region). It was also concluded that the many of the region's magisterial districts also surpass the international SO_2 standards for agriculture during the growing season, which also exacerbates the yield losses. This presentation will highlight the importance of these findings in terms of stressors on agriculture, and will also compare with the potential risk to human health through inhalation of these pollutants.

Roland von Glasow Memorial Lecture: Tropospheric Halogen Sources from Sea Spray Aerosol

Abstract ID : 1410

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Rainer Volkamer ,rainer.volkamer@colorado.edu ,(None) ,United States ,Boulder ,Presenting[1]

Mr. Theodore Koenig ,Theodore.Koenig@colorado.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Barbara Dix ,Barbara.Dix@Colorado.EDU ,(None) ,United States , ,Not Presenting[1]

Prof. Yuzo Miyazaki ,yuzom@lowtem.hokudai.ac.jp ,(None) ,Japan , ,Not Presenting[4]

Dr. Sebastian Schmidt ,johanalbrechtschmidt@gmail.com ,(None) ,Denmark , ,Not Presenting[5]

Dr. Mike Long ,mlong@seas.harvard.edu ,(None) ,United States , ,Not Presenting[6]

Dr. Alba Badia ,A.Badia-Moragas@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]

Prof. Claire Reeves ,C.Reeves@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]

Prof. Roland von Glasow ,R.von-Glasow@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]

Prof. ST TORERO & CONTRAST ,rainer.volkamer@gmail.com ,(None) ,United States ,Boulder ,Not Presenting[10]

1 - University of Colorado 2 - University of Colorado 3 - University of Colorado 4 - University of Hokkaido 5 - University of Copenhagen 6 - Harvard University 7 - UEA Norwich 8 - UEA Norwich 9 - UEA Norwich 10 - NA

Tropospheric halogens are emitted from oceans into the atmosphere in organic form, and as sea spray aerosols. Heterogeneous chemistry on aerosol surfaces lead to the release of bromide (and chloride) to the gas-phase, and leaves aerosols depleted in bromide (and chloride) relative to their sodium ratios in sea-water. Chlorine is relevant in the atmosphere, because it of the $Cl + CH_4$ reaction, which is a sink of methane, a major greenhouse gas. Bromine and iodine participate in catalytic reaction cycles that destroy tropospheric ozone, another important greenhouse gas. They also affect oxidative capacity, oxidize mercury, modify aerosols, and can (iodine) form new particles, which affect cloud cover and Earth albedo. About 75% of the global O_3 and CH_4 destruction occurs at tropical latitudes.
Sea-spray is widely considered to be the largest source of tropospheric halogens globally. However, state-of-the-art atmospheric models differ in their treatment of the halogen source from sea-spray aerosol. This talk reviews the seminary contributions of the late Roland von Glasow in the field of tropospheric halogen chemistry, as well as new insights from field observations (ships and aircraft) as part of the TORERO (Tropical Ocean tRoposphere Exchange of Reactive Halogen Species and Oxygenated Hydrocarbons, Jan-Feb 2012) and CONTRAST (Convective Transport of reactions species in the troposphere, Jan-Feb 2014) field campaigns over the tropical Eastern and Western Pacific Ocean.

The ACCESS Annual Cycle and Seasonality (ACyS) Project

Abstract ID : 1442

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Neville Sweijd ,nsweijd@access.ac.za ,(Director) ,South Africa ,Cape Town ,Presenting[1]

Prof. Kingsley Ayisi ,Kwabena.Ayisi@ul.ac.za ,(None) ,South Africa , ,Not Presenting[2]

Dr. Hector Chokoore ,hector.chikoore@univen.ac.za ,(None) ,South Africa , ,Not Presenting[3]

Dr. Natalie Burls ,nats.burls@gmail.com ,(Assistant Professor) ,United States ,Fairfax ,Not Presenting[4]

Dr. Francois Engelbrecht ,FEngelbrecht@csir.co.za ,(None) ,South Africa , ,Not Presenting[5]

Prof. Barend Erasmus ,Barend.Erasmus@wits.ac.za ,(None) ,South Africa , ,Not Presenting[6]

Prof. Harold Annergarn ,hannegarn@gmail.com ,(None) ,South Africa , ,Not Presenting[7]

Prof. Lindsey Gillson ,lindsey.gillson@uct.ac.za ,(None) ,South Africa , ,Not Presenting[8]

Prof. Willem Landman ,willem.landman@up.ac.za ,(None) ,South Africa , ,Not Presenting[9]

Prof. Guy Midgley ,gfmidgley@sun.ac.za ,(None) ,South Africa , ,Not Presenting[10]

Dr. Caradee Wright ,Caradee.Wright@mrc.ac.za ,(None) ,South Africa , ,Not Presenting[11]

Dr. Pedro Monteiro ,pmonteir@csir.co.za ,(None) ,South Africa , ,Not Presenting[12]

Dr. Xolisa Ngwadla ,xolisa.ngwadla@gmail.com ,(None) ,South Africa , ,Not Presenting[13]

Prof. George Philander ,gphlder@Princeton.EDU ,(None) ,United States , ,Not Presenting[14]

Prof. Mathieu Rouault ,Mathieu.Rouault@uct.ac.za ,(Professor) ,South Africa ,Cape Town ,Not Presenting[15]

Prof. Les Underhill ,les.underhill@uct.ac.za ,(None) ,South Africa , ,Not Presenting[8]

Prof. Albert Modi ,ModiAT@ukzn.ac.za ,(None) ,South Africa , ,Not Presenting[17]

Dr. Johan Malherbe ,Johan@arc.agric.za ,(None) ,South Africa , ,Not Presenting[18]

Dr. Luthando Dziba ,LDziba@csir.co.za ,(None) ,South Africa , ,Not Presenting[13]

Dr. Moses Cho ,MCho@csir.co.za ,(None) ,South Africa , ,Not Presenting[13]

Dr. Emma Archer Van Garderen ,EArcher@csir.co.za ,(None) ,South Africa , ,Not Presenting[13]

Prof. Coleen Vogel ,colhvogel@gmail.com ,(None) ,South Africa , ,Not Presenting[22]

Dr. Stephan Woodborne ,swoodborne@tlabs.ac.za ,(None) ,South Africa , ,Not Presenting[23]

Dr. Sally Archibald ,sally.archibald1@gmail.com ,(None) ,South Africa , ,Not Presenting[24]

Dr. Pippan Anderson ,pippin.anderson@uct.ac.za ,(None) ,South Africa , ,Not Presenting[25]

Dr. Res Altwegg ,res.altwegg@gmail.com ,(None) ,South Africa , ,Not Presenting[25]

1 - ACCESS 2 - University of Limpopo 3 - University of Venda 4 - George Mason University 5 - CSIR/NRE 6 - University of the Witwatersrand 7 - Cape Peninsula University of Technology 8 - University of Cape Town 9 - University of Pretoria 10 - Stellenbosch University 11 - South African Medical Research Council 12 - 1Southern Ocean Carbon-Climate Observatory (SOCCO), CSIR, and Department of Oceanography University of Cape Town, Cape Town, South Africa 13 - Council for Scientific and Industrial Research 14 - Princeton University 15 - University of Cape town 16 - University of Cape Town 17 - University of Kwazulu Natal 18 - Agricultural Research Council 19 - Council for Scientific and Industrial Research 20 - Council for Scientific and Industrial Research 21 - Council for Scientific and Industrial Research 22 - University of Witwatersrand 23 - iThemba Labs 24 - WITS 25 - UCT 26 - UCT

The Alliance for Climate and Earth Systems Science (ACCESS) is a South African research programme which has embarked upon a project focussed on the past, current and future dynamics of the southern African coupled earth system viewed through the lens of the annual climate cycle. The goal of this programme is to further elucidate the generation of the annual climate cycle and its associated variability, its long-term trends due to past and future climate change, and its propagation through the earth system and respective sub-systems and biophysical processes at a range of time and space scales. Ultimately the project aims to contribute to a reduction of uncertainty, and improving predictability in the representation of the annual climate cycle and the seasonality in earth systems models. It seeks to elucidate the expression of the annual climate cycle in terms of the seasonal responses of relevant biophysical, biogeochemical, biological and human systems, including in the provision of ecosystem goods and services, human health and agriculture. In this contribution an overview of the state of knowledge and research gaps regarding the drivers and dynamics of the current annual cycle and its intra- and inter-annual properties will be presented and discussed. The consequence of these dynamics in driving ecosystem state and its impact on socio-economics of southern African society will be demonstrated. In order to understand the long term trajectory of the annual cycle dynamics, which is where long term climate change impacts actually manifest, one essential focus of this research is the role of the annual cycle and seasonality in the palaeontology of the current biosphere and the consequent distribution of a range of ecosystem processes. Together with the understanding of current annual cycle forcing, this provides empirical tests for the application of climate models at a range of space and time scales which will lead to increased confidence with which future predictions of the annual cycle and its potential impacts are made. The state of knowledge based on a collation of published research and new data will be presented along with a set of research questions for a soon to be launched set of multi-disciplinary research projects.

Ozone measurements for the Australian region, past, present and future

Abstract ID : 1468

Conflict Declaration : None

Content Motivation : I was invited by the IO3C to present on ozone - so this is a synthesis of all (ground based) ozone measurements made over the Australian region and some new results.

Additional Information : None

Dr. Robyn Schofield ,robyn.schofield@unimelb.edu.au ,(Senior lecturer) ,Australia ,Melbourne ,Presenting[1]

Dr. Ian Galbally ,ian.galbal@gmail.com ,(None) ,Australia , ,Not Presenting[2]

Ms. Suzie Molloy ,Suzie.Molloy@csiro.au ,(None) ,Australia , ,Not Presenting[2]

Dr. Matt Tully ,matt.tully@bom.gov.au ,(None) ,Australia , ,Not Presenting[4]

Dr. Stephen Rhodes ,S.Rhodes@bom.gov.au ,(None) ,Australia , ,Not Presenting[4]

Dr. Matthew Woodhouse ,Matthew.Woodhouse@csiro.au ,(None) ,Australia , ,Not Presenting[2]

Dr. Kane Stone ,stonek@mit.edu ,(None) ,United States , ,Not Presenting[7]

Dr. Andrew Klekociuk ,andrew.klekociuk@aad.gov.au ,(None) ,Australia , ,Not Presenting[8]

Dr. Robert Gillet ,rob.gillett@csiro.au ,(None) ,Australia , ,Not Presenting[2]

1 - University of Melbourne 2 - CSIRO Ocean and Atmosphere Business Unit, Aspendale, Australia 3 - CSIRO Ocean and Atmosphere Business Unit, Aspendale, Australia 4 - Bureau of Meteorology, Melbourne, Australia 5 - Bureau of Meteorology, Melbourne, Australia 6 - CSIRO Ocean and Atmosphere Business Unit, Aspendale, Australia 7 - Massachusetts Institute of Technology, Cambridge 8 - Australian Antactic Division 9 - CSIRO Ocean and Atmosphere Business Unit, Aspendale, Australia

Stratospheric measurements of ozone through ozonesoundings, Dobson total ozone column and Umkehr observations are fairly readily available to the international community. In contrast, tropospheric ozone measurements, made for multiple purposes, are generally less accessible for satellite validation, air quality / health assessments and chemistry-climate modeling efforts, though efforts such as the recent Tropospheric Ozone Assessment Report have strengthened this significantly. Here we present the ozone observation collections for the Australian region spanning the tropics to the Antarctic along with their data accessibilities. As cities move towards smart sensor networks and chemical weather forecasting - coordinated data accessibility will be a priority in the 21st century. Steps required at local, national and international levels to facilitate coordination and delivery of real-time quality assured ozone data is discussed along with case studies of data requirements for climate system validation versus health assessment / purposes.

Inverse Relations of PM2.5 and O3 in Air Compound Pollution between Cold and Hot Seasons over an Urban Area of East China

Abstract ID : 1488

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Tianliang Zhao ,tlzhao@nuist.edu.cn ,(None) ,China ,Nanjing ,Not Presenting[1]

Ms. Mengwei Jia ,jiamengwei8822@163.com ,(None) ,China , ,Presenting[2]

Dr. Xinghong Cheng ,cxingh@cma.gov.cn ,(None) ,China , ,Not Presenting[3]

1 - Nanjing University of Information Science & Technology 2 - Nanjing University of Information Science and Technology 3 - Chinese Academy of Meteorological Sciences

By analyzing the data of urban air pollutant measurements from 2013 to 2015 in Nanjing, East China, we found that the correlation coefficients between major atmospheric compound pollutants $PM_{2.5}$ and O_3 were respectively 0.40 in hot season (June, July and August) and −0.16 in cold season (December, January and February) with both passing the confidence level of 99%. This provides evidence for the inverse relations of ambient $PM_{2.5}$ and O_3 between cold and hot seasons in an urban area of East China. To understand the interaction of $PM_{2.5}$ and O_3 in air compound pollution, the underlying mechanisms on the inversion relations between cold and hot seasons were investigated from the seasonal variations in atmospheric oxidation and radiative forcing of $PM_{2.5}$ based on three-year environmental and meteorological data. The analyses showed that the augmentation of atmospheric oxidation could strengthen the production of secondary particles with the contribution up to 26.76% to ambient $PM_{2.5}$ levels. High O_3 concentrations in a strong oxidative air condition during hot season promoted the formation of secondary particles, which could result in a positive correlation between $PM_{2.5}$ and O_3 in hot season. In cold season with weak atmospheric oxidation, the enhanced $PM_{2.5}$ levels suppressed surface solar radiation, which could weaken O_3 production for decreasing ambient O_3 level with the low diurnal peaks. Under the high $PM_{2.5}$ level exceeding 115 $\mu g \cdot m^{-3}$, the surface O_3 concentration dropped to 12.7 $\mu g \cdot m^{-3}$ at noon with a significant inhibitory effect, leading to a negative correlation between $PM_{2.5}$ and O_3 in cold season. This observational study revealed the interaction of $PM_{2.5}$ and O_3 in air compound pollution for understanding on seasonal change of atmospheric environment.

CoMet: The Carbon Dioxide and Methane Mission for HALO

Abstract ID : 1495

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Anke Roiger ,anke.roiger@dlr.de ,(None) , , ,Not Presenting[1]

Dr. Gerhard Ehret ,gerhard.ehret@dlr.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Andreas Fix ,andreas.fix@dlr.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Axel Amediek ,axel.amediek@dlr.de ,(None) ,Germany , ,Presenting[1]

Dr. Christoph Gerbig ,cgerbig@bgc-jena.mpg.de ,(None) ,Germany , ,Not Presenting[5]

Dr. Heinrich Bovensmann ,heinrich.bovensmann@iup.physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[6]

1 - DLR 2 - DLR 3 - DLR 4 - DLR 5 - MPI-BGC 6 - Institute of Environmental Physics, University of Bremen

The lack of knowledge about the sources and sinks in the Global Carbon Cycle on all relevant temporal and spatial scales is currently recognized as the biggest deficit in understanding the processes of Global Change and developing solutions for adaptation measures.
In order to reliably predict the climate on our planet throughout the 21st century and to support attaining emission targets in the framework of international climate agreements, research on the fluxes of the two most important anthropogenic greenhouse gases - carbon dioxide (CO2) and methane (CH4) - is indispensable.
Here we will give an overview on primary objectives and first results from the HALO aircraft campaign CoMet (CO2 and Methane mission), which is planned in April-May 2017. During CoMet, a scientific payload consisting of the best currently available active (lidar) and passive remote sensing instruments will fly on HALO, supported by highly accurate in-situ measurements. The gained data sets will help to increase the knowledge about the variability of CO2 and CH4 on a subcontinental scale. The flights will be concentrated on Europe since the European continent is characterized by a very strong overlap between anthropogenic and biogenic sources. This will not only allow identifying local sources of emissions but also providing important input for the inverse models to infer regional budgets. A significant part of the HALO flights will be performed in coordination with two small Cessna aircraft that carry a passive remote sensor (MAMAP) and a suite of in-situ instrumentation and will concentrate on areas with strong localized sources.
Through analyzing the CoMet data set the knowledge about the carbon dioxide and methane cycle shall be improved and new insight gained about the spatial and temporal variations of greenhouse gases.
Moreover, the CoMet mission aims at preparing the validation activities for upcoming satellite missions such as the German-French Climate mission MERLIN (Methane Remote Sensing LIDAR Mission). Scheduled for Launch in 2021, this small satellite mission will measure the methane concentration in Earth's atmosphere to an unprecedented level of accuracy and thus further contribute to research into the causes of climate change.

Mortality and burden of disease from outdoor air pollution on a global scale

Abstract ID : 1509

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Jos Lelieveld ,jos.lelieveld@mpic.de ,(None) ,Germany ,None ,Not Presenting[1]

1 - Max Planck Institute for Chemistry, Mainz, Germany

The World Health Organization attributes illness and associated mortality to a range of causes, including air pollution by ozone and fine particulate matter (PM2.5). Quantifying the role of air pollution has been a challenge, in part due to uncertainty about human exposure to air pollution worldwide. We present results from a global atmospheric chemistry model, combined with population data, country-level health statistics and pollution exposure response functions. We calculate that outdoor air pollution, mostly by PM2.5, leads to 3.3 million premature deaths annually, predominantly in Asia (~75%). Contrary to the common view that traffic, industry and power generation are dominant sources, we show that residential energy use (e.g. heating, cooking) is the largest category worldwide due to its prevalence in India and China. While in the western world traffic and power generation are important, in the Eastern US, Europe, Russia and Japan agricultural emissions make the largest contribution to PM2.5. In Africa, natural PM2.5, notably desert dust, is prevalent. While it is generally assumed that all particles are equally toxic, carbonaceous PM2.5 may be most detrimental. In that case residential energy use and biomass burning gain importance, which is particularly relevant in Africa.

M02 - Recent development of lightning and thunderstorm detection networks and their applications in meteorology

Climatological characteristics and spatio-temporal correspondence of lightning and precipitation over the Qinghai-Tibet Plateau

Abstract ID : 201

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yijun Zhang ,zhangyj@camscma.cn ,(None) ,China ,Beijing ,Not Presenting[1]

1 - None

Climatological characteristics and spatio-temporal correspondence of lightning and precipitation over the Qinghai-Tibet Plateau

Yijun Zhang and Dong Zheng
State Key Laboratory of Severe Weather, Chinese Academy of Meteorological Sciences,Beijing,100081

Based on the analysis of TRMM data from 1998 to 2013, this study examines the climatological characteristics of lightning activities and precipitation and their relationships over the Qinghai-Tibet Plateau. The largest densities of lightning are located over the central and northeast parts of the plateau, with the maximum lightning density over the central plateau reaching to 6.2 fl km-2 yr-1. Nevertheless, the strongest precipition occurs over the southeast part of the plateau where the value is universal above 800 mm year-1. Both the lightning activity and precipition move westward on May and then retreat on September over most parts of the plateau, while the strong lightning activity over the northeast of the plateau move little. Unlike the lightning activity which features center of large density, the precipitation show a cascade change from southeast to northwest. In chosen specified areas, the lightning and precipitation show parallel changes, including their active periods from May to September and single peak patterns. Except for the west and south east parts of the plateau, the peak months of lightning and precipitation in other areas are same. The geographic distribtuion of the rainyield per flash (RPF) is then investigated and exhibites that the minimun RPF appears over the central and west parts of the plateau, ranging from 5×107 to 7×107 kg fl-1, and the large RPF, having the value above 1×109 kg fl-1, appears over the area going along the Himalayas and stretching to the southeast part of the plateau and the area located in the north of the plateau and near to the Kunlun Mountains. The midwest and northeast parts of the plateau account for the largest percentage of deep convective activities in the whole precipitation system, while the southeast parts of the plateau accounts for the smallest percentage, which indicates that most of the precipitation over the southeast parts of the plateau might be contributed by warm clouds.

A tentative analysis on lightning heating effect duration based on a case observed with a ground-based microwave radiometer

Abstract ID : 355

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Zhenhui Wang ,eiap@nuist.edu.cn ,(Nanjing Univ. Information Sci & Technology Nanjing 210044 P. R. China) ,China ,Nanjing ,Not Presenting[1]

Ms. Sulin Jiang ,b374757@163.com ,(None) ,China , ,Not Presenting[2]

Mr. Zhenhui Wang ,eiap@nuist.edu.cn ,(Nanjing Univ. Information Sci & Technology Nanjing 210044 P. R. China) ,China ,Nanjing ,Not Presenting[1]

1 - None 2 - NUIST 3 - None

A microwave radiometer was making brightness temperature observations at the India Space Launch Center (Trivandrum, Kerala, India) during pre-monsoon rain at around 12:20UT (5:50 LT) on March 29, 2010. The radiometer has 14 channels in the 51-59GHz band and brightness temperature (T_b) time series observed show that 51.248, 51.760 and 52.280 GHz T_b's are obviously greater by 29 K, 18 K and 12 K near 12:20:20. This spike is generally correlated in time and direction with multiple lightning strokes seen by eye. Since the radiometer channels sample the incident radiance sequentially at certain time intervals, the time difference between the 51.248 and 52.280 GHz would be an estimation of the lightning heating effect duration. The tentative analysis of this case shows that the duration can be as long as 8 seconds because the time interval for two adjacent channels is 4 seconds. Further studies are on the way.

Predicting the number and area of thunderstorms over Africa using WWLLN data

Abstract ID : 463

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Colin Price ,cprice@flash.tau.ac.il ,(Head of Porter School of Environment) ,Israel ,Tel Aviv ,Not Presenting[1]

1 - Tel Aviv University

One of the difficulties in predicting changes in future thunderstorm activity in a warmer climate is first knowing the climate parameters (in models), in the present climate, that are best related to thunderstorm activity. In addition, climate models supply only large scale parameters for use in their simulations, with no cloud microphysical details. Hence, any parameterization needs to use the available output of the climate model. Considering these limitations, we have used the NCEP/NCAR reanalysis product to investigate the large-scale parameters that are best related to thunderstorm activity over Africa. For the thunderstorm observations we use the WWLLN lightning detections, clustered into thunderstorm cells according to Mezuman et al. (2014). Comparisons between these thunderstorm clusters and the NCEP climate parameters revealed two significant large-scale parameters that predict thunderstorm activity over Africa: surface specific humidity (g/kg) and the LI lifted index (K). Using these two parameters we built an empirical model to predict both number and areal coverage of thunderstorms over Africa in any given month. This empirical model predicts the thunderstorm distribution of Africa with considerable skill. The next step will be to use this parameterization in climate models to study the changes in thunderstorm characteristics in a warmer climate.

Mezuman, K., C. Price and E. Galanti, 2014: On the spatial and temporal distribution of thunderstorm cells, Environ. Res. Lett., 9, doi:10.1088/1748-9326/9/12/124023.

Three-dimension Lightning Location Based on Low-frequency Electric Field Change and Preliminary Results

Abstract ID : 558

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Dong Zheng ,zhengaredong@163.com ,(None) ,China ,Beijing ,Not Presenting[1]

1 - Chinese Academy of Meteorological Sciences

Three-dimension Lightning Location Based on Low-frequency Electric Field Change and Preliminary Results

Dong Zheng[1], Yang Zhang[1], Dongdong Shi[1], Yijun Zhang[1], Weitao Lu[1], Zhigang Huang[1], Shaodong Chen[2], Xu Yan[2]
1 State Key Laboratory of Severe Weather, Chinese Academy of Meteorological Sciences, Beijing, 100081, China
2 Guangzhou Institute of Tropical and Marine Meteorology, Chinese Meteorological Administration, Guangzhou, 510080, China

A Lightning Low-Frequency E-filed Detection Array (LFEDA) is developed by Chinese Academy of Meteorological Sciences to locate the breakdown signals of lightning discharges at the frequency ranging from 160 Hz to 600 kHz from 2014. In this paper, we introduce the technology and algorithm of the LFEDA and investigate its performance and preliminary results during the observation experiment conducted in Guangzhou, China. The LFEDA shows a fine performance in the location of the triggered lightning flashes (TLFs) which was carried out in the inner of the network of the LFEDA, with the detection efficiency for TLFs and return strokes being 100% and 95%, respectively, and the average location error being 102 m. The combination of the three-dimensional locations of the total lightning during the evolution of thunderstorms and the radar echo also support the reliable performance of LFEDA; Furthermore, the locations show the potential in recognizing the rough distribution of charge regions. The characteristic parameters associated with the initial stage of lightning propagation in two thunderstorm processes were specially analyzed. In addition, LFEDA is capable of describing the three-dimensional channel of lightning to some extent; two examples including an intra-cloud lightning and the leader of a cloud-to-ground lightning are exhibited, while some parameters associated with the initial propagation of channels are also counted according to the location data.

The SAETTA-LMA network: from individual flashes to 3-year lightning climatology in Corsica

Abstract ID : 1242

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Defer Eric ,Eric.Defer@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[1]

Dr. Coquillat Sylvain ,Sylvain.Coquillat@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[1]

Dr. LAMBERT Dominique ,dominique.lambert@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[1]

Dr. PINTY Jean-Pierre ,jean-pierre.pinty@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[1]

Dr. Pont Véronique ,veronique.pont@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[1]

Dr. PRIEUR Serge ,serge.prieur@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[1]

1 - LA 2 - LA 3 - LA 4 - LA 5 - LA 6 - LA

The total lightning activity has been recorded in Corsica (Northwestern Mediterranean Sea) in the VHF range for about 3 years at high spatial and temporal resolutions by the SAETTA network (Suivi de l'Activité Electrique Tridimensionnelle Totale de l'Atmosphère), consisting of 12 LMA stations (Lightning Mapping Array, developed by New Mexico Tech, USA) and deployed in Corsica since July 2014.
The SAETTA network will be presented first. Typical and unusual lightning flashes will then be detailed. Lightning activity at the storm scale and its spatial and temporal properties will then be discussed to introduce the typical storm systems occurring in Corsica. Then a first climatology of the total lightning activity based on SAETTA observations will be shown. Finally we will discuss our plans in support to the cal/val campaigns of the LEO and GEO space-based lightning detection missions.

Characterizing a Network, Location Accuracy and Detection Efficiency of the ENTLN

Abstract ID : 1447

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Michael Stock ,mstock@earthnetworks.com ,(None) ,United States ,Germantown ,Not Presenting[1]

Dr. Stan Heckman ,SHeckman@whiskerlabs.com ,(None) ,United States , ,Not Presenting[1]

Mr. Yanan Zhu ,yananzhu@ufl.edu ,(None) ,United States , ,Not Presenting[3]

1 - Earth Networks 2 - Earth Networks 3 - University of Florida

Today, the Earth Networks Total Lightning Network (ENTLN) is composed of 1505 lightning sensors deployed in 94 different countries. Additionally, through a collaboration with the World Wide Lightning Location Network (WWLLN), 200 of these sensors supply VLF waveforms for use in the WWLLN time of group arrival processing, making for a truly global lightning location system. Every minute, more than 1000 lightning flashes are located. To find out how good these locations are, a detailed analysis of the location accuracy (LA) and detection efficiency (DE) of the network is presented. In both cases, techniques are described to allow LA and DE to be calculated anywhere on the planet using the lightning data itself to determine how well the network is performing. These self-assessment techniques are then validated against tall tower locations (for LA) and satellite lightning location (for DE) to show that they do indeed produce the correct results.

M03 - Lightning discharges and Transient Luminous Events: Characteristics, Physics and applications

A Synergic Approach to the Study of TGFs and Energetic Radiation from Thunderstorms

Abstract ID : 455

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Nikolai Ostgaard ,Nikolai.Ostgaard@uib.no ,(Professor) ,Norway ,Bergen ,Not Presenting[1]

Prof. Martino Marisaldi ,Martino.Marisaldi@uib.no ,(None) ,Norway , ,Not Presenting[1]

Mr. Alexander Skeltved ,abskeltved@gmail.com ,(None) ,Norway , ,Not Presenting[1]

Dr. Nikolai Lehtinen ,Nikolai.Lehtinen@uib.no ,(None) ,Norway , ,Not Presenting[1]

Mr. Kjetil Albrechtsen ,Kjetil.Albrechtsen@uib.no ,(None) ,Norway , ,Not Presenting[5]

Dr. Pavlo Kochkin ,Pavlo.Kochkin@uib.no ,(None) ,Norway , ,Not Presenting[1]

Dr. Andrey Mezentsev ,andrey.mezentsev@uib.no ,(None) ,Norway , ,Not Presenting[1]

1 - Birkeland Centre for Space Science 2 - Birkeland Centre for Space Science 3 - Birkeland Centre for Space Science 4 - Birkeland Centre for Space Science 5 - Birkeland Centre for Space Science 6 - Birkeland Centre for Space Science 7 - Birkeland Centre for Space Science

Terrestrial Gamma-ray Flashes (TGFs) are the manifestation of the most energetic natural particle acceleration phenomenon taking place on earth, in thundercloud electric fields. Although extremely bright and detectable from space hundreds of kilometers from the source region, TGFs are only one manifestation of a broader class of phenomena that involves acceleration of electrons and positrons in thunderclouds and production of photons with energy up to several tens of MeV. In fact, thunderclouds appear to produce ionizing radiation on several time scales, from microseconds to minutes, that can be observed from ground, aircraft and space. However, although there is a general consensus on the basic theoretical framework, after more than 20 years of research in this field several fundamental questions are still open, including: how much of the thundercloud energy is dissipated in the high-energy radiation channel? Do these high-energy phenomena have any influence on atmospheric chemistry and dynamics? The very same definition of TGF is debated. Moreover, the observational scenario is hampered mostly by sparse observations: space observations have global coverage but are limited to bright transient events (TGFs), ground observations are limited to specific spots on earth equipped with suitable instrumentation, and subject to peculiar thunderstorm characteristics, in situ observations by aircraft are still very rare, and experimental

activities in a controlled laboratory environment cannot achieve the electric field and voltage conditions at play in thunderclouds.
Given this complex scenario, a synergic approach including observations, theoretical modeling and experimental activities is needed to overcome the observational limitations. In this frame, we will present the latest results achieved within the Birkeland Centre for Space Science, including observations and modeling of TGFs detected by AGILE and weak TGFs detected by RHESSI, aircraft observations of gamma-ray glows, radio signals from TGFs, and the theoretical modeling of radiation production by lightning leaders and streamers encounters.

Upward connecting leader behavior during lightning attachment process

Abstract ID : 684

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Marcelo Saba ,marcelo.saba@inpe.br ,(Professor) ,Brazil ,S. Jose dos Campos ,Presenting[1]

Mr. José Silva ,claudio.silva@aptemc.com.br ,(None) ,Brazil , ,Not Presenting[2]

Mrs. Carina Schumann ,carina.schumann@gmail.com ,(None) ,Brazil , ,Not Presenting[3]

Mrs. Amanda Romão Paiva ,amandapaiva20@gmail.com ,(None) ,Brazil , ,Not Presenting[3]

Dr. Marco Antonio da Silva Ferro ,marcoferro66@gmail.com ,(None) ,Brazil , ,Not Presenting[5]

Dr. Kleber Pinheiro Naccarato ,kleber.naccarato@inpe.br ,(None) ,Brazil , ,Not Presenting[3]

Mr. Fernando Valadares Calheiros Siqueira ,fernandovldrs@gmail.com ,(None) ,Brazil , ,Not Presenting[7]

Dr. Gerhard Diendorfer ,G.Diendorfer@ove.at ,(None) ,Austria , ,Not Presenting[8]

1 - INPE - National Institute for Space Research 2 - APTEMC – Analysis, advices and training on EMC 3 - INPE – National Institute for Space Research 4 - INPE – National Institute for Space Research 5 - IAE - Institute of Aeronautics and Space 6 - INPE – National Institute for Space Research 7 - ITA –Technological Institute of Aeronautics 8 - ALDIS Austrian Lightning Detection and Information System

The physical mechanism of lightning attachment to grounded structures is one of the most important issues in lightning physics research and it is the basis for the design of the lightning protection systems. During the propagation of the downward leader towards ground, the inception of one or more upward connecting leaders may start directly from the ground or from objects or humans nearby. Most of what is known about the attachment process comes from leader propagation models that are mostly based on laboratory observations of long electrical discharges or from observations of lightning attachment to tall structures. In this paper, we present the characteristics of leaders during the attachment process to common structures that are present in almost every city (in this case, buildings under 60 m in São Paulo City, Brazil). We use high-speed videos together with electric field and upward connecting leader current measurements to analyze the propagation of downward leaders and the inception and propagation of upward connecting leaders. Parameters like speed, charge and current of upward connecting leaders used in lightning attachment models and in lightning protection standards, are revealed in this work.

M04 - Past Climate Changes: a key for the future

Rainfall elasticity of the main river discharges in La Plata basin

Abstract ID : 57

Conflict Declaration : None

Content Motivation : Presenting my research findings at the IAPSO-IAMAS-IAGA Joint Assembly would give me the possibility to discuss my results with other scientists attending the meeting and receive constructive feedback to improve my ongoing work. Given the meeting is a Joint Assembly it is very likely that many scientists with different backgrounds will attend. In this sense, I could contact other researchers which could give me a wider and more interdisciplinary view for my work. Last, but not least, I am sure many other Early Career Scientists (ECS) will attend and, as one of the Council members of the Young Earth System Scientists (YESS) community, I believe it is really valuable to meet other researchers at the early stages of their careers, as it is my own case. The interaction with them could lead to possible future collaborations as well as an engagement of more young scientists from other ECS networks to the YESS community.

Additional Information : I am applying for grant application. Please find attached the Grant Application Form and Motivational Letter from Institution. (Abstract for IAMAS M04 Session 3.)

Dr. Carla Gulizia ,gulizia@cima.fcen.uba.ar ,(Enrolled by the CONICET (National Council for Scientific and Technological Research, Argentina) under a Post-doctoral fellowship programme at the Research Centre of the Sea and the Atmosphere (CIMA).   Assistant Professor at the Department of Atmospheric and Oceanic Sciences (DCAO), Faculty of Science (FCEN), University of Buenos Aires (UBA), Argentina.) ,Argentina ,Buenos Aires ,Presenting[1]

Dr. Ines Camilloni ,ines@cima.fcen.uba.ar ,(None) ,Argentina ,None ,Not Presenting[1]

1 - Centro de Investigaciones del Mar y la Atmosfera (CIMA) / National Council for Scientific and Technological Research (CONICET) - University of Buenos Aires (UBA) 2 - Centro de Investigaciones del Mar y la Atmosfera (CIMA) / National Council for Scientific and Technological Research (CONICET) - University of Buenos Aires (UBA)

The main objective of the present study is to comprehend the amplification of the hydrological response in La Plata basin (LPB) in South America, and thus evaluate to what extent precipitation is able to explain runoff changes and variability. For this purpose, six sub-basins corresponding to the main rivers of LPB are selected within 1931-2010 period. Monthly runoff data was gathered from hydrological stations at six closing points and areal-averaged precipitation was derived from the Global Precipitation Climatology Centre gridded dataset. Comparing sub-periods 1931-1970 and 1971-2010, precipitation exhibit an increase in the latter period (4% to 6% in all sub-basins, except 11% in Uruguay River basin), while runoff positive changes are amplified, ranging between 27% and 37%. Given the non-linear relationship between precipitation and runoff, a non-parametric runoff elasticity index is calculated over each of the six sub-basins considering separately the period 1931-2010 and the two 40-yrs sub-periods, as well as for El Niño, La Niña and Neutral events' years, respectively. The elasticity index associates the percent change in runoff given a unit percent change

in climate (i.e. represented by precipitation). The more recent period, after 1970, exhibits smaller elasticity indices than the previous one for almost all river basins. These results could be partially explained by the possible influence of land-use change activities in LPB streamflows. Two additional parameters (coefficient of variation (CV) and amplification) at different timescales (annual, decadal and centennial) are analyzed. The CV is calculated as the ratio between the standard deviation and the long-term mean for each hydrological variable. The ratio between runoff and precipitation CVs is considered as an indicator of the streamflow's variability amplification relative to that of precipitation. Runoff CVs are considerably higher than precipitation CVs for all basins, which consequently exhibits runoff amplification, especially for El Niño years. However, CV corresponding to 1931-2010 period is explained to a greater extent considering only the ENSO neutral years. Furthermore, traditional Budyko Framework equations are also applied to infer observed runoff variability amplification, with consistent results particularly at the annual and decadal timescales.

Robust widening of the Hadley cell from the Last Glacial Maximum (LGM) to the future climate

Abstract ID : 105

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Seok-Woo Son ,seokwooson@snu.ac.kr ,(Associate Professor) ,South Korea ,Seoul ,Not Presenting[1]

Mr Seung-Ki Min ,skmin@postech.ac.kr ,(None) ,South Korea , ,Not Presenting[2]

Mr Seo-Yeon Kim ,koko2389@snu.ac.kr ,(None) ,South Korea , ,Not Presenting[1]

1 - Seoul National University 2 - POSTECH 3 - Seoul National University

The Hadley cell (HC) in the past, present and future climates are re-visited by examining the four sets of climate model simulations that are archived for the Paleoclimate Modelling Intercomparison Project phase 3 (PMIP3) and the Coupled Model Intercomparison Project phase 5 (CMIP5). Both HC width and intensity are evaluated for the 100-year long (quasi-)equilibrium simulations of the Last Glacial Maximum (LGM), the pre-industrial (PI), and the extended concentration pathway 4.5 (ECP4.5) and 8.5 (ECP8.5) conditions. In terms of global-mean surface air temperature, LGM condition, approximately 21,000 years before the present, is about -4.4°C colder than PI condition, whereas the 23rd century of ECP4.5 and ECP8.5 experiments is about 3.0°C and 9.0°C warmer than PI condition. All models show a systematic widening of the Hadley cell from the LGM to PI and to ECPs. Such widening is linearly correlated with global-mean surface air temperature change. Based on 500-hPa mass streamfunction diagnostics, 10°C surface warming is associated with about 5° widening of the HC. This trend, which is robustly found in both hemispheres with a stronger trend in the Southern Hemisphere than in the Northern Hemisphere, suggests that the reported HC widening in the late 20th and 21st centuries, which is often greater than 0.5° latitude per decade, is likely exaggerated. The HC intensity further shows a systematic weakening from the LCM to ECPs especially in the Northern Hemisphere. A simple scaling analysis reveals that this widening and weakening of the HC is highly associated with the enhanced subtropical static stability from the cold to warm climates.

Holocene temperature evolution in the Northern Hemisphere high latitudes – model-data comparisons

Abstract ID : 191

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Yurui Zhang ,yurui.zhang@helsinki.fi ,(PhD student) ,Finland ,Helsinki ,Not Presenting[1]

1 - None

1. Heterogeneous Holocene climate evolutions in the Northern Hemisphere high latitudes are primarily determined by orbital-scale insolation variations and melting ice sheets. Previous inter-model comparisons have revealed that multi-simulation consistencies vary spatially. We, therefore, compared multiple model results with compiled proxy reconstructions in Fennoscandia, Greenland, north Canada, Alaska and Siberia.
2. Our model-data comparisons reveal that data and models generally agree in Fennoscandia, Greenland and Canada, with the early-Holocene warming by 8-7 ka BP (hereinafter referred as ka) and subsequent gradual decrease to 0 ka. In Fennoscandia, simulations and pollen data suggest a 2°C warming by 8 ka, but this is less expressed in chironomid data. In Canada, a 4°C early-Holocene warming is suggested by both the simulations and pollen results. Adjustments in paleo-topography due to dynamic ice sheets and post-glacial rebound exert uncertainty in Fennoscandian and north Canadian model-data comparisons. In Greenland, the magnitude of early-Holocene warming ranges from 6°C in simulations to 8°C in δ18O-based temperatures.
3. Simulated and reconstructed temperatures are mismatched in Alaska. Pollen data suggest 4°C early-Holocene warming, while the simulations indicate 2°C Holocene cooling, and chironomid data show a stable trend. Meanwhile, a high frequency of Alaskan peatland initiation before 9 ka can reflect high temperature, high soil moisture or large seasonality. In high-latitude Siberia, although simulations and proxy data depict high Holocene temperatures, these signals are noisy owing to a large spread in the simulations and between pollen and chironomid results. On the whole, the Holocene climate evolution in Fennoscandia, Greenland and north Canada is well established and understood, but important questions regarding the Holocene temperature trend and mechanisms remain for Alaska and Siberia.

Modelling interglacial climate response to insolation and CO2 during the past 800,000 years

Abstract D : 267

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Qiuzhen Yin ,qiuzhen.yin@uclouvain.be ,(Research Associate) ,Belgium ,Louvain la Neuve ,Not Presenting[1]

Prof. Andre erger ,andre.berger@uclouvain.be ,(None) ,Belgium ,None ,Not Presenting[1]

1 - Université catholique de Louvain 2 - Université catholique de Louvain

The climate of nine interglacials of the past 800,000 years has been simulated with both snapshot and transient experiments using the model LOVECLIM. These simulations allow to investigate the relative contributions of insolation and CO2 to the intensity and duration of each interglacial as well as the differences between the interglacials at global and regional scales. The transient simulations which cover a full range of precession, obliquity and eccentricity allow to investigate the response of different climate variables at different latitudes to these three astronomical parameters.
The results show that the relative contribution of insolation and CO2 on the warmth intensity varies from one interglacial to another. They also show that CO2 plays a dominant role on the variations of the global annual mean temperature and the southern high latitude temperature and sea ice, whereas, insolation plays a dominant role on the variations of monsoon precipitation, vegetation and of the northern high latitude temperature and sea ice.
The results also show that, compared to today, the past interglacials are warmer during boreal summer and cooler during boreal winter leading to a warmer annual mean with varying length for different interglacials. The warm interval of MIS-11 is the longest, confirming its long duration as found in proxy records. The long duration of MIS-11 is related to a particular combination of eccentricity, obliquity and precession as well as to a high CO2 concentration. Through the comparison with other interglacials, unique features in precession and obliquity as well as in regional climate response are found in MIS-5e and MIS-11, which might help to understand why they appear as the two warmest interglacials during the past 800ka.
The transient simulations allow also to look for past interglacial analogues for our present interglacial and its natural future. The differences between the simulated seasonal behaviour of the past interglacials highlight the importance of seasonal climate reconstruction and therefore the necessity to obtain seasonal proxies.

Wetter subtropics in a warmer world: contrasting past and future hydrological cycles

Abstract ID : 316

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Natalie Burls ,nats.burls@gmail.com ,(Assistant Professor) ,United States ,Fairfax ,Not Presenting[1]

Dr. Alexey Fedorov ,alexey.fedorov@yale.edu ,(None) ,United States , ,Not Presenting[2]

1 - George Mason University 2 - Yale Univeristy

During the warm Miocene and Pliocene epochs, vast subtropical regions had enough precipitation to support rich vegetation and fauna. Only with global cooling and the onset of glacial cycles some 3 million years ago, towards the end of the Pliocene, did the broad patterns of arid and semi-arid subtropical regions become fully established. However, current projections of future global warming caused by CO_2 rise generally suggest the intensification of dry conditions over these subtropical regions, rather than the return to a wetter state. What makes future projections different from these past warm climates? Here, we investigate this question by comparing a typical quadrupling-of-CO_2 experiment with a simulation that closely reproduces sea surface temperature reconstructions for the early Pliocene. Based on these two experiments and a suite of other perturbed coupled climate simulations, we argue that this puzzle is explained by weaker atmospheric circulation in response to the different ocean surface temperature patterns of the Pliocene, specifically reduced meridional temperature gradients. Thus the Pliocene highlights that accurately predicting the response of the hydrological cycle to global warming requires predicting not only how global mean temperature responds to elevated CO_2 forcing (climate sensitivity) but also correctly quantifying how meridional SST patterns will change (structural climate sensitivity).

A new classification of large-scale climate regimes around the Tibetan Plateau based on seasonal moisture transport patterns

Abstract ID : 413

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Xin-Gang Dai ,daixg@tea.ac.cn ,(None) ,China ,Beijing ,Presenting[1]

Dr. Ping Wang ,pwang@camscma.cn ,(None) ,China , ,Not Presenting[2]

1 - RCE-TEA, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029 2 - Institute of Air Condition, Chinese Academy of Meteorological Sciences, Beijing 100081,

This study aims to develop a large-scale climate classification for investigating the characteristics of the climate regimes around the Tibetan Plateau based on seasonal precipitation, moisture transport and moisture divergence using in situ observations and ERA40. The results indicate that the climate can be attributed to four regimes around the Plateau, i.e., East Asia monsoon regime over the East Asia, South Asia monsoon regime over the South Asia, Central Asia regime over the Central Asia and westerly regime over the semi-arid zone in northern Central Asia throughout the dryland of northwestern China, despite of the Köppen climate classification. There are different collocations of seasonal temperature and precipitation in the regimes: 1) in-phase for the East and South Asia monsoon regimes, 2) anti-phase for the Central Asia regime, 3) out-of-phase for the westerly regime. The seasonal precipitation concentrations are coupled with moisture divergence in the monsoon areas and the divergence over the Mediterranean-like arid climate region and westerly-controlled zone in the warm season (May-October), while it reverses course in the cold season. In addition, the convergence/divergence is associated with northward/southward moisture transport, indicating that the wet and dry seasons are, to a great extent, dominated by the meridional moisture transport in these regime regions. The climate mean southward transport results in the dry-cold season in the Asian monsoon zone and the dry-warm season in Central Asia, leading to desertification or land degradation. The mean-wind moisture transport (MMT) is the major contributor to total moisture transport, while persistent northward transient eddy moisture transport (TEMT) plays a key role in dry season precipitation, especially in the Asian monsoon zone. The persistent TEMT divergence is an additional mechanism of the out-of-phase collocation in the westerly regime zone. Besides, the climate-mean MMT and TEMT are associated with the atmospheric stationary wave and storm track in Eurasian continent, which results from the uplift of orography and land-sea thermal contrast, as well known. Therefore, the paleoclimate changes in mid-latitude arid or semi-arid region are linked to the different phase stages of uplift of mountains and plate motion tied to the evolution of the Mediterranean.

Terrestrial rock weathering and the carbon cycle in the UVic Earth System Climate Model (ESCM): Applications to past and future climates

Abstract ID : 522

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Lawrence Mysak ,lawrence.mysak@mcgill.ca ,(Emeritus Professor) ,Canada ,Montreal ,Not Presenting[1]

Prof. Damon Matthews ,damon.matthews@concordia.ca ,(None) ,Canada , ,Not Presenting[2]

Dr. Marc-Olivier Brault ,marc-olivier.brault@mail.mcgill.ca ,(None) ,Canada , ,Not Presenting[1]

1 - McGill University 2 - Concordia University 3 - McGill University

The importance of the rock weathering feedback during the last deglacial period is investigated using the UVic ESCM with four box-model (zero-D) parameterizations of terrestrial weathering. The deglacial cooling is driven by prescribed changes in orbital parameters, atmospheric CO_2 and continental ice sheets. Over the course of the simulation (16000 to 4000 BCE), increases in weathering slowly remove CO_2 from the atmosphere, in opposition to the observed increase. Weathering transfers both carbon and alkalinity to the ocean, resulting in a 1000 Pg C increase in the total carbon, relative to a control run with constant weathering. A second set of simulations is used to estimate the impact of increasing weathering rates on atmospheric CO_2 when the latter is allowed to vary according to model carbon cycle dynamics. It is found that the CO_2 concentration is reduced by about 16 ppm over 8000 years as a result of increasing weathering alkalinity and carbon fluxes from LGM to 10000 BCE values.A spatially-explicit (2-D) weathering scheme which takes into account the worldwide distribution of rock types is also presented and applied to future carbon emission scenarios. Overall, the 2-D weathering model is more efficient than the zero-D model at restoring the carbon cycle to its pre-industrial state following pulse emissions. The model results show that the largest contributions to future changes in weathering rates come from the expansion of tropical and mid-latitude vegetation in grid cells dominated by weathering-vulnerable rock types. The results also confirm that only silicate rock weathering can lead to a full recovery of the carbon cycle on multi-millennial timescales.

Possible historical analogs to future African climates

Abstract ID : 1128

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Sharon Nicholson ,snicholson@fsu.edu ,(professor) ,United States ,Tallahassee ,Not Presenting[1]

1 - Florida State University

One of the notable features of African rainfall is continental-scale modes of interannual and decadal variability. These modes are examined using two diverse data sets. One is a semi-quantitative regional data set extending from 1800 to present. Data have an annual resolution and cover 90 regions. The second is a gauge data set for the 20th century that includes well over 2,000 stations and has monthly resolution. The most common spatial modes are increased aridity throughout nearly all of the continent and a dipole pattern with increased rainfall in the subtropical latitudes and decreased rainfall in a narrow equatorial belt. The first mode prevailed in the 1820s and 1830s and again in the 1980s, when devastating drought ravaged many parts of the continent. The second mode is less common and prevailed mainly in the 1950s. The fact that these modes are dominant in both the modern and historical record suggest they are inherent and robust features of African rainfall variability. Therefore, such continental-scale patterns can be anticipated for the future as well.

Towards reconstructing past surface solar radiation from tree-ring C13 records in Europe

Abstract ID : 1295

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr Eduardo Zorita ,eduardo.zorita@hzg.de ,(None) ,Germany , ,Presenting[1]

Dr. Mary Gagen ,M.H.Gagen@swansea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Isabel Dorado ,dorado.isabel@inia.es ,(None) ,Spain , ,Not Presenting[3]

Dr. Giles Young ,g.h.f.young@swansea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Ingo Heinrich ,ingo.heinrich@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[5]

1 - Helmholtz-Zentrum Geesthacht 2 - University of Swansea 3 - Instituto Nacional de Investigaciones Agrarias 4 - University of Swansea 5 - Helmholtz-Zentrum Potsdam

Changes in surface solar radiation, and thus of cloud cover, under future climate change is one of the most important climate feed-backs that determine the value of climate sensitivity. Climate models still show a large spread in the simulation of change sin cloud cover in the future. The analysis of C13 in tree rings records may help to estimate past variations of cloud cover in periods colder or warmer than the 20th century over the past millennium, providing a way to test climate models in this specific aspect. According to our understanding of photosynthetic activity in trees, tree-ring C13 can be an indicator of incoming short wave solar radiation (SWR) in non-moisture constrained sites, but the statistical identification of the SWR signal is hampered by its interannual co-variability with air temperature during the growing season.

In this contribution we present a spatio-temporal statistical analysis of the multivariate C13 data set over Europe provided by the ISONET network to assess its usefulness to reconstruct past solar radiation changes. The interannual co-variability of the C13 records clearly indicates that they more strongly co-var with solar radiation than with air temperature. The resulting spatial patterns of interannual co-variability are also strongly linked to the atmospheric circulation in a physically consistent manner. However, the multidecadal variations of the C13 records do not show a physically coherent picture, either regarding prior assumptions of changes in cloud cover or comparing with past millennium climate simulations, probably indicating that either the corrections applied for atmospheric C13 concentrations need revisions or that the multidecadal variations of soil moisture perturb the SWR in some sites. Preliminary results of strategies to bypass these problems will be presented.

Tropical impact on migration and health of Greenland partial melting

Abstract ID : 1397

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Gilles Ramstein ,gilles.ramstein@lsce.ipsl.fr ,(Gille Ramstein Research Director) ,France ,Gif sur Yvette ,Not Presenting[1]

Mr. Dimitri Defrance ,dimitri.defrance@locean.upmc.fr ,(None) ,France , ,Not Presenting[2]

Ms. Sylvie Charbit ,sylvie.charbit@lsce.ipsl.fr ,(None) ,France , ,Not Presenting[3]

Mr. Mathieu Vrac ,mathieu.vrac@lsce.ipsl.fr ,(None) ,France , ,Not Presenting[3]

Mr. Adjoua Moïse Famien ,Moise.Famien@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[2]

Mr. Benjamin Sultan ,Benjamin.Sultan@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[2]

Mr. Didier Swingedouw ,didier.swingedouw@u-bordeaux1.fr ,(None) ,France , ,Not Presenting[7]

Mr. Christophe Dumas ,christophe.dumas@lsce.ipsl.fr ,(None) ,France , ,Not Presenting[3]

Mr. François Gemenne ,Francois.Gemenne@uvsq.fr ,(None) ,France , ,Not Presenting[9]

Mr. Jorge Alvarez Solas ,jorge.alvarez.solas@fis.ucm.es ,(None) ,Spain , ,Not Presenting[10]

Mr. Jean-Paul Vanderlinden ,jean-paul.vanderlinden@uvsq.fr ,(None) ,France , ,Not Presenting[11]

Mr. Cyril Caminade ,cyril.caminade00@gmail.com ,(None) ,United Kingdom , ,Not Presenting[12]

1 - LSCE - CEA Saclay 2 - LOCEAN/IPSL, IRD, Paris, France 3 - LSCE - CEA Saclay 4 - LSCE - CEA Saclay 5 - LOCEAN/IPSL, IRD, Paris, France 6 - LOCEAN/IPSL, IRD, Paris, France 7 - EPOC, Université de Bordeaux, Pessac, France 8 - LSCE - CEA Saclay 9 - CEARC, OVSQ, Université Paris-Saclay, Guyancourt, France 10 - PalMA Group, Universidad Complutense de Madrid, Madrid, Spain 11 - LSCE/IPSL, CEA-CNRS-UVSQ, Université Paris-Saclay, Gif-sur- Yvette, France 12 - University of Liverpool, Institute of Infection and Global Health

A major uncertainty concerning the 21st century climate is the ice-sheet response to global warming. Paleodata indicates rapid ice-sheet destabilizations during the last deglaciation and during glacial episodes (as for instance Heinrich Event and melt water pulses). Ice sheet destabilization could therefore modify the sea level rise and its evolution by the end of this century. This feature has already been pinpointed in recent publications (DeConto and Pollard, Nature 2016). However, this climate change could not be only restricted to coastal areas but may extend to monsoon areas. To account for these potential instabilities, we explore the impact of different scenarios of abrupt partial Greenland ice sheet melting on Western African monsoon during the 21st century superimposed to RCP8, 5.

We will present the results of these freshwater housing experiments corresponding to a superimposed sea level rise varying from 0, 5 to 3m. We demonstrate that such a partial melting induces several consequences on the West African monsoon: duration, delay and a decreasing of the precipitation; similarly to what has already been shown for Heinrich Event (Mulitza, Paleoceanography 2008).

First, we investigate the agricultural impact of these abrupt climate changes on the very sensitive Sahel region. We quantify the agricultural area losses due to monsoon changes. Consequently, we pinpoint a large potential for migration of millions of people in the coming decades. Thus, the ice-sheet destabilization leads not only to costal damages, but also to a large population migration in monsoon area.

Secondly, the large changes of the hydrological cycle in tropical area may also provide favorable conditions for the spread of pathogens vectors. Using IPCC scenarios several studies have already shown the impact of climate changes as Malaria on extended areas (Caminade C, et al. PNAS, 2014). Here we explore the potential risk due to the major atmospheric tropical reorganization related with ice sheet destabilization.

Seasonality over southern Africa during the Last Glacial Maximum

Abstract ID : 1426

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Francois Engelbrecht ,FEngelbrecht@csir.co.za ,(None) ,South Africa , ,Not Presenting[1]

Dr. Francois Engelbrecht ,rnkoana@csir.co.za ,(None) ,South Africa , ,Not Presenting[1]

1 - CSIR/NRE 2 - CSIR/NRE

The Cape south coast of South Africa has a rich archaeological record of early occupation by modern humans, dating back to periods as long as 160k years ago. Coastal caves in the region provide evidence of human occupation even during periods of glacial maximums. This raises the question on whether the region was perhaps particularly habitable for humans, even during periods when the global climate was harsh. To gain more insight into Last Glacial Maximum (LGM) climate over the Cape south coast and the larger southern African, we describe the most detailed paleo climate downscaling experiment ever obtained for the region. The output of eight global simulations of LGM climate, obtained from coupled global climate models of the Coupled Model Intercomparison Project Phase Five (CMIP5) of the World Climate Research Programme (WCRP) were downscaled to 8 km resolution over the Cape South coast and adjacent regions, though a multiple nudging procedure. The dynamic climate model used to obtain these downscalings is the conformal-cubic atmospheric model (CCAM) of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia. CCAM was forced at its lower boundary with the sea-surface temperatures and sea-ice concentrations of the different CGCMs. Radiative forcing was consistent with that of the LGM: CO_2 concentrations of 180 ppm were used, with solar radiation estimated for the period 21k years ago. The simulations are indicative of a drastic northward displacement of westerly winds during the LGM. As a consequence, winter rainfall extended much further to the north, deep into the interior of southern Africa. It is projected that the Cape south coast region was significantly wetter compared to its present-day climate. Deeper into the interior, regions as far north as the present-day location of Pretoria are projected to have experienced a bimodal rainfall seasonality, with the summer rainfall peak supplemented by a significant winter rainfall peak. Our work demonstrates how climate model simulations can help to reconstruct the paleoscape for different periods in the past, whilst proxy records may be used simultaneously to test performance of the model under radiative forcings very different to that of the present-day.

HUMAN-ENVIRONMENT INTERACTION DURING THE MID-HOLOCENE IN EASTERN SOUTH AMERICA: REASSESSING THE "ARCHAIC GAP"

Abstract ID : 1510

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Astolfo Araujo ,astwolfo@usp.br ,(Lecturer) ,Brazil ,São Paulo ,Not Presenting[1]

1 - University of São Paulo

A decade ago, we suggested that the low frequency of archaeological sites dated from the mid-Holocene in several regions of Lowland South America (what we have called the "Archaic Gap") was due to an increase in the magnitude of dry periods. Since then, data regarding paleoenvironmental reconstructions for Lowland South America, coupled with an increase of the archaeological knowledge, allows us to reassess the idea of the "Archaic Gap" and redefine both the areal extent of the phenomenon and its possible causes. Our present analysis suggest that the extent of the areas that were somewhat depopulated during the mid-Holocene in Eastern South America are larger than previously thought; not only Central Brazil, but parts of the Amazon and the Pantanal (close to the Bolivian border) seem to show the same pattern. However, as expected, when larger datasets are available, it is possible to perceive oscilations in the archaeological signal that suggest reoccupation of some areas. Although we maintain that the main reasons underlying these patterns are still related to climate, they are most probably related to an increase in climatic variability, and not necessarily an increase in dryness. These observations are of interest for the current debate about the effects of the global warming in human populations.

M05 - Aerosol-cloud session

Measurements and Parameterization of Atmospheric Ice Nuclei in Different Background Regions in China

Abstract ID : 32

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yan Yin ,yinyan@nuist.edu.cn ,(Professor, Dean) ,China ,None ,Not Presenting[1]

Mr Hui Jiang ,13770863887@163.com ,(None) ,South Africa ,None ,Not Presenting[1]

Mr Kui Chen ,ch_k@163.com ,(None) ,South Africa ,None ,Not Presenting[1]

1 - Nanjing University of Information Science and Technology 2 - Nanjing University of Information Science and Technology 3 - Nanjing University of Information Science and Technology

The concentration of ice nuclei (IN) and the aerosol particles were measured under different conditions of air pollution in China. The difference of the IN concentration in different backgroud regions was analyzed, through comparison with the IN measurements obtained in Mts. Huangshan (a relatively clean mountainous site), Kuche (a desert region in Xinjiang, northwest China), and Nanjing. It is found that the concentrations of IN are the highest in the spring, followed by autumn, and the lowest is in the summer. This is possibly due to a greater abundance of soil dust particles in spring and autumn, while in summer more frequent rainfall could wash out a large number of IN. A comparison of the concentrations of IN at three different altitudes showed that the concentration of IN at the foot of the mountains was higher than at the peak, indicating that more aerosols near the ground cause high concentrations of IN.
Further analysis of the source of atmospheric ice nuclei found that high correlation was found between IN and aerosol particles with size larger than 0.5μm, indicating that the large aerosol particles contribute more to IN. Through the comparison with the IN measurements obtained in three different regions, it is found that the number concentration of IN in Nanjing is the highest, followed by that in Xinjiang (no-dust days), and the lowest on Mts. Huangshan. As for the proportionality of IN number concentration to aerosol particle concentration, it is the highest in Xinjiang and the lowest on Mts. Huangshan. In addition, some parameterizations were developed based on measurements to represent the variations of IN concentration with temperature, supersaturation, and the number concentration of aerosol particles with size larger than 0.5μm. They can be applied to the surface of the desert, the relatively clean background areas and the polluted city regions.

Size change of dust particles and their settling to the ocean influenced by sea salt and sulfate in marine near surface air

Abstract ID : 147

Conflict Declaration : None

Content Motivation : None

Additional Information : I hope this presentation could be accept as an oral presentation.

Dr. Daizhou Zhang ,dzzhang@pu-kumamoto.ac.jp ,(Professor) ,Japan ,Kumamoto ,Not Presenting[1]

Dr. Guangyu Shi ,shigy@mail.iap.ac.cn ,(None) ,China , ,Not Presenting[2]

Dr. Yasunobu Iwasaka ,iwasaka@mti.biglobe.ne.jp ,(None) ,Japan , ,Not Presenting[3]

1 - Prefectual University of Kumamoto 2 - Institute of Atmospheric Physics, Chinese Academy of Science 3 - University of Shiga Prefecture

Dust particles frequently become mixtures of mineral dust and salts such as sea salt, sulfate, and nitrate, during their transport in the marine boundary layer, consequently growing in size which causes changes in their settling velocities. In this study, the change of Asian dust particles caused by the occurrence of the salts on the particle surface was investigated. It was confirmed that the dust particles grew in size. The size increase of dust particles had a strong correlation with their sea salt content but was independent from their non-sea-salt sulfur content. This result suggests that the growth of dust particles in size during their dispersion in the marine atmosphere was dominated by the combination with sea salt rather than by other processes such as surface uptake of sulfate. Further investigation on the effects of the size growth on the gravitational settling of the particles showed that the adhering of sea salt to dust particles could dramatically increase the gravitational settling of the particles, in particular if the particles became larger than 3 or 4 um. Estimates with the observational data from six dust events in southwestern Japan revealed that, due to sea salt adhering, the gravitational settling flux of mineral dust increased approximately 14 ~ 17% in well-mixed events and 4 ~ 6% in less-mixed events, indicating a potential significant effect of sea salt on dust settling and the importance of considering this effect in the schemata of particle gravitational settling when mapping dust flux to the ocean.

The effective radiative forcing of partial internally and externally mixed aerosols and their effects on global climate

Abstract ID : 218

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Hua Zhang ,huazhang@cma.gov.cn ,(Professor) ,China ,Beijing ,Not Presenting[1]

1 - National Climate Center, CMA, China

The total effective radiative forcing (ERF) due to partial internally mixed (PIM) and externally mixed (EM) anthropogenic aerosols, as well as their climatic effects since the year of 1850, were evaluated and compared using the aerosol-climate online coupled model of BCC_AGCM2.0_CUACE/Aero. The influences of internal mixing (IM) on aerosol hygroscopicity parameter, optical properties, and concentration were considered. Generally, IM could markedly weaken the negative ERF and cooling effects of anthropogenic aerosols. The global annual mean ERF of EM anthropogenic aerosols from 1850 to 2010 was -1.87 W m-2, of which the aerosol-radiation interactive ERF (ERFari) and aerosol-cloud interactive ERF (ERFaci) were -0.49 and -1.38 W m−2, respectively. The global annual mean ERF due to PIM anthropogenic aerosols from 1850 to 2010 was -1.23 W m-2, with ERFari and ERFaci of -0.23 and -1.01 W m−2, respectively. The global annual mean surface temperature and water evaporation and precipitation were reduced by 1.74 K and 0.14 mm day-1 for EM scheme, and 1.28 K and 0.11 mm day-1 for PIM scheme, respectively. However, the relative humidity near the surface was slightly increased for both mixing cases. The intertropical convergence zone (ITCZ) was southwardly shifted for both EM and PIM cases, but was less southwardly shifted in PIM scheme due to the less reduction in atmospheric temperature in the mid and low latitudes of the Northern Hemisphere.

How often are biomass burning aerosols mixing into the Namibian stratocumulus deck? Initial results from year 1 of the ORACLES field campaign.

Abstract ID : 281

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Michael Diamond ,diamond2@uw.edu ,(Graduate Student) ,United States ,Seattle ,Not Presenting[1]

Mr. Rob Wood ,robwood2@uw.edu ,(None) ,United States , ,Not Presenting[1]

1 - University of Washington, Department of Atmospheric Sciences 2 - University of Washington, Department of Atmospheric Sciences

The world's subtropical marine stratocumulus (Sc) decks play an important role setting Earth's albedo, and thus cooling Earth's climate. Of particular importance are the three semi-permanent Sc decks (Californian, Peruvian, and Namibian), in which stratiform low cloud fraction never falls much below 50%. Smoke produced from widespread biomass burning (BB) across south and central Africa can influence the effective radiative forcing (ERF) over the southeast Atlantic (SEA), including the Namibian Sc deck, through both aerosol-radiation and aerosol-cloud interactions and concomitant cloud adjustments.
Large eddy simulation (LES) studies suggest that the net impact of the smoke above clouds in the SEA region is cooling, in large part due to aerosol-cloud interactions. When the smoke and cloud layers are not in direct contact, these studies show the net effect of the BB aerosol is warming. Persistent clear slots, or "gaps," between cloud and smoke layers in the SEA region have been identified from observations; however, there is reason to believe that current cloud-smoke contact frequency estimates from satellites are too low due to signal attenuation from thick smoke plumes. The extent of mixing of biomass burning aerosol into the Namibian stratocumulus cloud deck remains poorly constrained, despite its importance for the magnitude and sign of the regional ERF.
Initial results from the ObseRvations of Aerosols above CLouds and their intEractionS (ORACLES) NASA Earth Venture suborbital campaign, based out of southern Africa, show that although there are many cases of very clear separation between the smoke and cloud layers, there is also evidence that aerosol is indeed reaching the clouds tops, perhaps more frequently than satellite measurements suggest.
Before being able to quantify the effective radiative forcing of BB aerosols in the SEA region, therefore, it is necessary first to assess the extent of mixing of BB aerosol into the Sc deck. This will require a better understanding of both the horizontal and vertical smoke transport pathways over the SEA.
Using the first year of ORACLES field data, satellite imagery, and trajectory analyses, I will address the temporal and spatial extent of smoke-cloud mixing and the transport pathways that lead to mixing.

Aerosol/Cloud interactions and the effects on droplet size distribution, the onset of coalescence and ice processes in convective clouds

Abstract ID : 398

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Roelof Bruintjes ,roelof@ucar.edu ,(Project Scientist) ,United States ,Westminster, CO ,Not Presenting[1]

1 - NCAR

It is clear that aerosols contribute to the observed differences in cloud droplet size distributions between maritime and continental and between non-polluted and polluted convection. In addition, other factors such as cloud base temperature, boundary layer depth, thermodynamic profile (updraft speeds) that vary between land and ocean regions, could also be contributing to the observed differences or acting in concert with aerosol effects. In addition, the initial cloud droplet spectra at cloud base to a large extent determines the microphysical processes of precipitation formation (water and ice) at higher levels in the clouds and thus the vertical transport of aerosols and gases in deep convective clouds. During the 2013 NASA SEAC^{4}RS field campaign we have collected a large amount of microphysical data in both shallow and deep convective clouds. This data is compared to data from other field campaigns to detect specific characteristics of the cloud base droplet size distribution and relate it to onset and evolution of the coalescence process and ice processes in clouds. The presentation will provide a survey of the cloud droplet size distributions at cloud base in both shallow and deep convective clouds and will relate them to environmental parameters to better understand aerosol-cloud interactions and the other parameters that play a role in the onset of coalescence in convective clouds. We will relate the airborne aerosol variations (size and concentration in different environments) to the cloud droplet size distribution. Model simulations using a detailed coalescence model will be used to obtain a better understanding of the onset of the coalescence and ice proceses in convective clouds.

In-Cloud Electric Charge Modulated Scavenging Affecting Contact and Immersion Ice Nucleation: Parameterized Simulations for Modelling Observed Responses

Abstract ID : 402

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Brian Tinsley ,Tinsley@UTDallas.edu ,(Professor Emeritus) ,United States ,Richardson ,Not Presenting[1]

1 - University of Texas at Dallas

The discrepancy between observed rates of production of ice in mixed phase clouds and the rates calculated from observed concentrations of ice-forming nuclei concentrations has been a puzzle since Hobbs and Rangno pointed it out in 1985. Contact and immersion ice nucleation rates from standard microphysical schemes, especially for updrafts, are not great enough, since the net non-electric phoretic forces are repulsive for condensing droplets. However, the electrical forces between droplets and particles, with even weak electrification in clouds, can significantly increase or decrease collision and scavenging rates for particles that can act as contact and immersion nuclei. Atmospheric ionization is ubiquitous, forming bipolar (i.e., of both signs) charged nuclei within clouds due to cosmic ray influx, and largely unipolar charged nuclei at cloud boundaries due to the flow of current in the global electric circuit. Effects of electric charge on scavenging of nuclei were explored by Pruppacher and his students, and now with much faster computers we have constructed a trajectory model that yields rates of nuclei-droplet collisions, as they are modulated by electric charges, thermo-phoretic and diffusio-phoretic forces, particle weight and flow fields. We use a Monte-Carlo simulation of diffusion along the collisional trajectories, for relative humidities from 80% to 102% a wide range of particle and droplet charges and sizes and particle densities. For larger nuclei, electro-scavenging caused by image forces increases the collection rates nearly irrespectively of charge sign. For smaller nuclei, electro-scavenging by Coulomb forces for opposite sign charges on droplets and particles can increase collision rates, while electro-anti-scavenging for Coulomb forces in unipolar environments (same sign charges) can decreases the rate of collection.
We summarize the results of simulations of these electrically modified collision rates affecting contact ice nucleation and immersion nucleation and parameterizations of the results suitable for use in cloud models.

Linear depolarization ratio of varied ice crystal habits: lessons from laboratory measurements and Ray Tracing simulations

Abstract ID : 441

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Ann Webb ,ann.webb@manchester.ac.uk ,(Professor) ,United Kingdom ,Manchester ,Not Presenting[1]

Dr. Helen Smith ,h.smith20@herts.ac.uk ,(Instrument Scientist) ,United Kingdom ,Hatfield ,Not Presenting[2]

Dr. Paul Connolly ,p.connolly@manchester.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Anthony Baran ,anthony.baran@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[4]

1 - University of Manchester 2 - University of Hertfordshire 3 - University of Manchester 4 - Meteorological Office

Ice clouds can have either a positive or negative effect on net radiative forcing, and as such represent one of the largest uncertainties in prediction of climate change. The magnitude and direction of this forcing by cirrus is highly dependent on the microphysical properties of the ice particles forming the cloud. The interaction of cloud particles with radiation is also fundamental to the interrogation of the clouds by remote sensing, either from above or below, as is our ability to model the processes and hence interpret backscattered signals. Ice clouds were generated in the Manchester Ice Cloud Chamber (MICC), and the backscattering linear depolarization ratio (LDR) measured for a variety of habits. Particular morphologies were created by varying the humidity in the chamber throughout each experiment, resulting in a range of habits from the pristine to the complex. Repeating the process at three temperatures: -7^{o}C, -15^{o}C and -30^{o}C produced both solid and hollow columns, plates, sectored plates and dendrites. A linearly polarized 532nm continuous wave diode laser was directed through a section of the cloud using a non-polarizing 50:50 beam splitter. Measurements of the scattered light were taken at 178^{o}, 179^{o} and 180^{o} using a Glan-Taylor prism to separate the co- and cross-polarized components. The scattered intensities of the two components were measured with two amplified photodetectors, to give the linear depolarization ratio (LDR). Three particle models with variable dimensions were able to represent a wide range of crystal morphologies seen in the MICC, and these were used with a ray tracing model to determine the LDR for different ice particles at 532 nm and in close proximity to exact backscatter. In general, Ray Tracing overpredicted LDR, particularly for pristine solid hexagons. However, by creating particle models with internal structures that were more representative of those observed in experimental conditions the discrepancies between model and measurements were reduced.

Balloon-borne measurements of aerosol size distributions using the Universal Cloud and Aerosol Sounding System (UCASS) during the ICE-D campaign

Abstract ID : 525

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Helen Smith ,h.smith20@herts.ac.uk ,(Instrument Scientist) ,United Kingdom ,Hatfield ,Not Presenting[1]

Prof. Joseph Ulanowski ,z.ulanowski@herts.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Paul Kaye ,p.h.kaye@herts.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Edwin Hirst ,e.hirst@herts.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Warren Stanley ,w.stanley@herts.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Hertfordshire 2 - University of Hertfordshire 3 - University of Hertfordshire 4 - University of Hertfordshire 5 - University of Hertfordshire

This presentation discusses balloon borne measurements of particle concentrations and size distributions made during the Ice in Clouds Experiment - Dust (ICE-D) campaign, based in Cape Verde , August 2015. The main aim of the ICE-D campaign was to study the impact of desert dust on the primary nucleation of ice particles in clouds and the subsequent development of precipitation and glaciation. The project utilized both ground based and aircraft based instrumentation to characterize aerosol and cloud particles in and around clouds. In addition to aircraft based instrumentation, in situ data were gathered from balloon-borne instrumentation launched from Instituto Nacional de Meteorologia e Geofisica (INMG), located on Sal island, Cape Verde. Each payload consisted of a Graw DFM-09 meteorological sonde, in tandem with a Universal Cloud and Aerosol Sounding System (UCASS). The UCASS is an open path optical particle counter, which sizes particles on the basis of elastic light scattering. Soundings were conducted coincident to nearby SAVEX flights, or synchronised with the on-site sun photometer almucantar scans. Comparisons show good agreement between the UCASS data and the aircraft mounted instrumentation including the PCASP and CDP. Comparisons are also made to AERONET sun photometer retrievals, where there is close agreement for smaller particle sizes, but in the course mode, retrievals show lower concentrations compared with UCASS data.

he ground-based observation of aerosol optical properties from the China Aerosol Remote Sensing Network (CARSNET)

Abstract ID : 563

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Huizheng CHE ,chehz@camscma.cn ,(Professor) ,China ,Beijing ,Not Presenting[1]

1 - Chinese Academy of Meteorological Sciences

Long-term measurements of aerosol optical depths (AOD) and Angstrom exponents (Alpha) made for CARSNET were compiled into a climatology of aerosol optical properties for China. Quality-assured monthly mean AODs are presented for 50 sites representing remote, rural, and urban areas. AODs were 0.14, 0.34, 0.42, 0.54, and 0.74 at remote stations, rural/desert regions, the Loess Plateau, central and eastern China, and urban sites, respectively, and the corresponding Alpha values were 0.97, 0.55, 0.82, 1.19, and 1.05. AODs increased from north to south, with low values (< 0.20) over the Tibetan Plateau and northwestern China and high AODs (> 0.60) in central and eastern China where industrial emissions and anthropogenic activities were likely sources. AODs were 0.20−0.40 in semi-arid and arid regions and some background areas in north and northeast China. Alphas were > 1.20 over the southern reaches of the Yangtze River and at clean sites in northeastern China. In the northwestern deserts and industrial parts of northeast China, Alphas were lower (< 0.80) compared with central and eastern regions. Dust events in spring, hygroscopic particle growth during summer, and biomass burning contribute the high AODs, especially in northern and eastern China. The AODs show decreasing trends from 2006 to 2009 but increased ~0.03 per year from 2009 to 2013.

Effects of Entrainment-Mixing Processes on Relative Dispersions of Cloud Droplet Size Distributions

Abstract ID : 569

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Chunsong Lu ,luchunsong110@gmail.com ,(None) ,China ,Nanjing ,Not Presenting[1]

Mr. Yangang Liu ,lyg@bnl.gov ,(None) ,United States , ,Not Presenting[2]

Mr. Shengjie Niu ,niusj@nuist.edu.cn ,(None) ,China , ,Not Presenting[1]

Mr. Xiaohao Guo ,824808991@qq.com ,(None) ,China , ,Not Presenting[1]

1 - Nanjing University of Information Science and Technology 2 - Brookhaven National Laboratory 3 - Nanjing University of Information Science and Technology 4 - Nanjing University of Information Science and Technology

Aerosol affects cloud droplet number concentration and also relative dispersion of cloud droplet size distribution. Actually, relative dispersion is also affected by entrainment-mixing processes. In this study, the effects of entrainment-mixing processes on relative dispersions are examined by observational data and numerical simulations. Shallow cumulus clouds were observed during the Routine AAF [Atmospheric Radiation Measurement (ARM) Aerial Facility] Clouds with Low Optical Water Depths (CLOWD) Optical Radiative Observations (RACORO) field campaign over the ARM Southern Great Plains (SGP) site near Lamont, Oklahoma, US. Deep cumulus clouds were observed during the Tropical Ocean Global Atmosphere Coupled Ocean Atmosphere Response Experiment (TOGA-COARE) field campaign over the western Pacific. Relative dispersion is found to be positively correlated with entrainment rate in shallow cumulus clouds, but generally negatively correlated with entrainment rate in deep cumulus clouds, although homogeneous mixing is found to be dominant in both types of clouds. Further analysis shows that small droplet number concentration is a key factor determining the sign of correlation. The effects of homogeneous/inhomogeneous entrainment-mixing mechanisms on the relative distributions are further studied using the Explicit Mixing Parcel Model (EMPM). It is found that relative dispersion is positively correlated with homogeneous mixing degree for small relative humidity (RH) in the entrained dry air. However, as RH increases to some certain value, the correlation changes from positive to negative. This phenomenon is related to dissipation rate. For low RH, higher dissipation rate (more homogeneous mixing) keeps more small droplets, i.e., tending to have bigger relative dispersion. For high RH, the subadiabatic clouds are close to adiabatic clouds, and higher dissipation rate (more homogeneous mixing) causes smaller relative dispersion due to more homogeneous distribution of water vapor and temperature felt by each droplet. The results are important for improving understanding of aerosol-cloud interactions and aerosol indirect effects.

Simulation of the Ice Nuclei Particles (INP) concentration observed over the Canadian Arctic during the summers of 2014 and 2016.

Abstract ID : 679

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Eric Girard ,girard.eric@uqam.ca ,(Professor) ,Canada ,Montreal ,Presenting[1]

Dr. Ana Cirisan ,cirisan@sca.uqam.ca ,(None) ,Canada , ,Not Presenting[2]

Prof. Allan Bertram ,bertram@chem.ubc.ca ,(None) ,Canada , ,Not Presenting[3]

Ms. Vickie Irish ,vickieirish3450@gmail.com ,(None) ,Canada , ,Not Presenting[3]

Dr. Jean-Christophe Raut ,Jean-Christophe.Raut@latmos.ipsl.fr ,(None) ,France , ,Not Presenting[5]

Dr. Jacques Pelon ,jacques.pelon@latmos.ipsl.fr ,(None) ,France , ,Not Presenting[6]

1 - University of Quebec at Montreal 2 - UQAM 3 - University of British Columbia 4 - University of British Columbia 5 - LATMOS-UPMC 6 - LATMOS - UPMC

Cloud microstructure is strongly linked to the aerosols and their ability to nucleate liquid water (CCN) or ice (INP). Cloud phase is mostly determined by the aerosol thermodynamics properties. It is therefore important to understand these aerosol-cloud interactions since they determine cloud phase and cloud radiative forcing. In this study, the Weather and Research Forecasting Model coupled with chemistry (WRF-CHEM) is used to simulate the INP concentration observed during the NETCARE field experiments (Network on Climate and Aerosols Addressing Key Uncertainties in Remote Canadian Environments) that took place over the Canadian Arctic during the summers of 2014 and 2016. WRF-CHEM simulates several gases and particle matters relevant for ice nucleation. Using this information combined to parameterizations based on field and laboratory studies, it is shown that the model generally simulates within a factor 5 the observed INP concentration depending on the ice nucleation parameterization used. It is also shown that large particles are the main contributor to the INP concentration. The contribution of other (smaller) particles, although in much higher concentration, is negligible. The INP concentration is particularly sensitive to the mean particle diameter suggesting that a bin scheme for the simulation of the aerosol size distribution (such as the one used in WRF-CHEM) is needed to get more realistic INP values.

Effects of the surface heat flux on the cloud development and behavior over the Tibetan Plateau in boreal summer

Abstract ID : 764

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jinghua Chen ,chenjh1213@163.com ,(Lecturer) ,China ,Nanjing ,Not Presenting[1]

Dr. Yan Yin ,yinyan@nuist.edu.cn ,(Professor, Dean) ,China ,None ,Not Presenting[1]

1 - Nanjing University of Information Science and Technology 2 - Nanjing University of Information Science and Technology

The influence of the surface heat fluxes on the generation and development of the cloud and precipitation and its relative importance with the large-scale circulation patterns is investigated via the Cloud-Resolving Model (CRM) simulations and the diagnostic approach over the Tibetan Plateau (TP) in boreal summer. The diagnostic results show that the precipitation shows a positive relationship with the apparent heat over the Eastern TP (ETP), which is similar to the Eastern China. However, this relationship is negative over the Western TP (WTP), which is mainly caused by the different characteristics of the surface heat fluxes. Simulation results show that the heavy rainfall is mainly controlled by the dynamical and thermal properties of the atmosphere while the surface heat fluxes impose weak influence on the heavy rainfall process (e.g., the Middle and Low reaches of Yangtze River). However, the surface thermal driving force is a necessary factor for the heavy rainfall in the ETP and WTP. The warm and ice cloud processes are substantially restricted when the surface heat fluxes are weakened. As a consequence, the heavy rainfall cannot be aroused under this situation. Over the ETP, the deep cloud can be triggered by the intensive surface thermal driving due to its relative abundant moisture, leading to precipitation process. Over the WTP, the heavy rainfall evens are closely related to both the strong surface heat fluxes and the moisture which is transported from the southern tropical ocean. In addition, the surface heating effects take the main responsibility for the high frequent convections in the afternoon and the cloud top of convections shows a positive relationship with the intensity of the surface heat fluxes. Except the convections in the afternoon, the convections show a second-high incidence in the evening, which is mostly related to the large-scale circulation.

Aircraft measurements of aerosol spatial distribution and relation with cloud over Eastern China

Abstract ID : 765

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jian Hao ,haojiannuist@163.com ,(None) ,China ,Nanjing ,Not Presenting[1]

Dr. Yan Yin ,yinyan@nuist.edu.cn ,(Professor, Dean) ,China ,None ,Not Presenting[2]

1 - None 2 - Nanjing University of Information Science and Technology

To investigate the spectral and spatial distribution characteristics of aerosol particles over Eastern China, a set of aircraft measurements were conducted during 12-28 August, 2014 over Anhui Province, China. The aerosol number concentration and size distributions from 5 flights together with cloud and meteorological parameters were analyzed. The average number concentration of aerosol particles in the size range of 0.1-3.0 μm in Anhui Province was 481±199 cm^{-3}, accumulation mode particles accounted for more than 95% of total aerosol particles. The majority of the aerosol particles was concentrated in the layer below 1000 m and the number concentration decreased with altitude, except in the presence of thermal inversion layers (TILs). The TILs prevented vertical transport of aerosol, and led to higher number concentration in the whole boundary layer. A large fraction of aerosol particles was removed when clouds were present, and the removed in-cloud aerosols lead to increament of cloud droplet concentrations ranged in 3.5-10.0 μm. The results are valuable for understanding the spatial distribution of aerosol particles and the interactions with clouds.

Parameterizations of ice formation in tropospheric clouds based on AIDA experiments

Abstract ID : 771

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ottmar MÖHLER ,ottmar.moehler@kit.edu ,(None) ,Germany ,76021 Karlsruhe ,Not Presenting[1]

Dr. Romy Ullrich ,romy.ullrich@kit.edu ,(None) ,Germany , ,Not Presenting[1]

Mrs. Franziska Vogel ,franziskabarbaravogel@web.de ,(None) ,Germany , ,Not Presenting[1]

Mrs. Thea Schiebel ,thea.schiebel@kit.edu ,(None) ,Germany , ,Not Presenting[1]

Dr. Kristina Höhler ,kristina.hoehler@kit.edu ,(None) ,Germany , ,Not Presenting[1]

Dr. Isabelle Steinke ,isabelle.steinke@kit.edu ,(Postdoctoral fellow) ,Germany ,Karlsruhe ,Not Presenting[6]

Dr. Robert Wagner ,robert.wagner2@kit.edu ,(None) ,Germany , ,Not Presenting[1]

Dr. Corinna Hoose ,corinna.hoose@kit.edu ,(None) ,Germany ,Karlsruhe ,Not Presenting[1]

1 - KARLSRUHE INSTITUTE OF TECHNOLOGY 2 - KARLSRUHE INSTITUTE OF TECHNOLOGY 3 - KARLSRUHE INSTITUTE OF TECHNOLOGY 4 - KARLSRUHE INSTITUTE OF TECHNOLOGY 5 - KARLSRUHE INSTITUTE OF TECHNOLOGY 6 - Karlsruhe Institute of Technology 7 - KARLSRUHE INSTITUTE OF TECHNOLOGY 8 - KARLSRUHE INSTITUTE OF TECHNOLOGY

The life cycles and radiative properties of tropospheric mixed-phase and cirrus clouds are largely influenced by primary ice formation processes induced by ice nucleating particles (INPs), a very minor subset of atmospheric aerosols. Therefore, the abundance of INPs must be known in order to properly formulate their impact on e.g. the initiation of precipitation in mixed-phase clouds or the balance between radiative cooling and heating of cirrus clouds.
The INP abundance can either directly be measured in the atmosphere with respective mobile instruments, or can be inferred from parameterizations formulated as function of temperature, relative humidity and aerosol properties. The ice nucleation properties of e.g. desert dust, fertile soil dust, or soot aerosols in the immersion freezing and deposition nucleation modes were investigated in AIDA (Aerosol Interaction and Dynamics in the Atmosphere) cloud expansion experiments. Based on these experiment series conducted in a wide range of temperature and relative humidity, the primary ice formation by the various aerosols was parameterized in terms of the ice nucleation active site (INAS) density concept. This contribution gives an overview of the respective AIDA experiments, discusses the INAS density results for immersion freezing and deposition nucleation, and shows first model applications of the new parameterization framework.

Modelling of water isotope ratios in a 1.5D bin-resolved cloud microphysics model

Abstract ID : 909

Conflict Declaration : None

Content Motivation : None

Additional Information : obviously oral preferred

Prof. Andrea Flossmann ,andrea.flossmann@uca.fr ,(Prof. Dr.) ,France ,Aubière ,Presenting[1]

Mr. Wolfram Wobrock ,w.wobrock@uca.fr ,(None) ,France , ,Not Presenting[1]

1 - UCA 2 - UCA

Modelling of water isotopes is commonly used in climate models to validate the models with respect to past climate variations documented in ice core histories.
However, the study of the evolution of water isotope ratios in clouds provides also a powerful tool for cloud modelling since it archives the cloud's history of phase changes. During each phase change, the water molecules holding an 18O atom instead of the more common 16O atoms favour the condensed state, with an additional preference for the solid phase. A fractionation happens, thus, at every phase change, charging the condensed phase with the heavier water molecules.
Bin microphysics models, in contrast to most bulk models, predict explicitly supersaturation and allow for a finer calculation of liquid and solid condensation/evaporation rates than via a saturation adjustment. Thus, they allow calculating a time dependent variation of the heavy isotopes as a function of the drop and crystal size, as well as humidity fields.
A 1.5D cloud dynamics will be used to evaluate the impact of this sophisticated calculation of the isotope ratios and compare them with the equilibrium approaches so far used in most climate models. Different ice formation parameterizations (heterogeneous and homogeneous) and different aerosol particle spectra serving as CCN and IN will be used to study their possible impact on isotope ratio evolution and distribution.
The discrepancies will be studied and the potential of this method to determine the importance of certain ice nucleation processes as well as the region of origin of water vapour mass will be assessed.
This work is part of the ANR-AC-AHC2 project that aims to improve our understanding of the warming of the polar regions by quantifying the atmospheric moisture transport to the arctic and discriminating between local sources and long distance moisture transport, as well as in-cloud processes.

Cloud processing of aerosol particles in marine stratocumulus clouds

Abstract ID : 910

Conflict Declaration : None

Content Motivation : please move to M05 if considered out of scope for M06

Additional Information : obviously oral preferred

Prof. Andrea Flossmann ,andrea.flossmann@uca.fr ,(Prof. Dr.) ,France ,Aubière ,Presenting[1]

Mr. Wolfram Wobrock ,w.wobrock@uca.fr ,(None) ,France , ,Not Presenting[1]

1 - UCA 2 - UCA

A marine stratocumulus cloud, as studied during the VOCALS campaign will be simulated using the 3D non-hydrostatic model of Clark and Hall (1991) coupled to the bin resolved cloud microphysics and scavenging Model DESCAM (Leroy et al., 2009; Flossmann and Wobrock, 2010).
The cloud forms on a typical marine aerosol particle distribution. The evolution of the cloud and development of drizzle size droplets is observed.
In order to be able to quantify the amount of processing during the cloud event, we have extended our bin resolved microphysics model to fully consider two types of aerosol particle spectra (Flossmann and Wobrock, 2010). The first type holds the initial particle spectrum on which the cloud forms. The second type is initially empty and is only activated once a steady state stratocumulus deck has developed. Then, the second type of particles is opened and fills up only by deactivated and cloud-processed particles.
These particles will then be transported in the same way as the initial particles and can serve again as CCN in a new cloud cycle. Inside cloud, these processed particles will also be traced separately. This technique allows a rather complete picture of the cloud processing of aerosol particles by a marine stratocumulus cloud, and it become evident that the processed particles affect the entire marine boundary layer, until dominating over the pristine particles. The associated time scales will be studied.
In a second set of simulations, a pollution line potentially from a ship exhaust, will provide a second type of aerosol particles. Their incorporation into clouds and their subsequent dispersion in the marine boundary layer will be studied.
This approach will allow quantifying for the first time the extension of particle processing via marine boundary layer clouds.

Land versus ocean production of ice nucleating particles and potential for cold cloud influences

Abstract ID : 972

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Paul DeMott ,Paul.Demott@colostate.edu ,(Senior Research Scientist) ,United States ,Fort Collins ,Presenting[1]

Ms. Christina McCluskey ,mccluscs@atmos.colostate.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Thomas Hill ,Thomas.Hill@colostate.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Kaitlyn Suski ,kaitlyn.suski@pnnl.gov ,(None) ,United States , ,Not Presenting[4]

Dr. Ezra Levin ,elevin@atmos.colostate.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Sonia Kreidenweis ,soniak@colostate.edu ,(None) ,United States , ,Not Presenting[1]

Ms. Anna Miller ,anmiller@reed.edu ,(None) ,United States , ,Not Presenting[7]

Dr. Alain Protat ,alain.protat@bom.gov.au ,(None) ,Australia , ,Not Presenting[8]

Dr. Ruhi Humphries ,Ruhi.Humphries@csiro.au ,(None) ,Australia , ,Not Presenting[9]

Dr. Melita Keywood ,Melita.Keywood@csiro.au ,(None) ,Australia ,Canberra ,Not Presenting[9]

Dr. Michael Harvey ,Mike.Harvey@niwa.co.nz ,(None) ,New Zealand , ,Not Presenting[11]

Ms. Charlotte Beall ,cbeall@ucsd.edu ,(None) ,United States , ,Not Presenting[12]

Dr. Kim Prather ,kprather@ucsd.edu ,(None) ,United States , ,Not Presenting[12]

Mr. Jesus Vergara-Temprado ,eejvt@leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[14]

Dr. Ken Carslaw ,K.S.Carslaw@leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[14]

Dr. Benjamin Murray ,B.J.Murray@leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[14]

Dr. Jurgita Ovadnevaite ,jurgita.ovadnevaite@nuigalway.ie ,(None) ,Ireland , ,Not Presenting[17]

Dr. Colin O'Dowd ,colin.odowd@nuigalway.ie ,(None) ,Ireland , ,Not Presenting[17]

1 - Colorado State University 2 - Colorado State University 3 - Colorado State University 4 - Pacific Northwest National Laboratory 5 - Colorado State University 6 - Colorado State University 7 - Reed College 8 - Bureau of Meteorology 9 - CSIRO 10 - CSIRO 11 - NIWA 12 - University of California, San Diego 13 - University of California, San Diego 14 - University of Leeds 15 - University of Leeds 16 - University of Leeds 17 - National University of Ireland Galway 18 - National University of Ireland Galway

Aerosol-cloud interactions involving the ice phase remain as poorly explored phenomena. As capabilities improve for realistic inclusion of aerosol impacts on mixed-phase and ice clouds in climate

models, considerations given to sources of particles impacting ice nucleation and results from recent laboratory and field measurements suggest regions where the signal of aerosol impacts should be apparent and where an influence on the radiation balance may be realized. In particular, it has been confirmed recently that ice nucleating particle (INP) emissions from land are higher than from the ocean, and that these two populations are distinct in composition and behavior. The consequence is an expectation that the microphysical and radiative properties of mixed-phase clouds topping the boundary layer over remote ocean regions should be different and require aerosol-aware treatment in order to be captured properly by climate models. This expectation leads to a hypothesis that a major source of the inability of global climate models to properly capture the surface energy budget over higher latitude Southern Ocean regions, ostensibly due to a failure to capture the extent and persistence of lower and mid-level supercooled clouds, is microphysical in origin due to INP aerosol differences that are not accounted for in present simulations.

We will review evidence for land versus oceanic boundary layer contrasts of INP number concentrations present in measurements made of aerosols and rainwater from various locales, discuss recent global aerosol and regional cloud model simulations that support a role of such emissions contrasts, note that emissions of INPs are not only controlled by desert emissions of inorganic mineral dusts but by biologically-mediated populations from land and ocean that are not yet fully reflected in aerosol models, and briefly discuss the complex aerosol and cloud process scenario present over Southern Ocean regions that will be subject of upcoming investigations (Southern Ocean Clouds, Radiation, Aerosol Transport Experimental Study) to prove or disprove possible aerosol control on cloud phase and radiative transfer.

The interaction between aerosol particles, cloud and precipitation during the HyMeX IOP7a event

Abstract ID : 1023

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Wolfram Wobrock ,w.wobrock@opgc.univ-bpclermont.fr ,(Professor) ,France ,Aubière ,Presenting[1]

Mrs. Christina Kagkara ,C.Kagkara@opgc.univ-bpclermont.fr ,(None) ,France , ,Not Presenting[2]

Mrs. Céline Planche ,C.Planche@opgc.univ-bpclermont.fr ,(None) ,France , ,Not Presenting[2]

Prof. Andrea Flossmann ,andrea.flossmann@uca.fr ,(Prof. Dr.) ,France ,Aubière ,Not Presenting[1]

1 - UCA 2 - Laboratoire de Météorologie-Physique 3 - Laboratoire de Météorologie-Physique 4 - UCA

The ANR-MUSIC project (MUltiscale process Studies of Intense Convective precipitation events in Mediterranean) aims to identify critical parameters to improve the forecast of intense convective precipitation events in the Mediterranean. In the current study the aerosols-cloud-precipitation interactions are being investigated. For this purpose, the HyMeX (HYdrological cycle in Mediterranean EXperiment) IOP7a, heavy precipitation event (26th September 2012), that occurred during the Special Observation Period 1 (SOP1) in the Cévennes-Vivarais region in the South of France has been selected to assess in particular the role of the aerosol particles on cloud and precipitation development and quantity. Observations from the 95GHz cloud radar RASTA, as well as in-situ measurements obtained by the combination of two particle imagers (2-D stereo and precipitation) probes on-board of the French Falcon 20 aircraft are exploited in order to evaluate quantitatively the respective simulation results from the 3-D mesoscale model DESCAM (Flossmann and Wobrock, 2010). This research model uses bin resolved microphysics and a detailed representation of the aerosol particles as well as multiple staggered grids. Ground observations from X band radar and rain gauges were also incorporated into the comparison. Different scenarios concerning the initial number concentration of aerosol particles are being compared and discussed, in relation to the formation, structure and evolution of the convective system. According to the results, the rain accumulation at the ground is significantly depended on the total number of aerosol particles at the beginning of each simulation. The spatial and temporal distributions of the rainfall, as well as its amount vary between the different study cases.

Climate impact of anthropogenic aerosols on cirrus clouds

Abstract ID : 1137

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Joyce Penner ,penner@umich.edu ,(Professor) ,United States ,Ann Arbor ,Not Presenting[1]

1 - University of Michigan

Cirrus clouds have a net warming effect on the atmosphere and cover about 30% of the Earth's area. Aerosol particles initiate ice formation in the upper troposphere through modes of action that include homogeneous freezing of solution droplets, heterogeneous nucleation on solid particles immersed in a solution, and deposition nucleation of vapor onto solid particles. However, the efficacy with which particles act to form cirrus particles in a model depends on the representation of updrafts. Here, we use a representation of updrafts based on observations of gravity waves, and follow ice formation/evaporation during both updrafts and downdrafts. We examine the possible change in ice number concentration from anthropogenic soot originating from surface sources of fossil fuel and biomass burning, from anthropogenic sulfate aerosols, and from aircraft particles that have previously formed ice in contrails. Initial results (for 5 years of simulation) show that fossil fuel and biomass burning soot aerosols with this version exert a radiative forcing of $-0.02\ Wm^{-2}$ while aircraft aerosols exert a forcing of $0.17\ Wm^{-2}$. The magnitude of the forcing in cirrus clouds can be comparable to the forcing exerted by anthropogenic aerosols on warm clouds, but of opposite sign. This assessment could therefore support large negative forcings in warm phase clouds, as seen in some satellite observations, while still allowing climate models to fit the overall historical temperature change.

Microphysical and dynamical signatures in cloud-top phase distributions of deep convective clouds

Abstract ID : 1154

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Corinna Hoose ,corinna.hoose@kit.edu ,(None) ,Germany ,Karlsruhe ,Presenting[1]

Dr. Christian Barthlott ,mail2@here.com ,(None) ,Germany , ,Not Presenting[2]

Mr. Markus Karrer ,mail3@here.com ,(None) ,Germany , ,Not Presenting[2]

Ms. Constanze Wellmann ,mail4@here.com ,(None) ,Germany , ,Not Presenting[2]

1 - KARLSRUHE INSTITUTE OF TECHNOLOGY 2 - Karlsruhe Institute of Technology 3 - Karlsruhe Institute of Technology 4 - Karlsruhe Institute of Technology

While aerosols as ice nucleating particles are crucial for initiating ice formation in the temperature range between 0 and -40°C, it is unclear how this translates into an aerosol-related impact on the thermodynamic phase of the cloud, which results from a combination of microphysical processes following the primary ice formation, such as ice multiplication, depositional growth, and vertical redistribution. In particular, cloud phase observations from passive satellite sensors, while providing a high spatial coverage and long time series, can only give information on the uppermost layers of a cloud. Here, we have used idealized and semi-idealized simulations with a large-eddy model to study the liquid/ice partitioning within the cloud and at cloud top for an evolving deep convective cloud. In general, we find that the in-cloud and cloud-top phase distributions are qualitatively similar and exhibit similar sensitivities to microphysical processes. However, we show that at a given temperature, the simulated average ice mass fraction is higher at cloud top than within the cloud. This is due to the suppression of the Wegener-Bergeron-Findeisen process in strong updrafts. Furthermore, we investigate and quantify the sensitivity of the cloud-top phase distribution to the concentrations of heterogeneous ice nuclei and to secondary ice formation processes.

Changes in deep convective cloud properties due to forest fire aerosols in the summer of 2012

Abstract ID : 1166

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Azusa Takeishi ,azusa.takeishi@yale.edu ,(Ph.D. candidate) ,United States ,New Haven ,Not Presenting[1]

Prof. Trude Storelvmo ,trude.storelvmo@yale.edu ,(None) ,United States , ,Not Presenting[1]

1 - Yale University 2 - Yale University

The year of 2012 observed an unusually high number of forest fires in the U.S. These fires emitted significant amounts of aerosols into the atmosphere, while the timing and the location of the emissions were sporadic and non-uniform. The impacts of these aerosols on the microphysical and radiative properties of deep convective clouds (DCCs) remain poorly understood; both forest fires and DCCs generally occur in warm seasons, yet their episodic nature makes in-situ observations extremely difficult. Moreover, another complication is added by the generally hydrophobic nature of forest fire aerosols such as organic carbon and black carbon. This calls their ability to act as cloud condensation nuclei into questions, and may also allow them to serve as ice nuclei inside clouds. Given the projected increase in the number and intensity of forest fires in a warmer future climate, however, it is of significant importance to investigate the potential changes in microphysical, dynamical, and radiative properties of DCCs due to forest fire aerosols. Our cloud-resolving (4-km horizontal resolution) WRF-CHEM simulations resolve the detailed microphysics inside DCCs without using a convective parameterization scheme, while the simulation domain covers the entire continental U.S. for a simulation period of two months. By comparing simulations with and without a high-resolution forest fire emission input, fire effects on the mass and number of hydrometeors, vertical velocities, anvil cloud properties, and the amount of precipitation are investigated. These large-domain and long-term simulations also allow us to collect data from numerous DCCs and investigate statistically robust changes in cloud properties, and thus climate, due to forest fires.

A missed sea salt aerosol (SSA) CCN source from the sea ice covered zone

Abstract ID : 1317

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Xin Yang ,xin.yang2145@gmail.com ,(Atmospheric chemistry modeller) ,United Kingdom ,Cambridge ,Presenting[1]

Dr. Markus Frey ,maey@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Rachael Rhodes ,rhr34@cam.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Mr. Sarah Norris ,snorris@env.leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Prof. Ian Brooks ,.brooks@see.leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[5]

Dr. Phil Anderson ,Philip.Anderson@sams.ac.uk ,(None) ,United Kingdom , ,Not Presenting[6]

Prof. Kouichi NISHIMURA ,knishi@nagoya-u.jp ,(None) ,Japan , ,Not Presenting[7]

Dr. Anna Jones ,aejo@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Prof. Eric Wolff ,ew428@cam.ac.uk ,(None) ,United Kingdom , ,Not Presenting[9]

1 - British Antarctic Survey 2 - British Antarctic Survey 3 - Earth Sciences Department/University of Cambridge 4 - School of Earth and Environmental Sciences/University of Leeds 5 - School of Earth and Environment/University of Leeds, Leeds 6 - Scottish Association for Marine Science 7 - Graduate School of Environmental Studies, Nagoya University 8 - British Antarctic Survey 9 - Department of Earth Sciences, University of Cambridge

Measurements of aerosol and blowing snow parameters were made during a recent cruise in the Weddell Sea during austral winter. The measurements confirmed that blowing snow events on sea ice are generally associated with large numbers of aerosols in the size range of 0.4 -10 microns. The results strongly support a previous hypothesis that blown salty snow particles could, via a sublimation process, be a large sea salt aerosol (SSA) source [Yang et al., 2008]. The chemistry transport model pTOMCAT, with this SSA production scheme implemented, was able to reproduce the observed aerosol plumes along the cruise track. Furthermore, the model also predicted that the sea ice covered zone is a large CCN-size SSA source, with a winter flux even larger than that from sea spray. Direct comparisons between observations and model outputs in both aerosol number densities and size spectra are presented here, based on the campaign data. In particular, possible production mechanisms regarding the SSA creation from blowing snow are tested through various carefully-designed model experiments. Finally, a micro-physical picture of SSA production from blowing snow is given. Since this SSA-CCN source has not been included in any current climate models, its climate implication is not yet known.

Contrasts of cloud microphysical relationships between the dry and wet seasons in Amazon measured during the GoAmazon campaign

Abstract ID : 1335

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Seong Soo Yum ,ssyum@yonsei.ac.kr ,(None) ,South Korea ,Seoul ,Presenting[1]

Mr. Jae Min Yeom ,jaemin6252@yonsei.ac.kr ,(None) ,South Korea , ,Not Presenting[1]

Dr. Fan Mei ,Fan.Mei@pnnl.gov ,(None) ,United States , ,Not Presenting[3]

Dr. Beat Schmid ,beat.schmid@pnnl.gov ,(None) ,United States , ,Not Presenting[4]

Dr. Jennifer Comstock ,Jennifer.Comstock@pnnl.gov ,(None) ,United States , ,Not Presenting[4]

Dr. Luiz Machado ,luiz.machado@inpe.br ,(None) ,Brazil , ,Not Presenting[6]

Dr. Micael Cecchini ,micael.cecchini@cptec.inpe.br ,(None) ,Brazil , ,Not Presenting[6]

1 - Yonsei University 2 - Yonsei University 3 - Pacific Northwest National Laboratory 4 - Pacific Northwest National Laboratory 5 - Pacific Northwest National Laboratory 6 - National Institute for Space Research 7 - National Institute for Space Research

Cloud microphysical properties are sensitively dependent on the cloud microphysical processes and the environmental (i.e., aerosol and thermodynamic) conditions under which clouds are formed. The entrainment and mixing processes that modulate cloud microphysical relationships may occur differently depending on the environmental conditions. In this regard, the Green ocean Amazon (GoAmazon) campaign is unique in that contrasting aerosol, thermodynamic, and cloud microphysical properties of the dry and wet seasons were measured. Here we present some important results of the measurement. In general, cloud spatial dimension was larger in the wet than the dry season, but clouds were more diluted in the dry season. The clouds in the dry season displayed larger relative dispersion with more abundance of small droplets than those in wet because aerosol concentrations were higher and particles in the accumulation mode were larger in the dry season. Cloud microphysical relationships and mixing diagram analysis strongly suggest homogeneous mixing for most cloud segments in both the dry and wet seasons like in our previous studies for marine stratocumulus clouds over the southeast Pacific and for continental clouds in Oklahoma. Uniquely, however, in the dry season the concentration of very small droplets increased in the diluted sections (perhaps due to entrainment) in many cloud segments, which are suggested to be the newly activated droplets during the entrainment and mixing processes. Speculatively, new droplet activation on entrained aerosols would be more likely to occur in the dry season due to more favorable conditions for that: larger accumulation mode particles, higher fluctuations of vertical velocity and larger turbulent dissipation rate. More detail will be presented at the meeting.

Investigation of the optical properties of aerosol particles in a super-ellipsoidal shape space

Abstract ID : 1354

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Lei Bi ,bilei@zju.edu.cn ,(None) ,China ,Hangzhou ,Not Presenting[1]

1 - None

The optical properties of aerosol particles (the extinction efficiency, the single-scattering albedo and the phase matrix) play a fundamental role in atmospheric radiaive transfer and remote sensing studies involving aerosols. However, aerosol particles in the atmosphere from multiple sources (soot, sulfate, dust, etc.) have complex morphologies and compositions. Mixture of different aerosol particles could further result in an extremely complex light scattering system. A predefined shape may not be representative of realistic shapes, and thus fails to reproduce the range of observation data, for example, large depolarization ratios (>0.6) observed by the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) satellite.
This study will focus on the investigation of the optical properties of aerosol particles in a super-ellipsoidal shape space. The advantage of super-ellipsoids is the flexibility to modify the shape with more freedom than spheroids. In particular, we will illustrate the backscattering properties of super-ellipsoidal particles that would have important implications in aerosol typing and aerosol transport studies. The observation data from the CALIPSO will be used for reference to analyze the backscattering mechanism associated with the microphysics of aerosol particles.

Sensitivity of simulated stratocumulus clouds in southern Africa to aerosol particle characteristics

Abstract ID : 1398

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Rebecca Garland ,rgarland@csir.co.za ,(Principal Researcher) ,South Africa ,Pretoria ,Presenting[1]

Mr. Zane Dedekind ,zdedekind@csir.co.za ,(Research Scientist) ,South Africa ,Pretoria ,Not Presenting[2]

Dr. Christien Engelbrecht ,engelbrechtc@arc.agric.za ,(None) ,South Africa , ,Not Presenting[3]

Dr. Mary-Jane Bopape ,mbopape@csir.co.za ,(Senior Resercher) ,South Africa ,Pretoria ,Not Presenting[4]

Dr. Marcus Thatcher ,marcus.thatcher@csiro.au ,(None) ,Australia , ,Not Presenting[5]

Prof. Stuart Piketh ,stuart.piketh@nwu.ac.za ,(Director) ,South Africa ,Potchefstroom ,Not Presenting[6]

Dr. Francois Engelbrecht ,FEngelbrecht@csir.co.za ,(None) ,South Africa , ,Not Presenting[7]

1 - CSIR 2 - CSIR NRE 3 - ARC 4 - CHPC-CSIR 5 - CSIRO 6 - NWU 7 - CSIR/NRE

Africa contains the largest sources of biomass-burning aerosols and dust, globally. An accurate representation of these aerosols in climate models is needed to understand the regional and global radiative forcing and climate impacts of aerosols, at present and under future climate change. Here, we investigate the sensitivity of the southern African climate to the presence of aerosol particles and their transport patterns, with a particular focus on understanding the simulated aerosol climatology and transport patterns off the southwestern coast of Africa, and the resultant impact on clouds off this coast. This area can be impacted by different sources of aerosols (e.g. marine, biomass burning, dust, anthropogenic), and is of importance climatologically due to the presence of the stratocumulus clouds that form off the Namibian and Angolan coasts. In this study we analyse historical simulations from the Conformal Cubic Atmospheric Model (CCAM), consistent with the experimental design of CORDEX. CCAM has a prognostic aerosol scheme for organic carbon, black carbon, sulfate, dust, and diagnostic sea salt, and simulates the aerosol direct and indirect effect. Aerosol and synoptic climatologies were generated using self-organizing maps to understand the aerosol patterns and their transport pathways, and the associated synoptic conditions. Preliminary results suggest that the position of the high(s) in this region have an influence on the transport patterns of aerosol particles. Similar climatologies were generated for simulated clouds and synoptic conditions for historical runs both with and without aerosol particles present in the model. The presence of aerosol particles in the model was found to impact the average cloud cover in this region during the southern African biomass burning period. The impacts of simulated aerosol characteristics on clouds were also investigated, as well as comparison to measured data towards improving the representation of aerosol-cloud interactions in CCAM. This work is towards the development of the first African-led submission to CMIP6.

The Microphysical Processing and Transport of Dust by Tropical Cyclones

Abstract ID : 1419

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Susan van den Heever ,sue@atmos.colostate.edu ,(Professor) ,United States ,Fort Collins ,Not Presenting[1]

Mr. Stephen Herbener ,Stephen.Herbener@colostate.edu ,(None) ,United States , ,Not Presenting[2]

Mr. Stephen Saleeby ,Stephen.Saleeby@ColoState.EDU ,(None) ,United States , ,Not Presenting[2]

Dr. Cynthia Twohy ,chtwohy@gmail.com ,(None) ,United States , ,Not Presenting[4]

Ms. Kate Sauter ,sauter2@wisc.edu ,(None) ,United States , ,Not Presenting[5]

Prof. Tristan L'Ecuyer ,tlecuyer@wisc.edu ,(None) ,United States , ,Not Presenting[5]

Prof. Annica Ekman ,annica@misu.su.se ,(None) ,Sweden , ,Not Presenting[7]

1 - Colorado State University 2 - Colorado State Univerity 3 - Colorado State Univerity 4 - North Western Research Associates 5 - University of Wisconsin Madison 6 - University of Wisconsin Madison 7 - University of Stockholm

The vertical redistribution of dust within the troposphere has important implications for static stability, new cloud formation, upper tropospheric warming, long-range transport and ocean fertilization. Convective storms play a fundamental role in transporting dust from the boundary layer to the mid- and upper troposphere. However, the efficiency of this transport process, defined as the ratio of aerosols detrained in the mid- or upper troposphere to those ingested by the storm, is not well understood. Cloud resolving model simulations using the Regional Atmospheric Modeling System (RAMS) have been conducted of Tropical Storm Debby (2006) in order to assess how efficiently these storms transport dust from the Saharan Air Layer to the mid- and upper troposphere, as well as the predominant microphysical and dynamical processes determining this efficiency. RAMS has a prognostic aerosol scheme in which dust is activated based on the environmental conditions, tracked within different hydrometeor species, and returned to the atmosphere following sublimation and evaporation. Furthermore, all of the microphysical processes within the model are also tracked thus allowing for an evaluation of their role in dust removal processes. A dust budget of those processes impacting dust redistribution at the middle and upper levels has been constructed. This budget has also been compared with CloudSat and Calipso data obtained along A-Train transects of TS Debby. The role of entrainment and detrainment in these mid- and upper-level dust signals has also been analyzed. The results demonstrate that the mass of dust transported by TS Debby to the upper troposphere is about two orders of magnitude smaller than that deposited on the surface in association with wet and dry deposition processes, whereas the dust mass transported to mid-levels is similar to that deposited on the surface. Both the modeling and observational results will be presented, and the microphysical and dynamical processes responsible for this vertical redistribution of dust will be discussed.

Aerosol decreases in recent years over the Sichuan Basin, China: A perspective from MODIS observations

Abstract ID : 1489

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Xiaobo Zheng ,zxb-816@126.com ,(None) ,China ,Guiyang ,Presenting[1]

Prof. Tianliang Zhao ,tlzhao@nuist.edu.cn ,(None) ,China ,Nanjing ,Not Presenting[2]

Prof. Yueqing Li ,yueqingli@163.com ,(None) ,China , ,Presenting[3]

1 - Guizhou Institute of Mountainous Climate and Environment 2 - Nanjing University of Information Science & Technology 3 - Institute of Plateau Meteorology, CMA, Chengdu, China

In order to identify the role of aerosols in precipitation and air quality change in the Sichuan Basin (SB), China, we employ aerosol optical depth (AOD) from 2001 to 2015 derived from MODIS. The overall AOD values in the basin are larger than 0.5 in annual averages. The AOD reveals two high value zones locate along the west of the basin from north to south and the southernmost part separately. The AOD values are higher in cold season (spring and winter) than in warm seasons (summer and autumn). During the 15 years, the AOD shows a declining trend in interannual AOD over the SD, implying the decreasing aerosol loading in the atmosphere in recent yeras. The decreasing trends of AOD were spatially distributed over almost all of the SB region, where the high decreasing rates (-0.02 to -0.03 $year^{-1}$) were mainly loacted from the center to the southernmost part of the basin. The topography could exert an impact on the AOD distribution and change over the SB, especially in the high AOD centers. The wind speed was increasing in the SB over year 2001 to 2015, which could facilitate the dilution and diffusion of aerosol particles. Relative humidity experienced a drying trend in the interannual variation, reflecting less hygroscopic growth and the secondary transformation in dry atmosphere could be result in the decreasing of AOD in recent years.

M08 - Advances in Atmospheric Dynamics

Helicity in Atmospheric Dynamics

Abstract ID : 72

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Michael Kurgansky ,kurgansk@ifaran.ru ,(Leading researcher) ,Russia ,Moscow ,Not Presenting[1]

Mr Alexey Khapaev ,aakhapaev@gmail.com ,(None) ,Russia , ,Not Presenting[2]

Mr Leonid Maximenkov ,leonidmax@gmail.com ,(None) ,Russia , ,Not Presenting[2]

1 - A.M.Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences 2 - A.M. Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences 3 - A.M. Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences

An overview of kinetic helicity, defined by the scalar product of velocity and vorticity 3D vectors, and of the role of this concept in an ongoing research in the field of atmospheric dynamics is given. We bring together different, both known in the literature and novel formulations of the helicity balance equation, also taking into account the effects of air compressibility and rotation of the Earth. We present equations and relationships that are valid under different approximations commonly made in dynamic meteorology, e.g. Boussinesq approximation, quasi-static approximation, quasi-geostrophic approximation. Emphasis is placed on the analysis of the helicity budget in large-scale atmospheric motions. An explicit expression for the helicity injection rate in a non-linear Ekman boundary layer (HI, hereafter) is presented, which also accounts for the cyclone-anticyclone asymmetry. It is shown that this injection is exactly balanced by turbulent viscous destruction of helicity within the boundary layer. It is conjectured that HI serves as a measure of the intensity of atmospheric circulation over extratropical latitudes of both terrestrial hemispheres. Based on re-analyses data, examples are provided of HI variability, both seasonal and interannual.

Semibalance Model in Terrain-Following Coordinates

Abstract ID : 175

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. JIE CAO ,iamcaojie@126.com ,(Reseach Associate) ,China ,Beijing ,Not Presenting[1]

Dr. QIN XU ,qin.x@noaa.gov ,(None) ,United States , ,Not Presenting[2]

1 - Institute of Atmospheric Physics, Chinese Academy of Sciences 2 - NSSL, NOAA

By partitioning the hydrostatically balanced flow into a nonlinearly balanced primary-flow part and a remaining secondary-flow part and then truncating the secondary-flow vorticity advection and stretching-tilting terms in the vector vorticity equation, the previous semibalance model (SBM) in pseudoheight coordinates is rederived in terrain-following pressure coordinates, called <yeta> coordinates. The involved truncation is topologically the same as that in pseudoheight coordinates but the truncated terms in h coordinates are not equivalent to those in pseudoheight coordinates. Because its potential vorticity (PV) is conserved and invertible, the rederived SBM is suitable for studying balanced dynamics via "PV thinking" in real weather events, such as slowly varying vortices and curved fronts in which the primary-flow velocity and secondary flow vorticity are nearly parallel in <yeta> coordinates.

Generation and backreaction of spontaneously emitted inertia-gravity waves

Abstract ID : 178

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Norihiko Sugimoto ,nori@phys-h.keio.ac.jp ,(Associate Professor) ,Japan ,Yokohama ,Presenting[1]

Dr. Plougonven Riwal ,plougon@lmd.ens.fr ,(None) ,France , ,Not Presenting[2]

1 - Keio University 2 - École Polytechnique

Spontaneous generation of inertia-gravity waves from balanced flows is investigated in idealized simulations of dipoles. Long integrations are performed for dipoles with different Rossby numbers (Ro) to identify the backreaction of the waves. The numerical model used is DCPAM5-plane (Dennou-Club Planetary Atmospheric Model, *Takehiro et al.* [2011]) which solves the dry primitive equations on an *f*-plane with a sigma coordinate in the vertical. The domain is 3000 km times 3000 km in horizontal and 20 km in the vertical direction. The control run has 128^2 grid points and 80 layers, which corresponds to a resolution of ~23.4 km in the horizontal and ~250 m in the vertical. The boundary conditions are doubly periodic in the horizontal and rigid in upper and lower boundaries. Emission of waves is detected only for large enough Ro (>0.15). The waves emitted appear in the front of the dipole, with characteristics consistent with wave-capture, consistently with previous studies. This emission leads to a slow decay of the dipole's kinetic energy (0.2% per day for Ro=0.3). A major finding is that this decay is well captured by the simulations: simulations with 192^2 and 256^2 grid points describe essentially the same decay of the dipole's kinetic energy. In contrast, the details of the waves (wavelengths, positions, amplitude at the front of the wave packet) appear still sensitive to the resolution: in particular their maximum vertical velocity increases linearly with resolution. The interpretation is that the emission process is well-resolved and fairly insensitive to resolution (because it results from the characteristics of the balanced dipole, which is large scale), while the propagation and dissipation at small scales remains sensitive to resolution. The implication is that the simulations yield an estimate of the upper bound for the leakage of energy from balanced motions to gravity waves, providing a useful estimate of a poorly constrained flux in the ocean's energy budget. This upper bound (~0.3 TW) is already much weaker than previous estimate (~1 TW).

The modulation of stationary waves, and their response to climate change, by parameterized orographic drag

Abstract ID : 209

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Annelize van Niekerk ,a.vanniekerk@pgr.reading.ac.uk ,(PhD student) ,United Kingdom ,London ,Not Presenting[1]

Prof. Theodore G. Shepherd ,theodore.shepherd@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. John F. Scinocca ,john.scinocca@canada.ca ,(None) ,Canada , ,Not Presenting[3]

1 - University of Reading 2 - University of Reading 3 - Canadian Centre for Climate Modelling and Analysis

The parameterization of orographic drag processes in atmospheric models remains uncertain due to a lack of observational and theoretical constraints on their formulation and free parameters. While previous studies have demonstrated that low-level parameterized orographic drag has a significant impact on the atmospheric circulation, this work follows a more systematic approach to investigate its impacts on the large scale circulation and how this affects the circulation response to climate change. A set of experiments with a comprehensive atmospheric general circulation model is used to ascertain the range of climatological circulations that may arise from parameter uncertainty. Northern Hemisphere (NH) wintertime climatological stationary wave amplitudes are found to be strongly modulated by the magnitude of the parameterized orographic drag, particularly over the North Atlantic and North Pacific, although in opposite ways in the two basins. The amplitude of the stationary wave response to climate change across the experiments is shown to scale with their present-day climatological stationary wave amplitudes over different sectors of the NH, with stronger climatological stationary wave amplitudes leading to a larger magnitude stationary wave response to climate change. This work highlights the importance of model fidelity and demonstrates that the spread in climatological basic states among models, as a result of parameter tuning or otherwise, can contribute to the uncertainty in the regional circulation response to climate change.

Understanding the spatial and temporal variability of atmospheric heat transport in a hierarchy of models

Abstract ID : 232

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Gabriele Messori ,gabriele.messori@misu.su.se ,(Research Scientist) ,Sweden ,Stockholm ,Not Presenting[1]

Dr. Ruth Geen ,r.geen@exeter.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Arnaud Czaja ,a.czaja@ic.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - Stockholm University 2 - University of Exeter 3 - Imperial College London

Meridional atmospheric heat transport by transient motions is a fundamentally sporadic process. At any given location in the extra-tropics, the net seasonal heat transport is effectively set by a few extreme days every season. Similar conclusions hold when considering the zonally integrated meridional heat transport. The present study analyses the spatial and temporal variability of such transport in a hierarchy of datasets. These are a highly idealised two-layer model seeded with point geostrophic vortices, an intermediate complexity Global Climate Model (GCM) and the ERA-Interim reanalysis data. In both the two-layer model and the GCM the largest values (or pulses) of zonally integrated transport are associated with extended regions of anomalously strong local meridional heat transport. In the two-layer model these large-scale coherent transport regions are linked to densely packed baroclinic vortex pairs and can be diagnosed as low wavenumber streamfunction anomalies. In the GCM they are associated with both the warm and cold sectors of mid-latitude weather systems. Both these features are also found in ERA-Interim: the large-scale coherent transport regions match weather systems and occur primarily in the storm track regions, which in turn correspond to planetary-scale climatological streamfunction anomalies. We interpret the temporal variability of the zonally integrated heat transport as a manifestation of the cyclical variations in the storm track activity, also referred to as storm track lifecycle. The existence of such pronounced variability in the zonally integrated meridional heat transport has important consequences for the interplay between mid-latitude dynamics and the energy balance of the high latitudes.

Daily to decadal modulation of jet variability

Abstract ID : 361

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Tim Woollings ,Tim.Woollings@physics.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Oxford

The variance of a jet's position in latitude is found to be related to its average speed: when a jet becomes stronger its variability in latitude decreases. This relationship is shown to hold for observed midlatitude jets around the world and also across the hierarchy of numerical models. We propose an underlying barotropic mechanism to explain this behaviour, related to the change in refractive properties of a jet as it strengthens, and the subsequent effect on the distribution of Rossby wave breaking. North Atlantic jet variability is shown to be modulated on decadal timescales, with decades of a strong, steady jet being interspersed with decades of a weak, variable jet. These modulations are also related to variations in the basin-wide occurrence of high-impact blocking events. A picture emerges of complex multidecadal jet variability in which recent decades do not appear unusual.

Beyond Warm and Cold: An Objective Classification for Maritime Mid-Latitude Fronts

Abstract ID : 534

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Clemens Spensberger ,clemens.spensberger@uib.no ,(PostDoc) ,Norway ,Bergen ,Presenting[1]

Dr. Michael Sprenger ,michael.sprenger@env.ethz.ch ,(None) ,Switzerland , ,Not Presenting[2]

1 - Geophysical Institute and Bjerknes Centre, University of Bergen 2 - Institute for Atmospheric and Climate Science, ETH Zurich

The distinction between warm and cold fronts is one of the essential building blocks for our understanding of mid-latitude dynamics. The distinction is well founded in conceptual models describing the life cycle of extratropical cyclones, but has also proved helpful in a wealth of other contexts. However, in these conceptual models there exists a third front type, occluded and bent-back fronts, respectively, that is independent of the distinction between warm and cold. To accommodate for those, as well as to better capture differences between individual cold and warm fronts, we introduce a comprehensive and more detailed classification of mid-latitude maritime fronts.
To this end, we objectively detect three-dimensional front objects in the ERA-Interim data set, and classify them using an EOF analysis. In addition to the distinction between warm and cold fronts, the EOF analysis exposes several further dimensions of variability between front objects: (a) front intensity, (b) surface fluxes and (c) intensity of the associated conveyor belts. These additional dimensions of variability are robust, because they consistently make up the dominating patterns of variability between fronts in a large number of locations in the Atlantic, Pacific and Indian oceans. We also demonstrate the dynamical significance of the additional dimensions by lagged composites that illustrate the different temporal evolution for the different front types. Finally, we show that the additional front types can be redefined based on simple parameter thresholds, such that our results can easily be applied to other contexts without repeating the EOF analysis.

Sources of forecast error in the short-term prediction of drought in the United Kingdom

Abstract ID : 685

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Tess Parker ,tess.parker@physics.ox.ac.uk ,(Postdoctoral Research Assistant) ,United Kingdom ,Oxford ,Not Presenting[1]

Dr. Tim Woollings ,Tim.Woollings@physics.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Antje Weisheimer ,Antje.Weisheimer@physics.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Oxford 2 - University of Oxford 3 - University of Oxford

The North Atlantic Oscillation (NAO) is the main source of variability over the North Atlantic in winter. A negative NAO describes periods when upper-level Rossby wave-breaking events over the North Atlantic result in high-latitude blocking over Greenland. Negative NAO events are linked to the diversion of rain-bearing storm systems away from the UK, leading to reduced precipitation in winter. In this research, ensemble sensitivity analysis is used to determine the sources of forecast error using the ECMWF TIGGE ensemble of forecasts at both 10-day and 5-day lead times, for identified winter Greenland blocking events from 2006-2015. The analysis examines dynamical precursors in both the troposphere and stratosphere, and the mechanisms by which variability in the tropics and over the poles could affect the NAO through tropical-extratropical and stratosphere-troposphere interactions.

Finite amplitude wave activity versus enstropy: Budget equations for error growth in a barotropic model framework

Abstract ID : 775

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Volkmar Wirth ,vwirth@uni-mainz.de ,(None) ,Germany ,Mainz ,Presenting[1]

Mr. Paolo Ghinassi ,pghinass@uni-mainz.de ,(None) ,Germany , ,Not Presenting[1]

Mrs. Marlene Baumgart ,mbaumga@uni-mainz.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Michael Riemer ,mriemer@uni-mainz.de ,(None) ,Germany , ,Not Presenting[1]

1 - Johannes Gutenberg University Mainz 2 - Johannes Gutenberg University Mainz 3 - Johannes Gutenberg University Mainz 4 - Johannes Gutenberg University Mainz

Diagnosing the growth of errors in numerical weather forecast models has been and continues to be an important challenge in meteorology. Small-scale errors at initial time can grow in amplitude and scale, and nonconservative processes have been shown to play an important role in this context. Once the errors have reached the synoptic scale, they may continue to grow upscale and often propagate in the form of Rossby wave packets.
This contribution investigates the larger-scale aspects of error growth in the framework of the barotropic model on a sphere. Global and regional budget equations are presented for enstropy as well as for a more recent formulation of local finite amplitude wave activity, and both quantities will be related to each other. A focus will be on nonconservative terms which is obtained as a residuum of the remaining terms. Numerical simulations of Rossby wave packets along an idealized jet indicate that the nonconservative terms from numerical errors tend to play a non-negligible role owing to the fact that entstropy goes to small scales for barotropic flow.
Finally the budget equation for error enstropy is investigated. In contrast to total enstrophy, the total error enstropy may grow even for purely conservative conditions. This situation is illustrated using a simulation of barotropic instability, where both conservative and nonconservative terms contribute to the budget of total error enstrophy.

Global view of polar cold air outbreaks in isentropic analysis

Abstract ID : 829

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Toshiki Iwasaki ,Iwasaki@wind.gp.tohoku.ac.jp ,(Professor) ,Japan ,Sendai ,Presenting[1]

Mr. Yuki Kanno ,kanno@dc.tohoku.ac.jp ,(None) ,Japan , ,Not Presenting[1]

Mr. Rais Muhammad ,m.rais@dc.tohoku.ac.jp ,(None) ,Japan , ,Not Presenting[1]

1 - Tohoku University 2 - Tohoku University 3 - Tohoku University

Mass-weighted isentropic zonal mean (MIM) allows us to diagnose the zonal mean features of cold air outbreaks in winter hemispheres. The MIM shows a distinct extratropical tropospheric direct (ETD) circulations which indicate upper-level warm airmass inflow, cold air mass generations due to diabatic decent and low-level outbreak toward mid-latitudes. The strength of equatorward flow is under significant control of wave-mean flow interactions. The ETD circulations have a local maximum around 280K, for both winters, indicating that =280K may be an appropriate threshold of the polar cold air mass in a sense of the general circulation (Iwasaki et al., 2014, JAS). The total amount of cold air mass in NH winter is significantly greater than that in SH winter because of the longer residence time in high latitudes (Kanno et al., 2015, ASL).

Geographical distribution of the cold air mass and its stream below are analyzed according to a local conservation relation (Iwasaki et al., 2014, JAS). In the NH winter, there are two distinct polar cold air mass streams, hereafter called as East Asian (EA) stream and the North American (NA) stream. The former grows over the northern part of the Eurasian continent, turns down southeastward toward East Asia and disappears over the western North Pacific Ocean. The latter grows over the Arctic Ocean, flows toward the East Coast of North America and disappears over the western North Atlantic Ocean. The polar cold airmass intermittently outbreaks toward midlatitudes with pulse width of 3-5 days, and sometimes causes severe cold surges. In east Asia, lagged regression/correlation analyses indicate that Siberian high and Aleutian low play important roles in the outbreaks (Shoji et al., 2014, JC). In this processes, temporal variations of polar cold airmass and its outbreak can generally be understood as the so-cold "charge-discharge relationship" (Kanno et al., 2015, GRL).

The east Asian cold air outbreaks also have large interannual variability. An EOF analysis indicates that outbreaks occur more frequently on the western side of 135E at 45N in Lani-Na, but on its eastern side in El-Nino (Abdillah et al., 2017, JC, in press)

Polar-tropical coupling in the winter stratosphere

Abstract ID : 978

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Richard Scott ,rks4@st-andrews.ac.uk ,(None) ,United Kingdom ,St Andrews ,Not Presenting[1]

1 - None

An outstanding question in the dynamics of the middle atmosphere is whether and how the tropical quasi-biennial oscillation (QBO), a zonal wind anomaly of relatively shallow extent, can dynamically influence the deep vertically propagating waves on the edge of the winter stratospheric polar vortex. Traditional approaches to this problem have considered the effect of the QBO wind anomalies on linear wave propagation through the stratosphere, arguing that the further poleward location of the zero wind line in the QBO easterly phase may act to focus wave activity into polar regions. Here we take an alternative approach and examine the dynamical coupling of the two regions in terms of their fundamental potential vorticity distributions and the waves they support. Meteorological reanalysis indicates that QBO westerly anomalies have enhanced potential vorticity gradients located at the equator, while easterly anomalies have enhanced gradients in the subtropics, and that these alter the effective width of the surf zone surrounding the winter polar vortex. While potential vorticity gradients in the surf zone are weak and do not themselves support Rossby wave propagation, transfer of wave activity from the polar vortex edge to the subtropical barrier or the QBO westerly phase equatorial equivalent may still occur due to the nonlocality of potential vorticity inversion. Process studies with a mechanistic model with prescribed QBO and carefully controlled high-latitude wave forcing will be analyzed, guided by a reexamination of meteorlogical reanalysis, to address how such a dynamical linkage may influence in particular the resonant excitation of the winter vortex, and the occurrence of vortex-splitting sudden warming events. We consider also the difference in vortex response to zonal wavenumber one and wavenumber two forcing. Finally, we examine the associated transfer of wave activity from vortex edge to the tropics, consider under what conditions this becomes a significant source of easterly momentum in the driving of the QBO itself, and how the structure of the Brewer-Dobson circulation varies in response to the location of the QBO westerly winds in any given winter.

Will storm tracks shift poleward under climate change?

Abstract ID : 981

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Theodore G. Shepherd ,theodore.shepherd@reading.ac.uk ,(None) ,United Kingdom , ,Presenting[1]

1 - University of Reading

It is a commonly accepted view (e.g. in the IPCC reports) that storm tracks will shift poleward under climate change. Yet there is no accepted theoretical explanation for this phenomenon, and climate models can show divergent behaviour, especially in the Northern Hemisphere. This talk will review the evidence, and arguments, for storm track shifts under climate change, comparing and contrasting the behaviour in the two hemispheres.

North Atlantic storm tracks: static stability and the role of tropical-extratropical interactions

Abstract ID : 1096

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Cheikh Mbengue ,c.mbengue@wolfson.oxon.org ,(Postdoctoral Researcher) ,Saint Lucia ,Castries ,Presenting[1]

Dr. Tim Woollings ,Tim.Woollings@physics.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Helen Dacre ,h.f.dacre@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. Kevin Hodges ,k.i.hodges@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

1 - University of Oxford 2 - University of Oxford 3 - University of Reading 4 - National Centre of Atmospheric Science (Climate), University of Reading

North Atlantic sector seasonal-forecast skill in summer is generally worse than in winter. But recent research has shown that improving model physics enhances summer seasonal-forecast skill. This suggests that some predictable drivers of summertime variability may be missing from models and that fundamental summertime research may yield further improvements in summer seasonal-forecast skill. Static stability shapes North Atlantic sector variability by modulating the sensitivity of baroclinicity to meridional temperature gradients and to the tropopause height, and by modifying the baroclinicity itself. It is demonstrated that spatial variations in lower-tropospheric static stability can account for some of the seasonal differences in the amplitude of the storm-track response to predictable drivers of North Atlantic sector variability. An investigation of the interannual variability of the components of baroclinicity using reanalysis data reveals that during the summer upper-level static stability varies independently of the dominant mode of variability associated with the North Atlantic. Composites of high-stability years show enhanced storminess, as measured by vertically-integrated bandpass-filtered eddy kinetic energy and cyclone track density, over the North Atlantic sector and particularly over Europe. A dynamical mechanism is proposed in which changes in the subtropical jet, driven primarily by changes in the summertime tropical meridional overturning circulation, which is shifted poleward in summer, drive changes in extratropical upper-level static stability. This mechanism not only explains the observed increase in east Atlantic cyclone activity during the high-stability phase, but also allows east Atlantic cyclone genesis in the absence of antecedent cyclones.

Dynamics of Rossby Waves and Heat Waves in the Australian Region

Abstract ID : 1236

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Michael Reeder ,michael.reeder@monash.edu ,(Professor) ,Australia ,Melbourne ,Presenting[1]

Dr. Julian Quinting ,julian.quinting@monash.edu ,(None) ,Australia , ,Not Presenting[1]

Dr. Tess Parker ,tess.parker@physics.ox.ac.uk ,(Postdoctoral Research Assistant) ,United Kingdom ,Oxford ,Not Presenting[3]

1 - Monash University 2 - Monash University 3 - University of Oxford

In Australia, summertime heat waves are responsible for more deaths than any other natural disaster. Their frequency has increased over the past few decades, and climate projections indicate that their intensity, frequency and duration will increase in a warmer climate. Heat waves in southeast Australia are preceded by large-amplitude transient Rossby wave packets, and are characterised by the development of an upper-level anticyclone the southern part of the continent and an upper-level trough to the north. Trajectory calculations are used to investigate the origin of the air in the upper anticyclone. Most of this air comes form the midlatitudes and subtropics, although some comes from the tropics after being processed by tropical convection. Prior to becoming part of the anticyclone, most of this air ascends diabatically ahead of a low-level front and upper-level trough. Trajectory calculations also show that the near surface air does not originate from the centre of the continent, but instead from the midlatitudes. Although most of the warm is associated with adiabatic compression as the air subsides, adiabatic heating in the boundary layer increases the temperature in the last part of the trajectory. The precipitation is enhanced in the vicinity of the upper-level trough to the north anticyclone, consistent with adiabatically forced vertical motion, destabilisation of the atmosphere, and modified moisture fluxes.

Equatorial superrotation at Earth's surface

Abstract ID : 1256

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Rodrigo Caballero ,rodrigo@misu.su.se ,(None) ,Sweden , ,Not Presenting[1]

Mr. Henrik Carlson ,henrik@misu.su.se ,(None) ,Sweden , ,Not Presenting[1]

1 - Stockholm University 2 - Stockholm University

A growing body of recent work indicates that as tropical surface temperatures warm, the amplitude of Madden-Julian Oscillation (MJO)-like variability increases. Since the MJO converges zonal momentum onto the equator at upper levels, the result is a high-temperature transition to equatorial superrotation--a state with westerly winds along the equatorial upper troposphere. While this transition is dynamically interesting, the effects of superrotation on Earth's climate will remain subtle and indirect so long as the superrotation is confined to the upper troposphere. If superrotation were to extend all the way to the surface, on the other hand, it would lead to a radical reorganization of the tropical climate; in particular, surface equatorial westerlies would presumably lead to a permanent El Nino state.
Here, we explore the conditions under which surface superrotation may occur, focusing on the role of vertical momentum transport by convective motions (CMT). We assume that lateral eddy momentum convergence peaks in the upper troposphere, as is the case for the MJO. We present theoretical arguments to suggest that two different momentum balances are possible: in the limit of weak CMT, eddy momentum convergence is balanced entirely by Hadley cell transport, with zero surface wind; in the opposite limit, upper-level eddy momentum convergence is transported to the surface and balanced by friction, yielding surface superrotation. Experiments with an idealized axisymmetric model show that both limits are indeed possible. Next, we explore the effects of artificially increasing CMT in a full-complexity GCM which displays upper-level superrotation. We find that a transition to surface superrotation fails to occur because the effect of enhanced CMT is to decrease the MJO's amplitude and momentum convergence. We conclude that surface superrotation is unlikely to be achieved so long as tropical variability is dominated by waves which converge momentum predominantly in the upper troposphere.

A preliminary climatology of surface cyclones associated with upper-levels potential vorticity anomaly over South America

Abstract ID : 1363

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Natália Machado Crespo ,nataliacrespo@model.iag.usp.br ,(PhD Student) ,Brazil ,São Paulo ,Not Presenting[1]

Prof. Rosmeri Porfírio da Rocha ,rosmerir@model.iag.usp.br ,(None) ,Brazil , ,Not Presenting[1]

1 - University of São Paulo 2 - University of São Paulo

Cyclones are synoptic scale systems very important for the energetic balance of the planet. A characteristic feature of their formation is the interaction with upper-levels of troposphere which could be studied using potential vorticity. In this work, a preliminary climatology of surface cyclogenesis associated with potential vorticity anomaly at upper-levels over South America and South Atlantic Ocean is shown. For both cyclone tracking and synoptic analysis, the data used was ERA-Interim reanalysis from the European Centre for Medium-Range Weather Forecasts (ECMWF), with resolution of 1.5° x 1.5°. For the period 1979-2015 there were identified 7300 surface cyclones over the study area, where 4111 (56.3%) are associated (APVA) and 3189 (43.7%) are not associated (NPVA) with potential vorticity anomaly (PVA) at 300 hPa. The APVA cases present higher mean traveled distance, total traveled distance and velocity than the NPVA cases. The more representative seasons for the APVA cases are winter (36.4 ± 7.5 cyclones) followed by spring (32.2 ± 5.8), while the NPVA occurs mainly in summer (25.5 ± 7.5). The lifetime of NPVA cyclones is shorter and they are less intense than APVA (according to the average central pressure). In general, most of the APVA cyclones are concentrated over extratropical oceanic region and close to the coast. It is also observed a belt of three different cyclogenesis regions with a gap in between them (for both APVA and NPVA). For the NPVA cyclones the preferential region of cyclogenesis is over the continent, around 30°S and subtropics. Centered composites fields of the synoptic environment of the cyclone's development will be also presented.

Projected Changes in South Atlantic Cyclones in a Warmer World using HadGEM2-ES

Abstract ID : 1370

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Carolina Barnez Gramcianinov ,carolina.barnez@iag.usp.br ,(PhD Candidate) ,Brazil ,Sao Paulo ,Not Presenting[1]

Dr. Kevin Hodges ,k.i.hodges@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Ricardo de Camargo ,ricamarg@usp.br ,(None) ,Brazil , ,Not Presenting[3]

1 - None 2 - National Centre of Atmospheric Science (Climate), University of Reading 3 - University of Sao Paulo

The South Atlantic Ocean (SAO) distribution and intensities of cyclones impacts directly on human activities, mainly due to their associated intense precipitation and winds which can result in loss of life and damage to property and infrastructure. For this reason, it is important to understand how these systems will change in the future. In the present work, the HadGEM2-ES climate model (1.25°x1.88°) was used to evaluate cyclone changes in climate projections in the SAO region. The NCEP-CFSR reanalysis (0.5°x0.5°) is also used to provide verification of the cyclone climatology (1991-2005) in the SAO, and also to calibrate the tracking algorithm in the region. In order to understand possible changes at the end of the century (2085-2099) we used RCP4.5 and RCP8.5 projection scenarios. A tracking algorithm was used with the 850hPa vorticity field to identify and track the cyclones and cyclone statistics derived for cyclone track, genesis and lysis density. Sea level pressure and 925hPa wind speed were associated with the vorticity tracks to measure the near surface intensity of the cyclones. The HadGEM2-ES historical experiment was able to reproduce the general distribution of cyclones in the domain. In both the historical experiment and reanalysis, three main regions are prone to cyclone generation: along the Brazilian Southeastern coast (RG1), in 30°S (RG2) and one centered at 45°S (RG3), in agreement with other studies. The HadGEM2-ES appears to generate less genesis in RG1 and RG2, probably due to poor representation of the orography. The future projections show a poleward shift of storm track in all seasons. The genesis regions RG1 and RG3, show a decrease in systems, while RG2 shows an increase of 16%. The poleward shift of storm track in the Atlantic was expected. According with previous studies, most of climate models indicate a poleward jet stream shift due to a decrease in meridional temperature gradient in a warming scenario. However, more information is still needed to explain the increase of cyclones in subtropical latitudes. More available humidity and a higher SST can help to produce more systems neutralizing the reduction of baroclinicity highlighted in the literature.

The North Atlantic Waveguide and Downstream Impact Experiment (NAWDEX)

Abstract ID : 1385

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. George Craig ,george.craig@lmu.de ,(Professor) ,Germany ,Munich ,Presenting[1]

1 - LMU Munich

The North Atlantic Waveguide and Downstream Impact Experiment (NAWDEX) was an international field campaign dedicated to improving weather prediction. The focus of the campaign was to study the impact of diabatic processes on disturbances to the jet stream over the North Atlantic, their influence on downstream propagation, and consequences for high-impact weather in Europe. The campaign took place from 19 September to 18 October 2016. Four aircraft from three different nations participated, deploying a variety of remote-sensing and in-situ instruments that provided an extraordinarily detailed picture of the interacting dynamics and thermodynamics. Thirteen intensive observation periods took place over the course of the campaign, including moisture inflow and diabatic processes in warm conveyor belts, cloud and dynamical structure in outflow and ridge-building events, as well as other events. This presentation will briefly review the scientific goals of NAWDEX and of the weather events that were observed during campaign. A preliminary evaluation will be made of the potential for the observations to contribute to new understanding of midlatitude weather systems. As an example, an analysis of the structure and evolution of ex-Tropical Storm Karl will be presented. This system was observed by a sequence of aircraft flights over a period of six days, as it moved from the subtropics into the midlatitudes off the coast of North America, reintensified explosively as a midlatitude cyclone south of Greenland, and eventually contributed to poor precipitation forecasts for Norway.

The weak temperature gradient approximation in midlatitudes

Abstract ID : 1416

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. George Craig ,george.craig@lmu.de ,(Professor) ,Germany ,Munich ,Presenting[1]

Dr. Tobias Selz ,tobias.selz@lmu.de ,(None) ,Germany , ,Not Presenting[1]

Ms. Lotte Bierdel ,lotte.bierdel@lmu.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Heiner Lange ,heiner.lange@lmu.de ,(None) ,Germany , ,Not Presenting[1]

1 - LMU Munich 2 - LMU Munich 3 - LMU Munich 4 - LMU Munich

Synoptic-scale motions in the atmosphere (length scale of 1000 km or more) remain close to geostrophic balance, which allows deep insights into their dynamics using quasigeostrophic and other approximate systems of equations. No similar balance has been identified for smaller scales. A general scale analysis of the governing equations (Klein, *Adv. Fl. Mech.* 2010) suggests that a broad class of motions on scales from tens to hundreds of kilometres should be characterized by a version of the weak temperature approximation, where vertical motion is forced by diabatic heating and fast gravity-wave transients are ignored. Such approximations have found increasing use in tropical meteorology, but the applicability to the mid-latitude atmosphere has not yet been examined. This presentation will show results of numerical simulations for an idealized radiative-convective equilibrium with a mid-latitude planetary rotation rate, as well as for a realistic weather situation. Weak temperature gradient balance is found to hold approximately, for the range of scales expected from theory. However the agreement is not as good as for geostrophic balance on larger scales. The implications of this balance for scale interactions, upscale error growth and balance in mesoscale data assimilation will be discussed.

M09 - Dynamics of Mountain Weather and Climate: Observations, Modeling and Prediction at All Scales

The causes of foehn warming in the lee of mountains

Abstract ID : 115

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Ian Renfrew ,i.renfrew@uea.ac.uk ,(Professor) ,United Kingdom ,Norwich ,Not Presenting[1]

Mr Andy Elvidge ,a.elvidge@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - University of East Anglia 2 - UEA

The foehn effect is well known as the warming, drying and cloud clearance experienced on the leeside of mountain ranges during 'flow over' conditions. Foehn flows were first described more than a century ago, when two mechanisms for this warming effect were postulated. An isentropic drawdown mechanism where potentially warmer air from aloft is brought down adiabatically; and a latent heating and precipitation mechanism, where air cools less on ascent - due to condensation and latent heat release - than on its dry descent on the leeside. Here, for the first time, the direct quantitative contribution of these and other foehn warming mechanisms are shown. The results suggest a new paradigm is required after it is demonstrated that a third mechanism, mechanical mixing of the foehn flow by turbulence, is significant. In fact depending on the flow dynamics any of the three warming mechanisms can dominate. A novel Lagrangian heat-budget model, back trajectories, high resolution numerical model output and aircraft observations are all employed. The study focuses on a unique natural laboratory - one that allows unambiguous quantification of the leeside warming - the Antarctic Peninsula and Larsen C Ice Shelf. The demonstration that three foehn warming mechanisms are important has ramifications for weather forecasting in mountainous areas and associated hazards such as ice shelf melt and wildfires.

The adjoint sensitivity of heavy rainfall to initial conditions in debris flow areas in China

Abstract ID : 173

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Feifan Zhou ,zhouff04@163.com ,(None) ,China ,Beijing ,Not Presenting[1]

1 - None

By studying three heavy rainfall events that were accompanied by debris flows in southwestern China, we find that 24-h accumulated rainfall is most sensitive to the initial temperature. The sensitivities to wind, surface pressure, and specific humidity are generally smaller. Moreover, the upper levels of the atmosphere are identified as the sensitive levels, and the sensitive areas are the areas with heavy rainfall. These results suggest that local temperature perturbations in the upper levels are a signal of short-term heavy rainfall in southwestern China. A validation experiment is carried out to justify the sensitivity results. The possible reasons are discussed and analyzed.

Impact of Surface Sensible Heating over the Tibetan Plateau on the Western Pacific Subtropical High: a Land–Air–Sea Interaction Perspective

Abstract ID : 198

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Anmin Duan ,amduan@lasg.iap.ac.cn ,(Senior Scientist) ,China ,Beijing ,Not Presenting[1]

1 - None

The impact of surface sensible heating over the Tibetan Plateau (SHTP) on the western Pacific subtropical high (WPSH) with and without the air-sea interaction was investigated in this study. Data analysis indicated that the SHTP acts as a relatively independent factor in modulating the WPSH anomaly compared with El Niño-Southern Oscillation events. Stronger spring SHTP was usually followed by an enhanced and westward extension of the WPSH in summer, and vice versa. Numerical experiments using both an atmospheric general circulation model (AGCM) and a coupled general circulation model (CGCM) confirmed that SHTP influences the large-scale circulation anomaly over the Pacific, which features a barotropic anticyclonic response over the northwestern Pacific and a cyclonic response to the south. Owing to different background circulation in spring and summer, such a response facilitates a subdued WPSH in spring but an enhanced WPSH in summer. Moreover, the CGCM results showed that the equatorial low-level westerly at the south edge of the cyclonic anomaly brings about a warm sea surface temperature anomaly (SSTA) in the equatorial central Pacific via surface warm advection. Subsequently, an atmospheric Rossby wave is stimulated to the northwest of the warm SSTA, which in turn enhances the atmospheric dipole anomalies over the western Pacific. Therefore, the air-sea feedbacks involved tend to reinforce the effect of SHTP on the WPSH anomaly, and the role of SHTP on general circulation needs to be considered in a land-air-sea interaction framework.

Wintertime Precipitation over the Australian Snowy Mountains: Evaluation of a Regional Forecast Model using High-density Ground-based Observations

Abstract ID : 416

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yi Huang ,vivian.huang@monash.edu ,(None) ,Australia ,Melbourne ,Presenting[1]

Prof. Steve Siems ,steven.siems@monash.edu ,(Associate Professor) ,Australia ,Melbourne ,Not Presenting[2]

Prof. Michael Manton ,michael.manton@monash.edu ,(None) ,Australia , ,Not Presenting[1]

Dr. Charmaine Franklin ,charmaine.franklin@bom.gov.au ,(None) ,Australia , ,Not Presenting[4]

Dr. Elizabeth Ebert ,beth.ebert@bom.gov.au ,(None) ,Australia , ,Not Presenting[4]

Dr. Thomas Chubb ,thomas.chubb@snowyhydro.com.au ,(None) ,Australia , ,Not Presenting[6]

Ms. Fahimeh Sarmadi ,fahimeh.sarmadi@monash.edu ,(None) ,Australia , ,Not Presenting[1]

1 - Monash University 2 - Monash University 3 - Monash University 4 - Bureau of Meteorology 5 - Bureau of Meteorology 6 - Snowy Hydro Ltd 7 - Monash University

The Snowy Mountains, consisting of the only peaks above 2000 m on the Australian continent, forms a vital water catchment over Australia. Wintertime precipitation over the Snowy Mountains has a significant contribution to the annual river runoff in this semi-arid region, which is critical to regional economy. This study evaluates a limited-area version of the Australian Community Climate and Earth-System Simulator (ACCESS) Numerical Weather Prediction system in forecasting precipitation across the Snowy Mountains for the cool seasons during 2014-2015, using a high-density precipitation gauge network.

Metrics based on seasonal accumulated and daily precipitation show that, while the model is able to reproduce the observed domain-mean accumulated precipitation reasonably well (with a slight overestimation), this is, in part, due to a compensation of various errors: both the frequency and intensity of the heavy precipitation days (domain-mean daily precipitation > 5 mm day-1) are overrepresented, particularly over the complex terrain and high-elevation areas, whereas the frequency of the very light precipitation days (domain-mean daily precipitation < 1 mm day-1) is underestimated, primarily over lower-elevation areas both the upwind and downwind of the mountains. Most of the precipitation is forecasted by the large-scale precipitation scheme, with appreciable snowfalls predicted over the high elevations.

The model also demonstrates appreciable skill in reproducing the observed synoptic regimes diagnosed from the upwind soundings. The proportion of the precipitation amount for each synoptic regime is well reproduced, although the orographic enhancement over the western slopes of the mountains is much more pronounced in the forecasts across all the regimes, particularly for the wetter regimes. A further examination on the effect of the lower-atmosphere stability (the effect of blocking by mountains) suggests that most of precipitation (50-70% over the high elevations) is produced

under the "unblocked" condition that is diagnosed 31% of the time, with the remainder being produced under the "blocked" condition.

Combined with a case study, the results of this study suggest that the misrepresentation of the fine-scale dynamics over the complex terrain and microphysical processes (i.e. liquid-ice conversion) in the large-scale precipitation parameterization may be the key to explaining the main model deficiencies.

Front-orography interactions during the landfall of the New Year Day's Storm 1992

Abstract ID : 536

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Clemens Spensberger ,clemens.spensberger@uib.no ,(PostDoc) ,Norway ,Bergen ,Presenting[1]

Dr. Sebastian Schemm ,sebastian.schemm@uib.no ,(None) ,Norway , ,Not Presenting[1]

1 - Geophysical Institute and Bjerknes Centre, University of Bergen 2 - Geophysical Institute and Bjerknes Centre, University of Bergen

The New Year Day's Storm was one of the strongest storms in the recorded history in Norway, with return periods for the wind speed exceeding 200 years in the most affected areas. The strongest winds were concentrated in a narrow band following the bent-back front. In his original description of the storm Grønås coined the term "poisonous tail" for this band of strong near-surface winds, which later inspired the term "sting jet".
While Grønås points out the importance of both diabatic processes and the formation of a warm seclusion for the dynamics of the storm in general and its poisonous tail in particular, he does not comment on orographic effects. Based on a high-resolution regional hindcast, we analyse the effect of the Scandinavian coastal range and the landfalling fronts on the further evolution of the storm. We show that the warm seclusion owes its existence to the orographically blocked warm front, leading to a rapid narrowing of the warm sector. With the landfall of the cold front, the narrowing leads to a cut-off, and the lower portion of the warm sector gets entirely separated from the cyclone core. We further present evidence that this cut-off process creates sudden imbalances in the mass and energy budgets around the warm seclusion, which in turn resulted in an intensification and reorientation of the bent-back front including the formation of its poisonous tail. We conclude that orographic effects likely played a role in making the poisonous tail as poisonous as it was.

Simulating the influence of topography on cut off lows over Southern Africa

Abstract ID : 1290

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Sabina Abba Omar ,sabinaabbaomar@gmail.com ,(PhD Student) ,South Africa ,Cape Town ,Not Presenting[1]

Mr. Babatunde Abiodun ,babiodun@csag.uct.ac.za ,(Senior Lecturer) ,South Africa ,Cape Town ,Not Presenting[2]

1 - University of Cape Town 2 - CSAG, UCT

Cut off lows can have significant socio-economic impacts on Southern Africa because of their association with extreme rainfall and flash flooding. Reliable forecasting of COLs could reduce the negative impacts of these events. Forecasting cut off lows can be challenging as it is too expensive to run high resolution prediction models that properly resolve topography. Therefore, understanding how COLs are impacted by topography is important. Most numerical studies that investigated this interaction over Southern Africa have either used global climate models (which have too low horizontal resolution to resolve the local-scale features) or used a regional climate model (with boundary condition problems that usually compromise the influence of the large-scale forcing on the local-scale feature). This study uses a global model with adaptive-grid to combat these shortcomings. This study explores the influences of topography on COL characteristics over Southern Africa by performing several experiments for a number of COL events. These experiments are run using the adaptive-grid global model as well as a regional climate model. The results are compared to gain insight into how different model configurations may affect the results. Experiments involve removing certain areas of Southern Africa's topography, namely the eastern escarpment, the western escarpment and then all of the topography. The experiments are analyzed for each COL event to determine how topography affects the cyclogenesis, track, speed, intensity and rainfall of the COL. Preliminary Results suggest that the western escarpment may influence COL characteristics more than the eastern escarpment. It is anticipated that the results of the study will give insight on how to improve the forecasting of COLs over Southern Africa.

Modelling rainfall at high resolutions over the eastern escarpment of South Africa

Abstract ID : 1362

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Zane Dedekind ,zdedekind@csir.co.za ,(Research Scientist) ,South Africa ,Pretoria ,Not Presenting[1]

Dr. Francois Engelbrecht ,FEngelbrecht@csir.co.za ,(None) ,South Africa , ,Not Presenting[2]

1 - CSIR NRE 2 - CSIR/NRE

Steep topography has an adverse effect on the realistic representation of the spatial and temporal distribution of rainfall totals in Regional Climate Model (RCM) simulations, as well as in satellite rainfall estimates. Here the Conformal-Cubic Atmospheric Model (CCAM) is applied for the period 1979 to 2005 using a grid spacing of 8 km horizontally over the eastern escarpment of South Africa and Lesotho. This region is characterised by very steep mountains that reach above 3000m above sea level in altitude in some places. Over this region the lower tropospheric flow is upslope and surface moisture is advected from the east originating from the Indian Ocean due to the ridging Mascarene high. The model simulations are verified against Tropical Rainfall Measuring Mission (TRMM) satellite and South African Weather Service (SAWS) station rainfall data. There exist large biases in the CCAM simulations especially at the north-eastern border of Lesotho, but the model is able to capture the west-east rainfall gradient and the diurnal cycle remarkably well. There is a strong relationship between higher rainfall and higher altitude against the escarpment within CCAM, but this relationship is only true under 1600m on the eastern side and under 1900m on the western side of the escarpment. Moreover, a new rainfall feature over Lesotho, which is undetected by the weather station network, was discovered from the model simulations and independently verified through the use of Normalised Difference Vegetation Index (NDVI) data. This result reinforces the importance and added value in using higher resolution simulations as this feature over Lesotho is not shown at a horizontal resolution of 50 km.

Mountain waves and cloud bands: a long research tradition framed by the case studies of 21 May 1937 and 1 February 2014

Abstract ID : 1390

Conflict Declaration : None

Content Motivation : None

Additional Information : Mentioned references above word count

Dr. Hans Volkert ,Hans.Volkert@dlr.de ,(Senior Research Scientist) ,Germany ,82234 Oberpaffenhofen ,Not Presenting[1]

1 - DLR, IPA

Airflow across mountain ridges can induce in a stably stratified atmosphere vertically oscillating motions, which are termed *mountain waves*. Such wave patterns can be stationary over hours and can have considerable extension downstream. When the ambient humidity is suitable, the wave crests are often marked by elongated *cloud bands*. These basic mechanisms have been gradually discovered and described in the 1930s, especially by German glider pilots and scientists. In a pioneering study, Küttner (1939) collected photographic evidence for wave clouds at quite a number of mountain ranges. Furthermore, he used no less than 22 barogrammes from gliders taking part in a regional competition to map out the vertical velocity field in the lee of the modest size *Riesengebirge* ridge at the border between Czechia (northern part of the Czech Republic) and Silesia (today in the southern part of Poland).

The dynamics of mountains waves in two- and three-dimensional settings with various degrees of idealization became a standard topic of (mesoscale) dynamical meteorology. At the turn of the century, the state of the art linking data from different observational platforms with three-dimensional episode-type simulations was documented for the Alpine case of 25 Sept. 1999 during MAP-SOP in Volkert (2003).

In recent years detailed, multi-channel satellite observations with high spatial resolution (MODIS-instrument on the TERRA and AQUA satellites) as well as high temporal resolution (SEVIRI instrument on Meteosat second generation) make possible the detailed documentation of waves generated cloud systems and help to infer their (quasi-)stationarity. Image sequences from mountain based web-cameras provide the human perspective from the surface. During the exceptional case of 1 February 2014 stationary cloud structures of various wavelengths could be detected embedded in the transient frontal cloud system within a southerly airflow over an area extending from the Alps to the *Riesengebirge* some 400 km further to the north (cf. self-steerable satellite loop under www.pa.op.dlr.de/~HansVolkert/GraWaves).

The presentation contains highlights from a research tradition spanning a period of more than 75 years and links the various findings with the development of observation technology and research interest.

M010 - Tropical Circulation Systems

Impact of Atmospheric Blocking on South America in Austral Summer

Abstract ID : 278

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Regina Rodrigues ,regina.rodrigues@ufsc.br ,(Associate Professor) ,Brazil ,Florianopolis ,Not Presenting[1]

Dr. Tim Woollings ,Tim.Woollings@physics.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - 2 - University of Oxford

In this study, we investigate atmospheric blocking over east South America in austral summer for the period of 1979-2014. Our results show that blocking over this area is a consequence of propagating Rossby waves that grow to large amplitudes and eventually break anticyclonically over subtropical South America (SSA). The SSA blocking can prevent the establishment of the South Atlantic Convergence Zone (SACZ). As such, years with more blocking days coincide with years with fewer SACZ days and reduced precipitation. Convection mainly over the Indian Ocean associated with Madden-Julian Oscillation (MJO) phases 1 and 2 can trigger the wave train that leads to SSA blocking whereas convection over the western/central Pacific associated with phases 6 and 7 is more likely to lead to SACZ events. We find that MJO is a key source of long-term variability in SSA blocking frequency. The wave packets associated with SSA blocking and SACZ episodes differ not only in their origin but also in their phase and refraction pattern. The tropopause-based methodology used here is proven to reliably identify events that lead to extremes of surface temperature and precipitation over SSA. Up to 80% of warm surface air temperature extremes occur simultaneously with SSA blocking events. The frequency of SSA blocking days is highly anti-correlated with the rainfall over southeast Brazil. The worst droughts in this area, during the summers of 1984, 2001 and 2014, are linked to record high numbers of SSA blocking days. The persistence of these events is also important in generating the extreme impacts.

The role of ocean warm eddy on rapid intensification of Supertyphoon Rammasun (2014)

Abstract ID : 357

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Qinbo Cai ,windandrain@126.com ,(Forecaster) ,China ,Haikou ,Not Presenting[1]

Ms. Wei Yang ,ywvirl@126.com ,(None) ,China , ,Not Presenting[2]

1 - 2 - None

The combined Analyses of satellite altimetry and observations are used to investigate the impact of warm eddy on Supertyphoon Rammasun over the South China Sea. The observation results show that Rammasun passes over two warm eddies when passing over the north of South China Sea. In the regions of warm ocean eddies, the sea surface temperature(SST) was more than 30?, the sea surface height anomaly(SSHA) was higher than 30 cm, the tropical cyclone heat potential(TCHP) was larger than 100 KJ/CM2 and a thick warm water reached over 70 m. During the 30 h of the Rammasun-eddies encounter, Rammasun's minimum sea level pressure drops by 60 hPa. The thicker upper-ocean warm layer in the warm eddies, which act as an effective insulator between typhoons, can prevents the deeper cold water from being entrained into the upper-ocean mixed layer and suppresses SST cooling. Meanwhile, a mesoscale coupled air-sea model is developed based on the non-hydrostatic mesoscale model WRF and the regional ocean model POM. The results suggest that the variation characteristics of simulated minimum surface pressure and maximum surface wind are consistent with observations well. Warm eddies increase the surface heat fluxes from ocean to atmosphere, especially the latent heat fluxes. In this study, the averaged total heat fluxes in the inner-core region of the typhoon increase by over 40 %, which contributes to further greater peak intensity but are not necessary for rapid intensification.

Vorticity budgets of tropical intraseasonal oscillations

Abstract ID : 444

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Adrian Matthews ,a.j.matthews@uea.ac.uk ,(Professor of Meteorology) ,United Kingdom ,Norwich ,Not Presenting[1]

1 - University of East Anglia

Intraseasonal variability of precipitation in the tropics is largely governed by recognised modes such as the Madden-Julian Oscillation (MJO) and its northern summer counterpart, the Boreal Summer Intraseasonal Oscillation (BSISO). The propagation direction and speed of these modes (eastward for the MJO, and northward and eastward for the BSISO) play a major role in the predictability of tropical precipitation on intraseasonal time scales. A dynamical analysis of this propagation is presented through a vorticity budget of the life cycles of the MJO and BSISO. The relative roles of advection of planetary and relative vorticity, vortex stretching, and tilting of horizontal vorticity into the vertical are assessed, and compared with theoretical models. In addition to furthering fundamental understanding of these intraseasonal modes, this vorticity analysis provides a useful metric by which model simulations of intraseasonal variability can be assessed.

Vertical structure of Western Disturbances in the subtropical jetstream and mechanisms associated with extreme rainfall in South Asia

Abstract ID : 495

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Kieran Hunt ,k.m.r.hunt@reading.ac.uk ,(Research Scientist) ,United Kingdom ,Reading ,Not Presenting[1]

Dr. Len C. Shaffrey ,l.c.shaffrey@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Andrew Turner ,a.g.turner@reading.ac.uk ,(Lecturer) ,United Kingdom ,Reading ,Not Presenting[1]

1 - University of Reading 2 - National Centre of Atmospheric Science (Climate), University of Reading 3 - University of Reading

Western disturbances (WDs) develop initially as cyclonic perturbations in the subtropical westerly jet (STWJ), and are typically incident on northern India about six times per month during the winter (Dec-Mar) season. They are often associated with heavy, sometimes extreme, rainfall events in and around the Karakoram region of northern India and Pakistan; yet the governing dynamics of both WDs and their associated rainfall remain fairly elusive, largely due to the case-study nature of previous attempts at understanding them.
Here, a novel tracking technique is applied to 38 years of reanalysis data to produce a database of over 3000 WDs. Events from this database are then interrogated using both Lagrangian and Eulerian approaches, providing a unique insight into the dynamical and thermodynamical development of these systems, and their interaction with the complex orography in northern India. The first detailed discussion on the three-dimensional structure of WDs is also presented. It is shown that WD frequency is a strong function of STWJ position, and the mechanism behind associated extreme rainfall events is identified and explored.

Tropical Precipitation Variability In the FGOALS-f High-resolution Coupled Climate Model

Abstract ID : 713

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Qing Bao ,baoqing@mail.iap.ac.cn ,(Associate Professor) ,China ,Beijing ,Not Presenting[1]

Dr. Bian He ,heb@lasg.iap.ac.cn ,(None) ,China ,Beijing ,Not Presenting[2]

Mr. Xiaocong Wang ,wangxc@mail.iap.ac.cn ,(None) ,China , ,Not Presenting[1]

Dr. Yimin Liu ,lym@lasg.iap.ac.cn ,(None) ,China ,Beijing ,Not Presenting[4]

Prof. Guoxiong Wu ,gxwu@lasg.iap.ac.cn ,(Professor) ,China ,Beijing ,Not Presenting[5]

1 - IAP 2 - LASG/IAP 3 - IAP 4 - LASG, Institute of Atmospheric Physics, CAS 5 - LASG, Institute of Atmospheric Physics, CAS

FGOALS-f is a next-generation Climate System Model from the Institute of Atmospheric Physics (IAP) State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), which is features of high-resolution up to 0.25° globally and a new scheme of resolving cumulus processes. The present climate control run has been carried out on China's Tianhe-2 machine for 50-year simulation, and AMIP type run has been done for the tropical cyclone evolution. The model behaviors of the major tropical precipitation characteristics have been investigated using the high-resolution TRMM-based precipitation products, SST products and tropical cyclone best track data (IBTrACS). The evolution of tropical systems includes ITCZ, MJO/TISO, ENSO teleconnection, the frequency and intensity of tropical daily precipitation, and tropical cyclone/typhoon. The results indicate that 0.25° FGOALS-f mitigates the double ITCZ problem, and well reproduces the eastward propagating MJO in the boreal winter and northward propagating TISO over equatorial Indian ocean in the boreal summer, which are taken as the long-standing challenges in the field of climate modeling. ENSO teleconnection pattern is demonstrated by the leading mode of SST in the interannual timescale. FGOALS-f gives not only a reasonable pattern but also the realistic explained variance for EOF. the frequency and intensity of tropical daily precipitation are also comparable to TRMM products. Finally, the behavior of the tropical cyclone/typhoon is reported and the future of applications is discussed.

Intraseasonal Oscillation Enhances C5 Typhoon Occurrence over the Tropical Western North Pacific

Abstract ID : 774

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Huang-Hsiung Hsu ,hhhsu@gate.sinica.edu.tw ,(Research Fellow Research Center for Environmental Changes) ,Taiwan ,Taipei ,Not Presenting[1]

1 - Academia Sinica

This study reveals that the atmosphere-ocean coupled intraseasonal oscillation (ISO) enhances the occurrence frequency of Category 5 (C5) typhoons in the western North Pacific (WNP). Climatologically, the major region of C5 typhoon occurrence in the WNP is collocated with the intraseasonal variance of outgoing longwave radiation and tropical cyclone heat potential. The active convection and large ocean heat content associated with ISO create an environment conducive to the occurrence of C5 typhoons. Between 1980 and 2009, approximately 82% of C5 typhoons occurred when one or both of the two conditions were fulfilled. Our results suggest that, compared with the thermodynamic factor of ocean heat content, dynamic factors (i.e., convection and near-surface moisture convergence) within the favorable intraseasonal background state likely play a more influential role in inducing C5 typhoons.

On the vertical structure of IWC and 3D wind in deep tropical convection observed during the HIWC-HAIC-experiment at Darwin

Abstract ID : 1025

Conflict Declaration : None

Content Motivation : None

Additional Information : could also go in M05

Mr. Wolfram Wobrock ,w.wobrock@opgc.univ-bpclermont.fr ,(Professor) ,France ,Aubière ,Not Presenting[1]

Prof. Andrea Flossmann ,andrea.flossmann@uca.fr ,(Prof. Dr.) ,France ,Aubière ,Not Presenting[1]

1 - UCA 2 - UCA

From January to March 2014, the HIWC-HAIC experiment took place over Northern Australia [1]. Numerous flights were performed in convective clouds at 10 and 11 km altitudes. The French research aircraft (Falcon 20) was equipped with a 95 GHz Doppler Radar (Rasta) providing profiles of cloud reflectivity and 3D wind components from the surface up to 18 km.
These observations were confronted with model simulations of the bin resolved cloud scale model Descam [2]. The model was run with a resolution of 500 m in the horizontal direction and 200 m in the vertical up to 20 km. Individual cells observed were compared with respect to updraft speed, reflectivity and IWC. Contoured frequency with altitudes diagrams (CFAD) were plotted for each individual flight case, which typically lasted 2 to 3 hours. The same technique was applied for the simulation results. Agreements and discrepancies of this comparison will be discussed. A projection of the model results to the regions of strongest convection not accessible to aircraft measurements will also be presented.
Additional sensitivity studies were performed for the role of the aerosol particle number concentration on the evolution of the ice water content and the size distribution of the ice crystals.

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Meteorological impacts over the central Amazon basin due to mesoscale convective systems during the GoAmazon project

Abstract ID : 1037

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Amanda Rehbein ,salvati.rehbein@gmail.com ,(Student) ,Brazil ,Sao Paulo ,Not Presenting[1]

Dr. Tércio Ambrizzi ,ambrizzi@model.iag.usp.br ,(None) ,Brazil , ,Not Presenting[2]

1 - 2 - USP/São Paulo

Mesoscale convective systems (MCSs) are responsible for several impacts where they occur. They cause high precipitation rates, storms, strong winds, downbursts which may favor deforestation like those observed in the Amazon region. Also, they are responsible for vertical exchanges of mass and momentum, latent heat release, acting as an energy source to generate waves. The Amazon basin is a natural nursery for the formation of MCSs, once it provides the basic ingredients for their formation, such as, heat and moisture. Despite their importance in local and global terms, it is difficult to identify and quantify the immediate impacts of MCSs. This is because these systems must pass over the monitoring sites to measure precipitation, temperature drop, pressure, gases, such as ozone, or other meteorological variables. A recent experiment called GoAmazon project provided two years of continuous data (2014 and 2015) in some specific sites over the Amazon basin allowing the comparison of MCSs occurrence and meteorological variables. The present study aims to analyze how MCSs may impact the meteorological variables collected during the GoAmazon project. Using the algorithm Forecasting and Tracking the evolution of Cloud Clusters (ForTraCC) and high resolution infrared satellite images, it was identified 105 MCSs over at least one of the 9 GoAmazon stations. The data available were analyzed along with the life cycle of these systems. Results showed that the MCSs influence the temperature, pressure, wind speed and direction, as well as ozone and other gases during their passages over the sites. However, it was noted that not all MCSs cause precipitation, because rainfall associated with them depends on their life cycle phase and proximity to the meteorological station. This study shows the impact of MCSs on the meteorological and environmental variables of the central region of the Amazon Basin.

The seasonal cycle over equatorial Africa

Abstract ID : 1130

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Sharon Nicholson ,snicholson@fsu.edu ,(professor) ,United States ,Tallahassee ,Not Presenting[1]

1 - Florida State University

It has long been assumed that the seasonal cycle of rainfall in equatorial Africa is controlled by a bi-annual passage of the Intertropical Convergence Zone. This is consistent with the bimodal rainfall regime that prevails in equatorial Africa. However, an analysis of circulation and rainfall shows that this paradigm is untenable. Moreover, it arose in a very haphazard manner, a legacy of early attempts to make sense of the tropical rainfall regime. In most of the region a distinct low-level convergence zone is not apparent in either rainy season. Other factors are seen to play a major role in creating the seasonal cycle and they are very different in eastern, central and western equatorial Africa. These factors are described.

Gravity waves in a moist atmosphere: A mechanistic picture

Abstract ID : 1266

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Nili Harnik ,harnik@post.tau.ac.il ,(None) ,Israel , ,Not Presenting[1]

Dr. Joy Monteiro ,joy.merwin@gmail.com ,(None) ,Sweden , ,Not Presenting[2]

Prof. Rodrigo Caballero ,rodrigo@misu.su.se ,(None) ,Sweden , ,Not Presenting[3]

1 - University of Tel Aviv 2 - MISU 3 - Stockholm University

Motivated by the need to understand the influence of convection on tropical variability, the interaction between gravity and Kelvin waves and moisture in a shallow water model is analyzed with an emphasis on physical interpretation. Convection is representated by a simple Betts-Miller type relaxation, and analytical solutions for the influence of moisture on wave speed and stability are obtained, both at the limit of a vanishing convective relaxation timescale (or ``strict quasi-equilibrium'' (SQE)) and for finite relaxation timescales. We show that the moisture and convergence are necessarily in-phase at the SQE limit, and that this phase relationship necessarily changes when SQE is relaxed. A relaxation timescale dependent ``gross moist stability'' and equivalent depth are derived for both one-dimensional gravity waves and Kelvin waves. In particular, we show that rotation constrains moist Kelvin waves to be unconditionally stable at the SQE limit in our system. The wavenumber dependence of the effect of moisture is also analyzed, and it is seen that for any given value of the convective relaxation time, larger scale waves are always closer to SQE than the smaller scale waves, as a natural consequence of the equivalence between SQE and the moisture-convergence phasing. The phasing between the height, convergence and moisture fields is calculated, and the behavior of moist gravity and Kelvin waves for finite relaxation timescales is explained using the phase differences between the various fields. Using this analysis, mechanistic explanations are provided for previous work with 3-dimensional models showing acceleration and damping of Kelvin waves as the relaxation time increases.

Key features of named subtropical cyclones over the southwestern South Atlantic Ocean

Abstract ID : 1343

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Rosmeri Porfírio da Rocha ,rosmerir@model.iag.usp.br ,(None) ,Brazil , ,Not Presenting[1]

Dr. Michelle Reboita ,reboita@gmail.com ,(researcher) ,Brazil ,Itajuba ,Not Presenting[2]

Dr. Tércio Ambrizzi ,ambrizzi@model.iag.usp.br ,(None) ,Brazil , ,Not Presenting[3]

1 - University of São Paulo 2 - Unifei 3 - USP/São Paulo

Subtropical cyclones are hybrid systems since they present warm core at low levels, as tropical cyclones, and cold core at upper levels, as extratropical cyclones. Moreover, the maximum sustained winds occur farther from the storm center different from the tropical cyclones and they do not have fronts as the extratropical cyclones. The subtropical cyclones can have genesis as a proper subtropical system or from the transition of extratropical to subtropical or tropical to subtropical cyclone. In the southwestern South Atlantic Ocean (SAO) the first named cyclone was Anita in March, 2010. This name was given by an agreement among the meteorological centers from Brazil. Only after this system, the Brazilian Navy Hydrographic Center passed to assign names to tropical and subtropical systems occurring in SAO. A threshold for it is the sustained wind speed, which must be at least 65 km/h. After Anita, the other named systems were: Arani (November, 2011), Bapo (February, 2015), Cari (March, 2015), Deni (November, 2016) and Eçaí (December, 2016). In this context, the purpose of this work is to describe the main features of the environment in that these systems developed. For this goal, Global Forecast System analyses were used. From these six systems, only Eçaí developed from an extratropical transition. The others started as a pure subtropical cyclone. All these systems formed between southeast and south coast of Brazil and in a region with moisture flux convergence extending, in general, from the continent to the ocean. The main features of the vertical structure of the six subtropical cyclones will also be presented.

Convective outbreaks over southern Africa and the regional circulation

Abstract ID : 1386

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Neil Hart ,neil.hart@ouce.ox.ac.uk ,(Postdoctoral Research Assistant) ,United Kingdom ,Oxford ,Not Presenting[1]

Prof. Richard Washington ,richard.washington@ouce.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Ross Maidment ,r.i.maidment@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. Rachel Stratton ,rachel.stratton@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[4]

1 - University of Oxford 2 - Oxford University 3 - University of Reading 4 - Met Office

This paper investigates the relationship between organised convection and the regional circulation over southern Africa with the aim of isolating the spatial scales of convection at which the relationship first becomes evident and the sensitivity of this answer to data sets. The southern African setting provides an intriguing template for the question. An elevated plateau, mostly in excess of 1500m altitude, extends sufficiently far southward to support wide-spread and evidently organised outbreaks of convection well into the subtropics. In addition to producing much of the local rainfall, these systems substantial modify the tropospheric heating through direct adjustments to the terms of the radiation budget and strong mid-level latent heating. We use a 35-year satellite-derived daily estimate of convective activity in order to characterise the convective outbreaks over southern Africa. Based on a range of spatial scales of convection, we examine accompanying semi-independent reanalysis data for evidence of concomitant organisation of low and mid-level circulation. We anticipate a break in scale of convection beyond which this relationship becomes obvious, particularly so at the near planetary scale of Tropical-Temperate Troughs which connect large-scale tropical convection with midlatitude transients to form coherent bands of convective cloud spanning the subtropics. The relationship established in the case of satellite and reanalysis data is assessed via a suite of GCM and RCM simulations including a convective-permitting climate simulation covering the African Continent at approximately 4km gird-spacing. Unlike the satellite and reanalysis data these simulations are internally consistent and may reveal differing thresholds at which the relationship between convection and the regional circulation becomes clear. We conclude by discussing the implications of the study for coarser spatial resolution climate models.

M011 - The Seasonal Cycle over the African Continent and Adjoining Oceans, Today and in the Past

The onset and cessation of seasonal rainfall over Africa

Abstract ID : 117

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Caroline Dunning ,c.m.dunning@pgr.reading.ac.uk ,(PhD Student) ,United Kingdom ,None ,Not Presenting[1]

Prof. Richard Allan ,r.p.allan@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Emily C.L. Black ,e.c.l.black@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Reading 2 - University of Reading 3 - University of Reading

The timing and seasonality of precipitation is of critical importance to the many African stakeholders who depend upon the seasonal rains for agricultural and domestic purposes. Failure or delays of these rains can lead to significant socio-economic impacts. A methodology for objectively determining the onset and cessation of multiple wet seasons across the whole of Africa has been developed and tested using five observational data sets and the ERA-Interim reanalysis. Compatibility with known physical drivers of African rainfall, consistency with indigenous methods, and generally strong agreement between satellite-based rainfall data sets confirm that the method is capturing the correct seasonal progression of African rainfall. The biannual rainfall regime is correctly identified over the southern West African coastline. This methodology is applicable to multiple data sets and to large regions, including those that experience multiple rainy seasons. As such, it provides a means for investigating both seasonal-interannual variability and long-term change in precipitation seasonality over the whole of Africa. The method is used to examine the representation of the seasonality of African precipitation in CMIP5 model simulations. Overall, AMIP and CMIP historical simulations represent essential aspects of the seasonal cycle; patterns of seasonal progression of the rainy season are captured, and for the most part mean model onset/ cessation dates agree with mean observational dates to within 2 weeks. However, unlike the AMIP simulations, the CMIP historical simulations do not capture the biannual regime over the southern West African coastline. Regions where climate models can be used with confidence to examine seasonality are identified, but results indicate that it is not possible to establish robust continental-scale projections of seasonality using CMIP5 coupled models.

The annual cycle of ocean to atmosphere turbulent flux of moisture in the Agulhas current system

Abstract ID : 231

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Arielle Stela Nkwinkwa Njouodo ,a.nkwinkwa@yahoo.fr ,(PhD Student) ,South Africa ,Cape Town ,Presenting[1]

Prof. Johnny Johannessen ,johnny.johannessen@nersc.no ,(None) ,Norway , ,Not Presenting[2]

Prof. Mathieu Rouault ,Mathieu.Rouault@uct.ac.za ,(Professor) ,South Africa ,Cape Town ,Not Presenting[3]

1 - University of Cape Town 2 - Nansen Environmental and Remote Sensing Centre 3 - University of Cape town

The dynamics of ocean-atmosphere interaction above the Agulhas Current is not well-known. We are using data from observations (NOCS), climate reanalysis (CFSR, MERRA-2, ERA-Interim, NCEP-R2 and ERA-40) and satellite remote sensing (HOAPS3, SEAFLUX) to study the annual cycle of turbulent latent heat flux in the Agulhas Current system. We first assess if the various dataset do represent the intense exchange of moisture that occurs above the core of the Agulhas Current and the Retroflection region. We are using monthly fields of latent heat flux (LHF, also called turbulent flux of moisture), sea surface temperature (SST), surface wind speed, saturated specific humidity (Qsst) and specific humidity at 10m (Q10). We also use MODIS SST and the satellite derived QuikSCAT SCOW wind climatology as reference for SST and surface wind. We conduct an inter-comparison of all those products in the Agulhas system. CFSR LHF and MERRA-2 LHF are similar to SEAFLUX. Compared to MODIS SST, all products underestimate the core of the Agulhas Current SST. The main difference between products is due to the difference in Q10. Reanalysis NCEP-2 and ERA-40 have lower SST in the core of the Agulhas Current due to their low resolution. NOCS is quite different from all other products with an inverse annual cycle compared to the rest. We study the annual cycle of LHF and its drivers in four locations: three in the Agulhas Current offshore Durban, offshore Port Elizabeth, in the Retroflection area and one offshore Cape Town outside of the Agulhas system. The highest LHF is 250 W/m² in the Retroflection in winter for all products except NOCS (100 W/m²). The lowest is 100 W/m² off Port Elizabeth in summer. To understand the drivers of LHF, we analyzed SST, QSST, Q10 and wind speed in the fourth locations. Offshore Port Elizabeth and in the Retroflection area, the annual cycle of LHF follows the wind speed which is not the case for Durban where Qsst-Q10 is the main driver of the amplitude of the annual cycle of LHF. Both Qsst-Q10 and wind speed drive the annual cycle of LHF off Port Elizabeth.

Recent changes in the South Atlantic anticyclone and impacts on regional wind patterns

Abstract ID : 604

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ross Blamey ,ross.blamey@uct.ac.za ,(PDRF) ,South Africa ,Cape Town ,Not Presenting[1]

Dr. Jennifer Veitch ,veitch.jennifer@gmail.com ,(None) ,South Africa , ,Not Presenting[2]

Dr. Fabien Desbiolles ,fabien.desbiolles@uct.ac.za ,(None) ,South Africa , ,Not Presenting[1]

Dr. Juliet Hermes ,juliet@saeon.ac.za ,(None) ,South Africa ,None ,Not Presenting[2]

Prof. Chris Reason ,chris.reason@uct.ac.za ,(None) ,South Africa , ,Not Presenting[1]

1 - University of Cape Town 2 - SAEON 3 - University of Cape Town 4 - SAEON 5 - University of Cape Town

The austral summer (December-February) wind regime along the west coast of southern Africa is driven predominantly by the pressure gradient between the South Atlantic anticyclone (SAA) and the thermal low pressure that forms over the continent. The resultant alongshore (south-easterly) winds adjacent to this stretch of coastline generate coastal upwelling, giving rise to cold, nutrient-rich surface waters that support the diverse marine ecosystem as well as a productive fishing industry. Evidence suggests that over the past few decades there has been a southward shift in the location of the SAA, which has influenced the local wind regime. Using an ensemble of reanalysis datasets, the seasonal cycle of the SAA is revisited and its apparent poleward shift is investigated. Results indicate that the shift can be associated with a positive trend in the Southern Annual Mode (SAM). There is also evidence that the strength and position of the Hadley circulation (weakening and expanding) is having an influence on local coastal upwelling patterns through the modulation of the SAA. What is not clear is whether the modulation of the SAA seen here is attributed to natural climate variability or anthropogenic climate change. The shift in the SAA is also evident in changes in the local wind patterns experienced over the Benguela upwelling system. A better understanding of the role of changes in the SAA on the Benguela upwelling system, whether natural or human-induced, will assist policy-makers in the development of appropriate marine management and mitigation strategies.

The Seasonal Cycle of the Angola Low

Abstract ID : 698

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Emma Howard ,emma.howard@ouce.ox.ac.uk ,(DPhil Student) ,United Kingdom ,Oxford ,Not Presenting[1]

1 - Oxford University

The Angola Low has been proven to have an important modulating role on the development of Temperate Tropical Troughs and Southern African Precipitation. However, the Angola Low is not a well understood feature of Southern African Climate. The exact mechanism with which it forms and evolves during the summer months - over which it ebbs and wanes periodically - is unknown. The Angola low exhibits a marked transition in December where it shifts from a dry convection driven heat low to a tropical low associated with latent heat release.

This work attempts to diagnose the mechanism of the Angola Low by considering the relative and potential vorticity budgets of the ERA-Interim and NCEP2 reanalysis datasets and in various atmospheric models. The seasonal evolution from the early summer heat low to the late summer tropical low will be carefully examined.

A novel idealised model of the Southern African climate designed to elucidate the fundamental dynamics of the Angola Low will be presented. This model has been designed so that it may act as a framework to test the role of surface heating, latent heat release, local topography and large scale circulation in setting up and maintaining the Angola Low. The modelled characteristics of the idealised low, including the relative and potential vorticity, will be compared to several reanalysis datasets. The model results from two forcing configurations will be presented, one representing spring and early summer and the other representing autumn and late summer. This will provide insight into the seasonal transition of the Angola Low.

On the seasonal cycle of the structure of the large-scale circulation over central Africa and its adjacent Oceans

Abstract ID : 1207

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Georges-Noel T. Longandjo ,gntiers@gmail.com ,(Researcher) ,South Africa ,Cape Town ,Not Presenting[1]

1 - University of Cape Town

In this paper, we used both reanalysis datasets and a state-of-art atmospheric climate model forced by SST (ECHAM version 5.3) to analyze what is the structure of the large-scale circulation over central Africa (07^{o}-33^{o}E; $15S^{o}$-10^{o}N) and its adjoining Oceans and how does it form and what do drive it. To do so, we compute the meridional-mean zonal mass-streamfunctions as mostly used (Cook, 2003; Oort and Yienger, 1996; Quan et. 2004). All datasets show, at low-levels, an existence of a zonal overturning circulation thermally direct, with a maximum and minimum intensity values in April and August, while its extension reaches the maximum in August and minimum in February respectively. However, there is no consistent trends in intensity and extension among datasets. In contrast, the eastern edge longitude of the central Africa zonal overturning cell has a tendency of shrinking in all datasets. On the other hand, no direct relationship between intensity and rainfall at annual and monthly time scale.
Nevertheless, when representing the meridional-mean zonal mass-streamfunctions in isentropic coordinates, it emerges that surrounding Oceans are not only the main suppliers of atmospheric moisture over central Africa, with cooler and warmer moist air from Atlantic and Indian Oceans respectively. But they might play crucial role in either to maintain or to regulate the westward (eastward) propagation of central Africa zonal overturning cell. In fact, based on the near-surface temperature gradient and less atmospheric moisture between central Africa inland and the adjoining Oceans, the unsaturated air uplifts dry adiabatically so that the low surface pressure over central Africa triggers a converging monsoon-like circulation at low-level. In the same time, aloft 700- hPa, the warm air flows westward, before subsiding over Atlantic Ocean. However, the seasonal displacement of the zonal ITCZ location is strongly related to the low surface pressure over central Africa, which in turn, is controlled by the zonal atmospheric energy transport. More interestingly, the zonal atmospheric energy transport seems to be a measure of the central Africa overturning cell, in terms of its strength, width and edge longitudes. So, the ECHAM5.3 simulation provides a support to this mechanism.

The annual cycle of rainfall in South Africa and its variabilty

Abstract ID : 1272

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Mathieu Rouault ,Mathieu.Rouault@uct.ac.za ,(Professor) ,South Africa ,Cape Town ,Not Presenting[1]

1 - University of Cape town

The annual cycle of rainfall in Southern Africa offer a great variability in timing and intensity. Much of the precipitation received in summer is of convective origin forced by large-scale dynamics. Southern Africa has a subtropical climate and is affected by temperate and tropical weather systems. It is under the influence of the Southern Hemisphere high pressure system, but in summer, a heat low is found over the interior. This helps to break the subsidence associated with high pressure systems which prevent rain to occur. Most of the interior lies on an elevated plateau and orography play an important role. The southwest region gets most of its rainfall in austral winter through temperate systems while the rest of Southern Africa gets most of its rainfall in austral summer. A marked sea-surface temperature gradient exists along the Southern African coast from the west, where a strong upwelling cools the coastal area, to the east where the Agulhas Current and Mozambique Channel bring warm water southwards. The Ocean has an important role on rainfall and moisture transport and Southern Africa which is also influenced by the Pacific Ocean which drive a high interannual variability of rainfall and temperature. The climate of southern Africa is highly variable and vulnerable to extremes such as droughts and floods. Although there is no particular relation between strength of El Nino and intensity and spatial extension of droughts, 10 of the 10 strongest droughts since 1900 happened during the mature phase of El Nino. However El Nino led to a severe drought only half of the time in Southern Africa. In general, annual mean rainfall is overestimated by Regional Climate Model over Southern Africa and Ocean Atmosphere Global coupled model. At last coupled model used by IPCC during CMIP5 do not represent the mechanisms associating El Nino and droughts very well and sometimes the opposite effect is simulated.

How is the seasonal cycle of tropical-extratropical cloud bands in the SICZ perturbed?

Abstract ID : 1401

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Neil Hart ,neil.hart@ouce.ox.ac.uk ,(Postdoctoral Research Assistant) ,United Kingdom ,Oxford ,Not Presenting[1]

Prof. Richard Washington ,richard.washington@ouce.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Prof. Chris Reason ,chris.reason@uct.ac.za ,(None) ,South Africa , ,Not Presenting[3]

1 - University of Oxford 2 - Oxford University 3 - University of Cape Town

The seasonal cycle of subtropical rainfall manifests an interplay between mid-latitude and tropical processes. Mid-latitude dynamics are in the first order related to variability in the westerly flow which supports a wide spectrum of wave activity. Tropical process are more strongly associated with variations in vertical instability. In the Southern Hemisphere subtropics, pronounced interaction between the mid-latitude and tropical processes occurs in three subtropical convergence zones in each of the main ocean basins. This study focuses on the weakest of the three: the South Indian Convergence Zone (SICZ). Synoptically, the SICZ is expressed in tropical-extratropical (TE) cloud bands which are frequent during austral summer. As with the other subtropical convergence zones, these cloud bands manifest as large-scale regions of deep convection which link the tropics to the extratropics. Dynamically such systems develop along leading edges of low-latitude upper-level westerly waves overlying moist static instability in the lower troposphere. The SICZ is characterised by two preferred locations for the development of these TE cloud bands, one rooted over southern Africa and another rooted over Madagascar. The seasonal cycle shows a November peak in cloudband likelihood over southern Africa before decaying weakly through the summer. For the Madagascan location, the seasonal cycle is weakly bimodal with peaks in November and March. Summers in which strong ENSO events develop substantially perturb the seasonal climatology of cloudband likelihood, especially in the southern African location. This often leads to severe drought and the mechanisms of this teleconnection remain actively researched. In this study we show how the likelihood of TE cloud bands is linked to the magnitude of moist static instability in the SICZ and the presence of a local subtropical jet that is separated from the poleward eddy-driven jet. By tracking the seasonal cycle of moist static instability and subtropical jet separation, we elucidate the reason behind the asymmetric seasonal cycle of southern African cloud bands which peak in early summer. This understanding helps conceptualize the way in which ENSO seasons perturb cloudband likelihood. Furthermore, this conceptual model provides an approach to explain the diversity of SICZ seasonal cycles simulated by GCMs.

20th-Century Climate Change over Africa: Seasonal Variation in Hydroclimate Trends and Sahara Extent

Abstract ID : 1437

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Sumant Nigam ,nigam@umd.edu ,(Professor of Atmospheric & Oceanic Science; Jefferson Science Fellow, US National Academy of Science, Engineering, and Medicine) ,United States ,Potomac ,Presenting[1]

Ms. Natalie Thomas ,nataliepthomas1@gmail.com ,(None) ,United States , ,Not Presenting[1]

1 - University of Maryland 2 - University of Maryland

Twentieth-century trends in seasonal temperature and precipitation over the African continent are analyzed from observational data sets and historical climate simulations. Given the agricultural economy of the continent, a seasonal perspective is adopted as it is more pertinent than an annual-average one which can mask off-setting but agriculturally-sensitive seasonal hydroclimate variations. Examination of linear trends in seasonal surface air temperature (SAT) shows that heat stress has increased in several regions, including Sudan and Northern Africa where largest SAT trends occur in the warm season. Broadly speaking, the northern continent has warmed more than the southern one in all seasons. Precipitation trends are varied but notable declining trends are found in the countries along the Gulf of Guinea, especially in the source region of Niger river in West Africa, and in the Congo river basin. Rainfall over the African Great Lakes - one of the largest freshwater repositories - has, thankfully, increased.

We show that the Sahara Desert has expanded significantly over the 20th century - by 12-20% depending on the season. The desert expanded southward in summer, reflecting retreat of the northern edge of the Sahel rainfall belt; and to the north in winter, indicating potential impact of the widening of the Tropics. Specific mechanisms driving the expansion in each season are investigated. Finally, this observational analysis is used to evaluate the state-of-the-art climate models from the comparison of the 20th-century hydroclimate trends with those manifest in historical climate simulations. The evaluation shows that modeling regional hydroclimate change over the Africa continent remains challenging.

How well do climate models simulate the seasonal cycle over Africa?

Abstract ID : 1469

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Rachel James ,rachel.james@eci.ox.ac.uk ,(Research Fellow (University of Oxford) Visiting Researcher (University of Cape Town)) ,South Africa ,Cape Town ,Not Presenting[1]

Prof. Richard Washington ,richard.washington@ouce.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Mr. Babatunde Abiodun ,babiodun@csag.uct.ac.za ,(Senior Lecturer) ,South Africa ,Cape Town ,Not Presenting[3]

Dr. Gillian Kay ,gillian.kay@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. Joseph Mutemi ,jnmutemi@yahoo.co.uk ,(None) ,Kenya , ,Not Presenting[5]

Dr. Wilfried Pokam ,wpokam@yahoo.fr ,(None) ,Cameroon , ,Not Presenting[6]

Dr. Neil Hart ,neil.hart@ouce.ox.ac.uk ,(Postdoctoral Research Assistant) ,United Kingdom ,Oxford ,Not Presenting[1]

Dr. Guleid Artan ,gartan@icpac.net ,(None) ,Kenya , ,Not Presenting[8]

Dr. Cath Senior ,cath.senior@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[4]

1 - University of Oxford 2 - Oxford University 3 - CSAG, UCT 4 - UK Met Office 5 - University of Nairobi 6 - University of Yaounde I 7 - University of Oxford 8 - IGAD Climate Prediction & Applications Centre 9 - UK Met Office

Despite the level of interest and expertise in the seasonal cycle over Africa, there is a relatively poor understanding of how it is represented in climate models. The vast majority of climate models have been developed outside of Africa, and mid-latitude processes have historically received more attention. Tropical phenomena, such as organised convection, and strong teleconnections to local and remote sea-surface temperatures, are still a struggle for global climate models. Targeted model evaluation, focusing on processes which matter for Africa, has the potential to vastly improve understanding of how models behave in African regions. Process-based, region-specific, evaluation could provide insights for model development, and inform confidence assessments, helping discern which, if any, climate projections can be trusted for adaptation planning.

The most important processes to evaluate may be different for every region. Collaboration with experts in African research institutions and met services is therefore crucial. Here we report on a concerted effort to better evaluate and improve the UK Met Office Unified Model over Africa, though collaboration between the UK modelling centre and African scientists. For each of Central, East, Southern, and West Africa, we review current understanding of climate models, and demonstrate an example of targeted evaluation. The seasonal cycle is an important aspect of this evaluation: including an analysis of the progression of the monsoon season over West Africa, and the seasonal cycle of tropical-extratropical cloud bands over southern Africa. A better understanding of the

modelled seasonal cycle may be a productive route towards assessing model capabilities on other timescales, including interannual variability and future change.

Our analysis is based on the Met Office Unified Model, but using diagnostics which might be applied to other models, and could contribute towards a hub of metrics for African climate. We encourage collaboration between model developers and African scientists to deliver such a hub, else models continue to develop without progress for this important continent. There are already plans underway to automate evaluation for the next generation of climate models: it is an opportune time to consider how this can include metrics which are important for Africa.

M012 - Middle Atmosphere Symposium (ICMA)

Future changes in large-scale tracer transport in the upper troposphere and lower stratosphere (UTLS)

Abstract ID : 77

Conflict Declaration : None

Content Motivation : None

Additional Information : Please find attached my application for travel funding.

Dr. Marta Abalos ,abalos@ucar.edu ,(Postdoctoral researcher) ,United States ,Boulder, CO ,Not Presenting[1]

Mr William Randel ,randel@ucar.edu ,(None) ,United States , ,Not Presenting[1]

Mr Douglas Kinnison ,dkin@ucar.edu ,(None) ,United States , ,Not Presenting[1]

Mr Garcia Rolando ,rgarcia@ucar.edu ,(None) ,United States , ,Not Presenting[1]

1 - NCAR 2 - NCAR 3 - NCAR 4 - NCAR

Long-term (1955-2099) simulations of the Whole Atmosphere Community Climate Model (WACCM) carried out for the Chemistry-Climate Model Initiative (CCMI) are used to investigate future changes in large-scale transport. In order to isolate transport changes from future changes in emissions and chemical processes, we focus on the artificial passive tracer e90, specifically designed to highlight the transition region between troposphere and stratosphere. The e90 tracer has constant and homogeneous emissions at the surface and decay time scale throughout the atmosphere, such that trends in e90 are exclusively due to changes in transport. The results show increased e90 concentrations in the lower stratosphere and reduced concentrations in the troposphere. These trends emphasize a key role of the rising tropopause height with climate change, which despite being a small altitude change (~30 m/decade), has a strong impact on UTLS dynamics and thus tracer transport. The tracer trends are then traced back to changes in the different transport terms, including resolved processes (meridional residual circulation and eddy transport) and sub-grid parameterized processes.

Decadal changes of age of air, tracers, ozone, and ozone-depleting substances, and their link to stratospheric circulation changes

Abstract ID : 96

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Gabriele Stiller ,gabriele.stiller@kit.edu ,(Senior Scientist/Group Head) ,Germany ,Karlsruhe ,Not Presenting[1]

1 - Karlsruhe Institute of Technology

Monthly zonal mean distributions of tracers, ozone, ozone-depleting substances, and age of stratospheric air have been derived from ten years of global observations with the MIPAS/Envisat instrument. They reveal systematic decadal variations, showing up as hemispherically asymmetric patterns if characterized as linear trends. This has been demonstrated recently from MIPAS observations (Stiller et al., 2012; Haenel et al., 2015; Eckert et al., 2014; Kellmann et al., 2012; Chirkov et al., 2016, Glatthor et al., 2016), but also from independent measurements (Mahieu et al., 2014; Nedoluha et al., 2015; Harrison et al., 2015). We demonstrate that these patterns can be explained by a shift of the stratospheric circulation over the time of the MIPAS observation period. We show that the subtropical transport barriers were shifted southward by about 5 degrees from 2002 to 2012, resulting in a shift of the global distribution patterns. The southward shift can explain the changes in ozone, CFC-11, CFC-12, HCFC-22, N2O, COS, NOy, and age of air. If trends of ozone or trace gases are calculated without taking the variations in circulation as demonstrated here into account, unrealistic and inconsistent trends are derived as a consequence. As an example, the observed increase of tropical lower stratospheric ozone around 20 km might be interpreted as a sign for a slow-down of the Brewer-Dobson circulation. However, it comes together with a decrease of the age of stratospheric air at that location (i.e. acceleration). This discrepancy is overcome when the shift of the circulation pattern is taken into account.

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Does stratospheric sudden warming occur more frequently during ENSO winters than during ENSO-neutral winters?

Abstract ID : 104

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Seok-Woo Son ,seokwooson@snu.ac.kr ,(Associate Professor) ,South Korea ,Seoul ,Not Presenting[1]

Mr Kanghyun Song ,kanghyunsong@snu.ac.kr ,(None) ,South Korea , ,Not Presenting[1]

1 - Seoul National University 2 - Seoul National University

Stratospheric sudden warming (SSW) events exhibit pronounced interannual variability. Based on WMO definition, it has been suggested that SSW events occur more preferably during El Niño-Southern Oscillation (ENSO) winters (both El Niño and La Niña winters) than during ENSO-neutral winters. This relationship is re-evaluated here by considering six different definitions of SSW. For all definitions, SSW events are detected more frequently during El Niño winters than during ENSO-neutral winters, in consistent with a strengthened planetary-scale wave activity. However, such systematic relationship is not found during La Niña winters. While two SSW definitions, including WMO definition, show a higher SSW frequency during La Niña winters than during ENSO-neutral winters, other definitions show no difference or even lower SSW frequency. This result is insensitive to the choice of reanalysis datasets and ENSO index, indicating that the reported ENSO-SSW relationship is not robust but dependent on the details of the SSW definition. The definition-defendant ENSO-SSW relationship is discussed in terms of different background wind and different planetary-scale wave forcings during El Niño- and La Niña-winter SSW events. Other issues of SSW definitions such as the application to climate models are also discussed.

Another Approach to Stratospheric Circulation: The Direct Inversion of the Continuity Equation

Abstract ID : 148

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Thomas von Clarmann ,thomas.clarmann@kit.edu ,(Head of research group) ,Germany ,Karlsruhe ,Not Presenting[1]

Dr. Udo Grabowski ,udo.grabowski@kit.edu ,(None) ,Germany , ,Not Presenting[1]

1 - KIT/IMK 2 - KIT/IMK

Two-dimensional concepts of the middle atmosphere has many applications, including investigations of stratospheric exchange, the analysis of the Brewer-Dobson circulation, or the subsidence of mesospheric air into the stratosphere, which is responsible for the indirect effect of energetic particle precipitation. As an empirical tool for inverstigation of stratospheric circulation, we propose to directly invert the two-dimensional continuity equation to obtain from global tracer measurements information on the advection vectors and mixing coefficients. This is, besides sequential or variational data assimilation or inverse modelling of sources, another independent category of inverse techniques. We have applied this method to global two-dimensional tracers fields measured by the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS). The resulting two-dimensional field of advection vectors has a spatial sampling of 4 degrees in latitude and 5 km in altitude, and the time resolution of the current tests is one month. Results reproduce the expected atmospheric features like major warmings, overturning mesospheric circulation, mesospheric intrusions, the tropical pipe as well as the upper and lower branch of the Brewer-Dobson circulation. Furthermore, the results are roughly consistent with measurements of the mean age of stratospheric air, which all gives confidence in this novel method. We propose to use resulting advection vectors and mixing coefficients to diagnose atmospheric processes in a more detailed manner than it was possible with the conventional empirical methods and to get more specific information about discrepancies between models and measurements than one would get with the analysis of the mean age of stratospheric air. This method is empirical because it allows to infer the atmospheric circulation without using any dynamical model. Both the method and results will be presented. Future developments will be discussed. These include the refinement of the treatment of sinks of the tracers, the extension of the method towards three spatial dimensions, and the inclusion of data other than MIPAS data.

Stratospheric Influence on Moist Convection in a Minimal Model of QBO-like Oscillation

Abstract ID : 161

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Shigeo Yoden ,yoden@kugi.kyoto-u.ac.jp ,(None) ,Japan ,Kyoto ,Not Presenting[1]

1 - Kyoto University

A self-sustained oscillation which is dynamically analogous to the equatorial quasi-biennial oscillation (QBO) was firstly obtained as a radiative-moist-convective quasi-equilibrium state in a minimal model of the stratosphere-troposphere coupled system by Held et al.(1993), and the robust feature of the oscillation, not sensitive to the choice of model configurations or top and bottom boundary conditions, was confirmed by Yoden et al.(2014). The minimal model is a two-dimensional cloud-system-resolving nonhydrostatic model without Coriolis effect, under a periodic lateral boundary condition to permit the oscillation of zonal mean zonal wind. The QBO-like oscillation shows downward propagation of the zonal mean signals in the stratosphere as observed, and also the periodic variations of organized features of moist-convective systems associated with the periodic variation of the mean zonal wind in the troposphere.
In this study, downward influence of the stratospheric QBO-like oscillation to moist convection is further investigated with the same minimal model in two series of parameter sweep experiments; *model top experiments* and *low-level nudging experiments*. In the model top experiments in which the height of top boundary is reduced, QBO-like oscillations are obtained even in the low top cases with oscillations of the mean zonal wind only in the troposphere. In the low-level nudging experiments, on the other hand, the zonal mean component of the zonal wind is nudged to 0 m/s in a certain depth from the bottom boundary to investigate the impact of the vertical shear of the mean zonal wind near the surface on the evolution of convective systems and the mean zonal wind oscillation.
The results show that the QBO-like oscillation modulates the convection via two mechanisms related to the vertical shear of zonal mean zonal wind. Large values of shear near the surface enhance the longevity and intensity of the convective systems in the form of squall line type. On the other hand, large values of shear near the cloud top disrupt the convective structure and leads to a smaller amount of precipitation. The first mechanism seems to be dominated, as the second one is revealed only when the low-level shear is nudged to some certain levels.

Transient stratospheric circulation changes in a grand ensemble of idealized CO2 increase experiments

Abstract ID : 207

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Elisa Manzini ,elisa.manzini@mpimet.mpg.de ,(None) ,Germany ,Hamburg ,Not Presenting[1]

Dr. Alexey Yu. Karpechko ,Alexey.Karpechko@fmi.fi ,(None) ,Finland , ,Not Presenting[2]

Dr. Luis Kornblueh ,luis.kornblueh@mpimet.mpg.de ,(None) ,Germany , ,Not Presenting[1]

1 - MPIM 2 - Finnish Meteorological Institute 3 - MPIM

The yearly evolution with increasing forcing of the stratospheric circulation is examined in a 68-member ensemble of 1pctCO2 scenario experiments performed with the MPI-ESM model. Each member of the experiment ensemble is integrated for 155 years, from initial conditions taken from a 2000-yr long pre-industrial control climate experiment. The 1pctCO2 scenario experiments are conducted following the protocol of including as external forcing only a CO2 concentration increase at 1%/year, till quadrupling of CO2 concentrations (occurring at year 140). MPI-ESM is the Max-Planck-Institute Earth System Model (including coupling between the atmosphere, ocean and seaice), with top of the atmospheric component extending above the stratopause. By averaging over the 68 members (ensemble mean), atmospheric variability is greatly reduced. The yearly evolution of the ensemble mean therefore reveals trends in the circulations as the CO2 concentration increase. While indicators of global change show the expected monotonic evolution with increasing CO2 for the whole integration period, the stratospheric circulation changes do not, for the Northern winter season. We find that as the CO2 concentration increases above doubling, Northern winter trends in some indicators of stratospheric circulation changes decrease or even reverse, posing the question on what are the causes of this nonlinear behavior.

Simultaneous Observations of Noctilucent Clouds and Mesospheric Summer Echoes at a mid-latitude site (Kühlungsborn/Germany, 54°N)

Abstract ID : 208

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Michael Gerding ,gerding@iap-kborn.de ,(None) ,Germany ,Kuehlungsborn ,Not Presenting[1]

Prof. Franz-Josef Lübken ,luebken@iap-kborn.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Marius Zecha ,zecha@iap-kborn.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Jochen Zöllner ,jochen.zoellner@uni-rostock.de ,(None) ,Germany , ,Not Presenting[1]

Mrs. Kathrin Baumgarten ,k.baumgarten@iap-kborn.de ,(None) ,Germany ,Kuehlungsborn ,Not Presenting[1]

1 - Leibniz-Institute of Atmospheric Physics 2 - Leibniz-Institute of Atmospheric Physics 3 - Leibniz-Institute of Atmospheric Physics 4 - Leibniz-Institute of Atmospheric Physics 5 - Leibniz-Institute of Atmospheric Physics

Occurrence of ice particles in the high and mid-latitude summer mesopause region is an intriguing phenomenon that can be observed either optically as Noctilucent Clouds (NLC) / Polar Mesospheric Clouds (PMC) or by radar as (Polar) Mesosphere Summer Echoes ((P)MSE). The relation of both phenomena is well understood and incorporates, beside others, the size distribution within the ice cloud. Simultaneous observations therefore allow insights into atmospheric properties like temperature, humidity, winds, turbulence, and electron density. Unfortunately, co-located observations of NLC and PMSE are mainly limited to polar latitudes, while data from mid-latitudes are lacking mainly due to instrumental limitations. Since 2010 we operate a daylight capable RMR lidar at our site at Kühlungsborn/Germany (54°N, 12°E) for optical observations of NLC during night and day, i.e. independent from solar elevation. In combination with the co-located OSWIN radar we are for the first time able to compare the occurrence and altitude structure of NLC and MSE at mid-latitudes. The lower edges of simultaneously observed NLC and MSE typically agree, as expected from higher latitudes. Though, the top edge of MSE is on average observed nearly 500 m above the NLC edge, indicating the presence of ice particles being too small to be observed by lidar. Nevertheless, the height difference is much smaller than observed at higher latitudes. This hints at different size distributions of mid and high latitude ice clouds and, by this, different growing conditions. The data suggest that advection plays a larger role for ice cloud occurrence at mid-latitudes compared to local formation in the cold mesopause region. We will present an overview on the comparison of simultaneously observed NLC and MSE layers and their main characteristics. In the morning twilight the onset of MSE is directly related to changing electron densities. We will present case studies of the onset of MSE during ongoing NLC observations. These show, e.g., an altitude dependence of the minimum electron density required for MSE.

A study of gravity waves having quasi-inertial frequency in the Antarctic troposphere and lower stratosphere observed by the PANSY radar

Abstract ID : 216

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Yuichi Minamihara ,minamihara@eps.s.u-tokyo.ac.jp ,(None) ,Japan ,Tokyo ,Presenting[1]

Prof. Masaki Tsutsumi ,tutumi@nipr.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Prof. Toru Sato ,sato.toru.6e@kyoto-u.ac.jp ,(None) ,Japan , ,Not Presenting[3]

Prof. Kaoru Sato ,kaorul@eps.s.u-toyko.ac.jp ,(None) ,Japan , ,Not Presenting[1]

1 - The University of Tokyo, Tokyo, Japan 2 - National Institute of Polar Research 3 - Kyoto University 4 - The University of Tokyo, Tokyo, Japan

The PANSY radar installed at Syowa Station (69.00[MISSING IMAGE: ,]S, 39.35[MISSING IMAGE: ,]E) is the first Antarctic MST/IS radar. Its observational time interval is about 200 s, which allows us to analyze almost the entire frequency range of gravity waves (GWs) from the inertial frequency ([MISSING IMAGE: ,]) [[MISSING IMAGE: ,]] to the Brunt-Väisälä frequency [[MISSING IMAGE: ,]] when Doppler shift by the background wind is negligible. The purpose of this study is to examine GWs in the Antarctic troposphere and lower stratosphere statistically using continuous observations over one year from October 2015 to September 2016 by the full system of the PANSY radar. Such a long-period continuous observation is unprecedented as that by MST radar observations at any locations including lower latitudes. The frequency power spectra of horizontal wind fluctuations have an isolated peak around [MISSING IMAGE: ,] in the lower stratosphere. The zonal momentum flux spectra ([MISSING IMAGE: ,]) are also largely negative around [MISSING IMAGE: ,]. Sato et al. (1999) showed using a GW-permitting GCM that power spectra of horizontal wind fluctuations have an isolated peak near *f* of each latitude in the lower stratosphere. It is considered that the waves having a quasi-inertial frequency observed by the PANSY radar are likely such inertia-GWs. A hodograph analysis is performed and statistically examined by focusing on the GWs with a quasi-inertial frequency (QIGWs) in the lower stratosphere. A striking feature is that the percentage of QIGWs propagating energy downward is significantly large above the height of *z* [MISSING IMAGE: ,] 15 km in the winter stratosphere, although that of QIGWs propagating energy upward is still more than half. These results suggest that the sources of QIGWs propagating energy downward exist in the stratosphere and/or above in winter. The distribution of ground-based phase velocities ([MISSING IMAGE: ,]) is much different between the QIGWs propagating energy upward and downward. A significant proportion of QIGWs propagating energy downward have large ***c*** pointing to the east, whereas most QIGWs propagating energy upward have ***c*** around 0 m [MISSING IMAGE: ,]. This result also supports that the QIGWs propagating energy downward originate from sources moving eastward and suggests that their most likely candidate is the polar night jet in the winter stratosphere.

The Downward Influence of Stratospheric Sudden Warmings

Abstract ID : 383

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ian White ,ian.white@mail.huji.ac.il ,(Postdoctoral Researcher) ,Israel ,Jerusalem ,Presenting[1]

Dr. Martin Jucker ,martin.jucker@unimelb.edu.au ,(None) ,Australia , ,Not Presenting[2]

Prof. Edwin Gerber ,gerber@cims.nyu.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Chaim Garfinkel ,chaim.garfinkel@mail.huji.ac.il ,(None) ,Israel , ,Not Presenting[1]

1 - Hebrew University of Jerusalem 2 - The University of Melbourne 3 - Courant Institute of Mathematical Sciences, New York University 4 - Hebrew University of Jerusalem

Stratospheric sudden warmings (SSWs) are events whereby the polar vortex rapidly decelerates and the winter Pole subsequently warms in the matter of just a few days. Such events have been shown in recent years to have a significant downward influence on the tropospheric circulation below, in some cases lasting for up to two months. However, the mechanism(s) by which this downward influence occurs are not well understood, nor are the factors governing the magnitude of the downward influence. It is particularly difficult to attempt to understand this coupling process as nonlinear tropospheric feedbacks effectively bury the mechanisms by which the stratospheric anomaly is initially communicated downward to the troposphere. Here, we use an idealised moist general circulation model (GCM) to understand the mechanisms which govern the downward influence of SSWs, and to constrain the factors that govern the magnitude of the downward influence. This model of 'intermediate complexity' is particularly suited to this study as it incorporates the radiation scheme that is utilised by operational forecast systems, including both the ECMWF and NCEP, as well as in the CMIP atmospheric models, in addition to allowing us to easily remove physical processes in order to bear down on the mechanisms at work. The radiation scheme also allows us to force the model with a realistic ozone profile, and thus to simulate realistic radiative timescales in the stratosphere. Four different topography options are here used: realistic Earth's topography, idealised zonal wavenumbers one and two, and a flat bottom, which together give rise to a large ensemble of SSW events to analyse. Finally the flexibility of the model enables us to easily modify the vertical resolution, and we assess the sensitivity of model simulated downward coupling to the placement of vertical levels. Results will be compared to SSW events in 1500 years of model output from the chemistry-climate model GEOSCCM and to SSW events in the observational record.

How does interhemispheric coupling respond to the solar cycle signal?

Abstract ID : 459

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Bodil Karlsson ,bodil@misu.su.se ,(Department of Meteorology Stockholm University) ,Sweden ,Stockholm ,Not Presenting[1]

1 - Stockholm University

In the period around solstice, the summer polar mesopause region is as good as constantly sunlit. Yet, this is the coldest place in the earth-atmosphere system. Even during solar maxima, when the upper parts of the atmosphere are significantly warmer due to intensified physical and chemical processes, the summer high latitude mesopause temperature appears to be relatively unaffected by direct diabatic heating.

We investigate - using the Kühlungborn Mechanistic General Circulation Model (KMCM) and the nudged version of the Canadian Middle Atmosphere Model (CMAM30) - the role of interhemispheric coupling when it comes to hemispheric differences in the middle atmosphere and discuss how this mechanism responds to enhanced solar fluxes. We find that the increased diabatic heating during the more active phase of the sun is counteracted by a strengthening of the meridional residual circulation, which cools the summer polar mesosphere adiabatically.

Effect of gravity waves from small islands in the Southern Ocean on the Southern Hemisphere atmospheric circulation

Abstract ID : 514

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Content Motivation : None

Additional Information : None

Dr. Chaim Garfinkel ,chaim.garfinkel@mail.huji.ac.il ,(None) ,Israel , ,Not Presenting[1]

Mr. Luke Oman ,luke.d.oman@nasa.gov ,(None) ,United States , ,Not Presenting[2]

1 - Hebrew University of Jerusalem 2 - GSFC

It has been suggested that drag from small islands in the Southern Ocean can impact the Southern Hemispheric stratospheric circulation, and account for the ``missing drag" that is necessary to close the momentum budget in reanalyses data. We evaluate the effect of these islands with a series of simulations using the NASA Goddard Earth Observing System Chemistry-Climate Model in which the topographic variance associated with these islands is included and enhanced. Including the topographic variance leads to a 2K warming of the springtime polar stratosphere, partially ameliorating biases in this region. However, resolved wave drag associated with zonal wavenumber-2 declines in the presence of the enhanced gravity wave drag, such that changes in gravity waves are partially compensated by changes in resolved waves. Biases in the tropospheric jet position and strength are also partially ameliorated.

Significant contributions of volcanic aerosols to decadal changes in the stratospheric circulation

Abstract ID : 529

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Mohamadou Diallo ,m.diallo@fz-juelich.de ,(Postdoc) ,Germany ,Juelich ,Presenting[1]

Dr. Felix Felix Ploeger ,f.ploeger@fz-juelich.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Thomas Birner ,thomas@atmos.colostate.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Paul Konopka ,p.konopka@fz-juelich.de ,(None) ,Germany , ,Not Presenting[4]

Dr. Rolf Mueller ,ro.mueller@fz-juelich.de ,(None) ,Germany , ,Not Presenting[5]

Prof. Martin Riese ,m.riese@fz-juelich.de ,(None) ,Germany , ,Not Presenting[6]

Prof. Bernard Legras ,legras@lmd.ens.fr ,(None) ,France , ,Not Presenting[7]

Dr. Hella Garny ,Hella.Garny@dlr.de ,(None) ,Germany , ,Not Presenting[8]

Dr. Eric Ray ,eric.ray@noaa.gov ,(None) ,United States , ,Not Presenting[9]

Dr. Gwenael Berthet ,gwenael.berthet@cnrs-orleans.fr ,(None) ,France , ,Not Presenting[10]

Dr. Fabrice Jegou ,Fabrice.jegou@cnrs-orleans.fr ,(None) ,France , ,Not Presenting[10]

1 - IEK-7 2 - IEK-7, Forschungszentrum Jülich GmbH, Jülich 52428, Germany 3 - CO State Univ-Atmospheric Sci Fort Collins CO 80523-1371 4 - IEK-7 Forschungszentrum Juelich Juelich D-52425 (Germany) 5 - IEK-7 Forschungszentrum Juelich Juelich D-52425 6 - Juelich research center 7 - Laboratoire de Météorologie Dynamique ENS Paris (France) 8 - German Aerospace Center DLR Oberpfaffenhofen Oberpfaffenhofen (Germany) 9 - University of Colorado at Boulder Boulder CO 80305-0000 (United States) 10 - Laboratoire de Physique et Chimie de l'Environnement et de l'Espace Orléans Cedex 2 (France) 11 - Laboratoire de Physique et Chimie de l'Environnement et de l'Espace Orléans Cedex 2 (France)

A major uncertainty in current climate model simulations concerns the evolution of the stratospheric Brewer-Dobson circulation. Models show decreasing mean age, indicating an accelerating circulation, while observations show opposite decadal age variations in the Northern hemisphere. Here, we quantify the effect of the stratospheric volcanic aerosol on mean age variability, using mean age from reanalysis-driven TRACZILLA and CLaMS simulations for the 1989-2012 period, showing decadal variations consistent with observations. Our method is based on a multilinear regression technique using satellite observations of aerosol optical depth including Pinatubo and smaller volcanoes after 2002. We find that the decadal age variations can be primarily attributed to the volcanic signals. In particular the smaller volcanic eruptions after 2002, which are not included in most climate model simulations, cause most of the positive mean age decadal change in the Northern hemisphere after 2002. Consequently, the discrepancy between climate models and observations regarding decadal mean age changes (2002-2012) is likely related to the representation of volcanic stratospheric aerosol in the models.

Dynamical Features and Minor Constituent Changes Related to the Anomalous QBO Phase Transition in 2016

Abstract ID : 568

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Toshihiko Hirooka ,hirook@geo.kyushu-u.ac.jp ,(Professor) ,Japan ,Fukuoka ,Presenting[1]

Mr. Ryoichi Kato ,2SC16218T@s.kyushu-u.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Nawo Eguchi ,nawo@riam.kyushu-u.ac.jp ,(None) ,Japan , ,Not Presenting[2]

1 - Department of Earth and Planetary Sciences, Kyushu University 2 - Kyushu University 3 - Kyushu University

The quasi-biennial oscillation (QBO) is a downward propagating zonal-wind oscillation observed in the equatorial lower stratosphere with an average period of about 28 months. In February 2016, the downward propagation of the QBO easterly shear was unexpectedly disrupted around 20 hPa and an unprecedented easterly jet formed within westerly wind regime below that level (Newman et al. 2016; Osprey et al. 2016). After that the easterly jet propagated downward to eventually disappear, and the westerly wind fully dominated the equatorial lower stratosphere. Neither plausible mechanisms to cause such anomalous behavior of the QBO phase transition nor changes of the associated meridional circulation have been fully investigated. Here, we make detailed analyses of the anomalous QBO phase transition, using the Japanese 55-year reanalysis data, JRA-55, along with volume mixing ratio data of minor constituents, such as ozone (O3), nitrous oxide (N2O), and hydrogen chloride (HCl), derived from Aura MLS observations. It is found that anomalous distribution of minor constituents concomitantly appeared with the anomalous QBO phase transition, which could be formed by meridional circulation changes associated with the corresponding equatorial temperature modulation. In the presentation, we will also discuss dynamical effects on the anomalous QBO phase transition from mid-latitudes.

Influence of Eurasian Snow Extent on the Northern extratropical stratosphere in a QBO resolving model

Abstract ID : 653

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Alexey Yu. Karpechko ,Alexey.Karpechko@fmi.fi ,(None) ,Finland , ,Not Presenting[1]

Dr. Nicholas Tyrrell ,nicholas.tyrrell@fmi.fi ,(None) ,Finland , ,Not Presenting[1]

Dr. Petri Räisänen ,petri.raisanen@fmi.fi ,(None) ,Finland , ,Not Presenting[1]

1 - Finnish Meteorological Institute 2 - Finnish Meteorological Institute 3 - Finnish Meteorological Institute

The possibility of seasonal prediction is based on the existence of sources of predictability, i.e. components of climate system which vary at slower time scales than weather systems. In particular, the extent of snow cover over Eurasia in autumn has been proposed as one of important factors that influence the wintertime circulation in the Northern Hemisphere extratropics and thus can be utilized for predicting winter climate. It has been suggested that snow anomalies generate an anomalous planetary wave activity flux, which disturbs the stratospheric circulation. Thereafter, the stratospheric circulation influences the troposphere through the stratosphere-troposphere coupling mechanisms. However, despite apparent observational evidences the modelling support for the snow-circulation link is limited. Biases in the background flow and lack of a well-resolved stratosphere in the models have been suggested as reasons for disagreement with observations. Here we address the link between autumn snow cover and winter atmospheric circulation using a version of the atmospheric model ECHAM6 with a well-resolved stratosphere and an internally generated quasi-biennial oscillation (QBO). In line with the proposed mechanism we find a statistically significant enhancement of wave activity flux into the stratosphere and a distorted stratospheric vortex as a response to an artificially increased amount of snow over Eurasia; however, the signal is weak in comparison to observations. Furthermore, we find no discernable signal propagating downward from the stratosphere to the troposphere thereafter. The potential for the QBO phase to influence the stratospheric response to snow anomaly is also considered. Implications of these findings for seasonal predictability are discussed.

Contribution of gravity waves to the mean meridional circulation and momentum budget in the middle atmosphere

Abstract ID : 669

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Kaoru Sato ,kaoru@eps.s.u-tokyo.ac.jp ,(Professor) ,Japan ,Tokyo ,Not Presenting[1]

Mr. Ryosuke Yasui ,yasui.ryosuke@eps.s.u-tokyo.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Yasunobu Miyoshi ,miyoshi@geo.kyushu-u.ac.jp ,(None) ,Japan , ,Not Presenting[3]

Mr. Soichiro Hirano ,soichiro_hirano@eps.s.u-tokyo.ac.jp ,(None) ,Japan , ,Not Presenting[2]

1 - The University of Tokyo 2 - Department of Earth and Planetary Science, The University of Tokyo 3 - Department of Earth and Planetary Sciences, Kyushu University 4 - Department of Earth and Planetary Science, The University of Tokyo

The mean meridional (summer to winter) circulation in the mesosphere is mainly driven by the forcing of gravity waves propagating from the troposphere. The circulation does not have simple one-celled structure, however, because the gravity-wave forcing (GWF) cannot balance with the Coriolis force associated with the mean meridional flow on the equator where the Coriolis parameter becomes zero. Moreover, GWF distribution is not latitudinally uniform but regional because of the filtering by the background wind depending strongly on the latitude and longitude. As a result, the GWF frequently causes anomalous potential vorticity gradient in the mean field and radiates large-scale Rossby waves. Such in-situ radiation of Rossby waves gives additional wave forcing and modulates the meridional circulation. In contrast, deep and shallow branches of the meridional circulation in the stratosphere (a part of the Brewer-Dobson circulation; BDC) are mainly driven by Rossby waves and by synoptic-scale waves, respectively. However, the mean easterly wind in the summer stratosphere prohibits upward propagation of Rossby waves and hence the summer hemispheric part of the BDC winter cell is expected to be driven by GWF. Strong GWF in the weak wind layer in the lower stratosphere also contributes to the formation of the shallow branch of BDC.
In the present study, the role of GWF in the momentum budget in the mesosphere and lower thermosphere is examined using outputs of a simulation by a whole atmosphere model (GAIA) which was nudged toward a reanalysis data. In-situ generation of gravity waves and Rossby waves are particularly focused on. The role of GWF in BDC is also examined using several reanalysis data in terms of seasonal variation. Last but not least, a progress of an international project "Interheispheric Coupling Study by Observations and Modelling (ICSOM)" with a core of global observational network of high-power atmospheric radars and high-resolution model simulation is also presented.

SANOMA- applications of an empirical model of nitric oxide in the upper mesosphere and lower thermosphere

Abstract ID : 732

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Joonas Kiviranta ,joonas.kiviranta@chalmers.se ,(43535) ,Sweden ,Mölnlycke ,Not Presenting[1]

Dr. Kristell Pérot ,kristell.perot@chalmers.se ,(None) ,Sweden , ,Not Presenting[1]

Prof. Donal Murtagh ,donal.murtagh@chalmers.se ,(None) ,Sweden , ,Not Presenting[1]

Dr. Patrick Eriksson ,patrick.eriksson@chalmers.se ,(None) ,Sweden , ,Not Presenting[1]

1 - Chalmers University of Technology 2 - Chalmers University of Technology 3 - Chalmers University of Technology 4 - Chalmers University of Technology

Joonas Kiviranta, Kristell Pérot, Patrick Eriksson, Donal Murtagh
Chalmers University of Technology, Department of Earth and Space Sciences, SE-412 96, Gothenburg, Sweden
Nitric oxide (NO) is produced by energetic particle precipitation (EPP) and soft solar X-rays in the lower thermosphere. NO can then be transported down to lower atmospheric regions during polar winter, where it can interact with ozone and thus affect the chemical, thermal and dynamical structure of the atmosphere.
An empirical model for NO, called NOEM, was developed by Marsh and Solomon (2004) based on 2.5 years of measurements from the Student Nitric Oxide Explorer (SNOE). A new model is based on 12 years of Odin Sub Millimeter Radiometer (SMR) measurements, and includes both day- and nighttime observations. This new model, called the SMR Acquired Nitric Oxide Model Atmosphere (SANOMA) predicts the amount of NO as a function of altitude between 85-115km, magnetic latitude, and time. As inputs, it only requires the Kp-index, the solar declination, and the F10.7 cm flux for a given day.
This presentation will validate the model against measured NO from the SCIAMACHY, MIPAS, ACE, and SOFIE instruments. Furthermore, it focuses on the possible applications of such a model, such as providing apriori information for retrievals of NO from satellite measurements, or being used as an input for chemistry climate models. Finally, this presentation discusses the future outlook of the applications of the SANOMA model, as well as the newest Odin-SMR NO dataset.
References
Marsh, D.R., Solomon, S.C.: Empirical model of nitric oxide in the lower thermosphere, Journal of Geophys.

Interannual variability of the semi-annual oscillation in middle atmosphere tropical zonal winds

Abstract ID : 742

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Anne Smith ,aksmith@ucar.edu ,(scientist) ,United States ,Boulder CO ,Presenting[1]

Mr Garcia Rolando ,rgarcia@ucar.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Andrew Moss ,andrew.moss@bath.edu ,(None) ,United Kingdom , ,Not Presenting[3]

Prof. Nicholas Mitchell ,N.J.Mitchell@bath.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - NCAR 2 - NCAR 3 - Bath University 4 - Bath University

The dominant mode of seasonal variability in the global tropical upper stratosphere and mesosphere zonal wind is the Semi-Annual Oscillation (SAO). However, it is notoriously difficult to measure winds at these heights from satellite or ground-based remote sensing. Here we use the balance wind relationship to derive monthly and zonally averaged zonal winds in the tropics from satellite retrievals of geopotential height from Aura/MLS and TIMED/SABER. The derived winds show prominent easterly maxima near the solstices at 1.0 hPa, westerly maxima near the equinoxes at 0.1 hPa, and easterly maxima near the equinoxes at 0.01 hPa. The pressure and timing of the wind minima and maxima are variable from year to year. For all seasons except NH winter, the SAO winds in the mesosphere vary with the phase of the QBO in the middle stratosphere. During easterly QBO, the westerly maxima are shifted upward, are about 10 m s^{-1} stronger, and occur approximately one month later than those during the westerly QBO phase.

Towards the coupling between stratosphere and troposphere during major warming events with strong polar-night jet oscillations

Abstract ID : 816

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Dieter H.W. Peters ,peters@iap-kborn.de ,(Scientist) ,Germany ,Kühlundborn ,Presenting[1]

Dr. Andrea Schneidereit ,schneidereit@iap-kborn.de ,(None) ,Germany , ,Not Presenting[2]

1 - Leibniz-Institute of Atmospheric Physics 2 - Leibniz-IAP at the University of Rostock

Major warming (MSSW) events determine the intra-seasonal variability of the middle atmosphere in winter. It is known that the main cause for stratospheric warming is the enhanced tropospheric forcing by planetary waves and their strong interaction with the background flow indicated by strong heat fluxes at 100 hPa and by zonal mean zonal wind reversal. In a case study of the MSSW 2009 event the interfering subtropical influence of the cold phase of ENSO (La Nina) and MJO is examined. Both contribute to the enhanced heat flux of wave 2 in the pre-phase. Furthermore the coupling of the stratosphere with the troposphere seems to be enhanced over two months as expected from former studies.

The aim of this study is to examine both the annual variation of Northern Annular Modes (NAMs) of geopotential height anomalies and the variability of Polar-night Jet Oscillations (PJOs) from 1979 until 2013, in order to investigate the coupling between troposphere and stratosphere and vice versa during major warming events. Based on ERA-Interim reanalysis data we determine 20 major sudden stratospheric warmings (MSSWs) by the use of a NAM threshold of -2.3 at the 10 hPa layer in agreement with former studies. With an extended definition of PJO events of Hitchcook et al. (2013) 9 strong PJOs (larger than (3σ for 100 degree)) and 7 no PJO events (smaller than (2σ for 100 degree)) are identified whereas 4 intermediate PJO events remain.

In addition, partially nudged ensemble runs with the ECHAM6 GCM for MSSW 2009 event are used in order to study in details the coupling of the stratosphere with the troposphere during the post-phase. We show that MSSWs with strong PJOs are odds-on favorite for enhanced coupling between stratosphere and troposphere with potential for seasonal forecasts.

Arctic Amplification of Stratospheric Variability

Abstract ID : 848

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Mark Baldwin ,m.baldwin@exeter.ac.uk ,(Professor) ,United Kingdom ,Exeter ,Not Presenting[1]

Dr. Thomas Birner ,thomas@atmos.colostate.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Blanca Ayarzaguena ,B.Ayarzaguena@exeter.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Exeter 2 - CO State Univ-Atmospheric Sci Fort Collins CO 80523-1371 3 - University of Exeter

At mid-to-high latitudes, the stratosphere contains >25% of the column of atmospheric mass. Large-scale vertically-propagating waves drive a synchronised meridional circulation that moves mass into and out of the polar cap, modulating adiabatic warming of the stratospheric polar air column, and altering the strength of the stratospheric polar vortex. These stratospheric changes are associated with substantial effects on surface weather and climate, especially on Northern Annular Mode (NAM) with associated long-lasting shifts in the jet streams, storm tracks, precipitation, and likelihood of blocking events. Despite unambiguous observations of this phenomenon, as well as numerical simulations, a clear physical explanation of this downward coupling remains elusive. Here we view the stratospheric polar vortex as an isolated potential vorticity (PV) anomaly, and we show that PV theory accounts for the observations that the meridional circulation extends below the tropopause, modulating the day-to-day thickness of the troposphere, especially over the Arctic. We argue, based on PV theory, that Arctic temperature anomalies at 100 hPa can be used as a proxy for the integrated effect of polar stratospheric PV anomalies above. We introduce a polar cap pressure index that provides a quantitative vertical measure of stratosphere-troposphere coupling that can be used to compare atmospheric climate/weather models to each other, as well as to observations. The stratospheric pressure anomaly signal is a minimum near the tropopause, and is amplified in the troposphere, where the signal is largest at the surface near the North Pole. This Arctic amplification of stratospheric variability cannot be accounted for by a stratospheric PV anomaly. Rather, it is consistent with self-amplification of the NAM by temperature advection, with polar surface PV (potential temperature) anomalies induced by variations of the strength of the stratospheric PV anomaly.

The CCMI ozone forcing database in support of CMIP6 (1850-2100)

Abstract ID : 871

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Michaela Hegglin ,m.i.hegglin@reading.ac.uk ,(Lecturer in Atmospheric Chemistry) ,United Kingdom ,Reading ,Not Presenting[1]

Mr Douglas Kinnison ,dkin@ucar.edu ,(None) ,United States , ,Not Presenting[2]

Dr. David Plummer ,david.plummer@canada.ca ,(None) ,Canada , ,Not Presenting[3]

Dr. Ramiro Checa-Garcia ,r.checa-garcia@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Keith P. Shine ,k.p.shine@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Irene Cionni ,irene.cionni@enea.it ,(None) ,Italy , ,Not Presenting[6]

1 - University of Reading 2 - NCAR 3 - Environment and Climate Change Canada 4 - University of Reading 5 - University of Reading 6 - ENEA

In this contribution we will present a newly compiled ozone forcing database within the IGAC/SPARC Chemistry-Climate Model Initiative (CCMI) in support of the upcoming Coupled Model Intercomparison Project CMIP6. We will discuss the philosophy behind the methodology used to produce the new database and point out major advantages but also shortcomings over the ozone database used in CMIP5, as revealed in comparisons with available observations over the past 30 years. We will also present new radiative forcing estimates since preindustrial times that highlight the importance of looking at ozone changes in a whole-atmosphere approach that accounts for stratosphere-troposphere chemical coupling.

Variability of Downward Wave Coupling under Natural and Climate Change Conditions

Abstract ID : 921

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Katja Matthes ,kmatthes@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[1]

Mr. Sandro Lubis ,slubis@uchicago.edu ,(None) ,United States , ,Not Presenting[2]

Mr. Nili Harnik ,harnik@post.tau.ac.il ,(None) ,Israel , ,Not Presenting[3]

Mr. Nour-Eddine Omrani ,Noureddine.Omrani@uib.no ,(None) ,Norway , ,Not Presenting[4]

Mr. Sebastian Wahl ,swahl@geomar.de ,(None) ,Germany , ,Not Presenting[5]

1 - GEOMAR Helmholtz Centre for Ocean Research Kiel 2 - University of Chicago 3 - University of Tel Aviv 4 - University of Bergen 5 - GEOMAR

Downward wave coupling (DWC) is an important process characterizing downward dynamical coupling between the stratosphere and the troposphere. DWC occurs when an upward-propagating planetary wave from the troposphere decelerates the flow in the upper stratosphere and forms a downward reflecting surface that redirects waves back to the troposphere. The associated circulation changes have a significant influence on surface climate. To understand the factors controlling DWC, we analyzed a suite of model simulations with NCAR's Community Earth System Model [CESM1(WACCM)], a state-of-the-art high-top chemistry-climate model, where different natural and anthropogenic forcing factors have been changed.
The results show that natural variability from the quasi-biennial oscillation (QBO) and SST variability significantly impact DWC. Without the QBO, the occurrence of DWC is significantly suppressed. In contrast, stronger and more persistent downward wave coupling occurs when SST variability is excluded.
The strengths of the tropospheric circulation and surface responses to a given DWC event, however, behave differently. The surface anomaly is significantly weaker (stronger) in the experiment with fixed SSTs (without QBO), even though the statistical signal of DWC is strongest (weakest) in this experiment. This apparent mismatch is explained by the differences in the strength of the synoptic-scale eddy-mean flow feedback and the possible contribution of SST anomalies in the North Atlantic during DWC events. The weaker synoptic-scale eddy-mean flow feedback and the absence of the positive NAO related SST-tripole pattern in the fixed SST experiment are consistent with a weaker tropospheric response to DWC.
Under climate change, i.e. greenhouse gases (GHGs) and ozone depleting substances (ODS), DWC is significantly surpressed in the future and its occurrence seasonally shifted from early to midwinter. Most of these changes can be attributed to increasing anthropogenic GHGs. The tropospheric response to DWC in the future resembles an eastward shift of the positive North Atlantic Oscillation (NAO)-like pattern which also involves an eastward shift of the climatological mean Atlantic eddy-driven jet and storm tracks. Our results highlight the importance of internal tropospheric variability

related to synoptic-scale eddies as well as atmosphere-ocean interactions in setting the tropospheric response to DWC.

Signatures of gravity waves, acoustic-gravity waves, and infrasonic signals derived from OH-Airglow by means of the Fast Airglow IMager, FAIM

Abstract ID : 936

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Michael Bittner ,michael.bittner@dlr.de ,(Professor for Atmospheric Remote Sensing at the University of Augsburg, Physics Department Head of Department "Atmosphere" at DLR-DFD, Oberpfaffenhofen) ,Germany ,Wessling ,Not Presenting[1]

Mr. Mario Fix ,mario.fix@dlr.de ,(None) ,Germany , ,Not Presenting[2]

Mr. Patrick Hannawald ,patrick.hannwald@dlr.de ,(None) ,Germany , ,Not Presenting[3]

Mr. Carsten Schmidt ,carsten.schmidt@dlr.de ,(None) ,Germany , ,Not Presenting[4]

Dr. Sabine Wüst ,sabine.wuest@dlr.de ,(Scientist) ,Germany ,Wessling ,Not Presenting[4]

1 - DLR-DFD and University of Augsburg 2 - DLR-DFD 3 - University of Ausgburg 4 - DLR 5 - DLR

Measurements of the nocturnal emission of the OH airglow (mesopause height region) covering the brightest OH vibrational-rotational bands between about 1.0 and 1.7 µm are recorded each night since December 2013 by the ground-based FAIM (Fast Airglow Imager) - instrument from Oberpfaffenhofen (48,1°N; 11.3°E), Germany. The station is part of the Network for the detection of Mesospheric Change, NDMC (http://wdc.dlr.de/ndmc).
FAIM acquires two frames per second. The area covered at mesopause heights is about 60 km x 6o km; the horizontal resolution is about 200 m. The data therefore allow studying signatures of atmospheric gravity waves, acoustic-gravity waves and probably infrasound.
The capability to observe acoustic-gravity waves or even infrasound is of particular interest in the context of tsunami early warning systems. Plans for setting up observational capacities at Paranal in 2017/2018, Chile, to routinely monitor the Chilean coast-line in this area will be outlined.
In our presentation, we focus on signals near the Brunt-Vaisala and acoustic cut-off frequencies, and use a wavelet-analysis based approach to extract them. For the first time, we present case studies showing acoustic gravity or even infrasonic waves captured by the FAIM system.

Regional Variability in Tropical Precipitation and Gravity Waves, and Relation to Circulation in the Upper Troposphere and Stratosphere

Abstract ID : 975

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. M. Joan Alexander ,alexand@nwra.com ,(Colorado) ,United States ,Boulder ,Not Presenting[1]

1 - NWRA

Atmospheric gravity waves generated by convection influence large-scale winds in the upper troposphere and stratosphere. Winds at these levels guide Rossby wave propagation and teleconnection patterns that strongly influence the simulation of regional-scale climate and skill of long-range weather forecasts. At seasonal forecast model resolutions, small-scale waves remain severely under-resolved, yet the influence of their drag forces on the circulation in the upper troposphere and stratosphere make them key players in predictability. Gravity wave drag parameterizations are used to tune both climate and forecast models with demonstrated effects on bias reduction and forecast skill. The tropical lower stratosphere quasibiennial oscillation, in particular, has demonstrated influence on seasonal predictability, and this circulation is forced in large part by non-orographic gravity waves emanating from tropical convection. The disruption of the QBO in 2016 revealed the inability of forecast models to predict the evolution of the QBO following the disruption. While the disruption event itself may have been caused by unusual extratropical wave drag, the poor performance of forecast models in predicting the evolution of tropical winds following the disruption is related to the parameterized gravity wave drag.

We present results of idealized models with realistic gravity waves generated by observed precipitation variability to examine regional changes in gravity wave generation and gravity wave drag and relationships to El Nino Southern Oscillation (ENSO) and Madden-Julian Oscillation (MJO) precipitation and circulation patterns. We find that ENSO changes not only the regional pattern of tropical gravity wave sources, but also their propagation properties and their effects on the stratospheric circulation. We find stratospheric gravity wave activity is enhanced at longitudes where tropopause winds are stronger easterlies. We also find associated shifts in the stratospheric circulation, and we investigate potential causes of these regional relationships among precipitation, wave activity, and circulation.

Mitigation of global cooling by stratospheric chemistry feedbacks in a simulation of the Last Glacial Maximum

Abstract ID : 1012

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Satoshi Noda ,noda@gfd-dennou.org ,(Program-specific researcher) ,Japan ,Kyoto ,Presenting[1]

Dr. Kunihiko Kodera ,kodera.kk@gmail.com ,(None) ,Japan , ,Not Presenting[2]

Mr. Yukimasa Adachi ,adachi0038@met.kishou.go.jp ,(None) ,Japan , ,Not Presenting[3]

Dr. Makoto Deushi ,mdeushi@mri-jma.go.jp ,(None) ,Japan , ,Not Presenting[4]

Dr. Akio Kitoh ,kito.akio.ff@u.tsukuba.ac.jp ,(None) ,Japan , ,Not Presenting[5]

Dr. Ryo Mizuta ,rmizuta@mri-jma.go.jp ,(None) ,Japan , ,Not Presenting[6]

Mr. Shigenori Murakami ,smurakami@mc-jma.go.jp ,(None) ,Japan , ,Not Presenting[7]

Dr. Kohei Yoshida ,kyoshida@mri-jma.go.jp ,(None) ,Japan , ,Not Presenting[4]

Prof. Shigeo Yoden ,yoden@kugi.kyoto-u.ac.jp ,(None) ,Japan ,Kyoto ,Not Presenting[1]

1 - Kyoto University 2 - ISEE 3 - JMA 4 - Meteorological Research Institute 5 - Univ. of Tsukuba 6 - MRI 7 - Meteorological College 8 - Meteorological Research Institute 9 - Kyoto University

A series of numerical simulations of the Last Glacial Maximum (21 kyr B.P.) climate are performed by using an Earth System Model of the Meteorological Research Institute of the Japan Meteorological Agency to investigate the impact of stratospheric ozone profile on the surface climate with decreased CO_2 condition and different orbital parameters. The contribution of the interactive ozone chemistry reveals a significant anomaly of +0.5 K (approximately 20 %) in the tropics and up to +1.5 K in high-latitudes for the annual mean zonal mean surface air temperature compared with those of the corresponding experiments with a prescribed ozone profile for preindustrial simulation of the fifth Coupled Model Intercomparison Project (CMIP5). In the tropics, this mitigation of global cooling is related to longwave radiative feedbacks associated with circulation-driven increases in lower stratospheric ozone and related increase in stratospheric water vapor and related decrease in cirrus cloud. The relations are opposite signs to and consistent with those of a global warming simulation. In high-latitudes, the polar amplification of mitigation of cooling associated with the change of sea ice area that is the same sign to and consistent with our previous paleoclimate simulation in the mid-Holocene (6 kyr B.P.). We recommend that climate models include sea ice and ozone profile that are consistent with CO_2 concentration.

Investigation of the filtering effect of gravity waves by planetary waves based on a three decadal time series of mesopause temperatures at mid-latitudes

Abstract ID : 1033

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. René Sedlak ,rene.sedlak@dlr.de ,(None) ,Germany , ,Presenting[1]

Ms. Lisa Küchelbacher ,lisa.kuechelbacher@dlr.de ,(PhD) ,Germany ,Munich ,Not Presenting[2]

Mr. Carsten Schmidt ,carsten.schmidt@dlr.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Sabine Wüst ,sabine.wuest@dlr.de ,(Scientist) ,Germany ,Wessling ,Not Presenting[2]

Ms. Alexandra Zuhr ,alexandra.zuhr@dlr.de ,(None) ,Germany , ,Not Presenting[5]

Prof. Ralf Koppmann ,koppmann@uni-wuppertal.de ,(None) ,Germany , ,Not Presenting[6]

Prof. Michael Bittner ,michael.bittner@dlr.de ,(Professor for Atmospheric Remote Sensing at the University of Augsburg, Physics Department Head of Department "Atmosphere" at DLR-DFD, Oberpfaffenhofen) ,Germany ,Wessling ,Not Presenting[7]

1 - University of Augsburg 2 - DLR 3 - DLR 4 - DLR 5 - University of Augsburg, Germany – Institute of Physics 6 - University of Wuppertal 7 - DLR-DFD and University of Augsburg

A nearly three decadal time series (1987 - 2017) of mesopause temperatures has been obtained by combining data of two GRIPS (Ground-based Infrared P-branch Spectrometer) instruments, derived from OH*(3-1) emissions at the airglow layer. Both instruments are operated within the Network for the Detection of Mesospheric Change, NDMC. Measurements have been performed at Wuppertal (51.3°N, 7.2°E), Germany and Oberpfaffenhofen (48.09°N, 11.28°E), Germany.
In order to quantify atmospheric gravity wave activity, we developed suitable indicators which are based on both the spectral distribution of observed temperature fluctuations and the estimation of the potential energy density.
We find an overall and clear anti-correlation of gravity and planetary wave activity. It is interesting to note that the respective variabilities show characteristic variations even on decadal scales.
Our results also reveal that gravity wave filtering depends significantly on the gravity wave spectrum. This suggests a period-dependent filtering mechanism between gravity and planetary waves. The longer periodic gravity wave activity exhibits an annual variation, being maximum in winter, which agrees well with previous research, while shorter periodic gravity wave activity tends towards a semi-annual pattern showing maximum gravity wave activity around the equinoxes. We will discuss the impact of these findings on the larger circulation patterns in the atmosphere.
The work presented here is funded by the Bavarian state ministry of the environment and consumer protection (LUDWIG, VoCaS-ALP).

Stratospheric circulation response to global warming

Abstract ID : 1085

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Tobias Haufschild ,tobias.haufschild@mpimet.mpg.de ,(PHD Student) ,Germany ,Hamburg ,Not Presenting[1]

Dr. Elisa Manzini ,elisa.manzini@mpimet.mpg.de ,(None) ,Germany ,Hamburg ,Not Presenting[2]

1 - Max-Planck Institute for Meteorology 2 - MPIM

The stratospheric circulation response to global warming is still unclear. In particular CMIP5 models show a significant inter- model spread in the easterly change of the Northern winter stratospheric circulation. The physical mechanisms responsible for the different responses are hard to segregate in a coupled atmosphere ocean general circulation model and so we develop a dry model that aims to isolate the causes of the stratospheric circulation change. The dry model is based on the ICON model at a horizontal resolution of approximately 40 km. It has a full radiative-dynamical representation of the stratosphere. The troposphere, however, the main region of wave generation, is simplified by excluding moisture and therefore interactions between dynamics and diabatic processes. The temperature tendencies of the parametrized processes are substituted by mean functions. With the dry model we have the option to perform various sets of sensitivity experiments by combining alternately climate change like thermal forcing in different settings with stationary waves and gravity wave parametrization. This approach enables us to test different possibilities of tropospheric wave generation and wave propagation and their impact on the stratospheric response and hence it gives us the possibility of isolating the causes of the stratospheric circulation response. Moreover, with this model we also have the option to study the impact of the stratospheric response on the tropospheric circulation. In the first set of experiments we study the stratospheric response to imposed tropical heating at two different vertical levels at equinox without stationary waves. We find that heating the tropical troposphere in both experiments result in two distinct and opposing responses of the Brewer-Dobson circulation. The BD- circulation weakens in the lower stratosphere and strengthens in the upper stratosphere. However, the strengthening in the upper stratosphere does not extend to the poles. The tropical upward mass flux indicates a much stronger and deeper weakening of the BD-circulation in the case of high level imposed heating than in the case of low level imposed heating.

Fine vertical structure of the Antarctic tropopause region in winter of 2016 obtained by balloonborne ozone and water vapor observations

Abstract ID : 1114

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yoshihiro Tomikawa ,tomikawa@nipr.ac.jp ,(Associate Professor) ,Japan ,Tokyo ,Presenting[1]

Dr. Masashi Kohma ,kohmasa@eps.s.u-tokyo.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Mr. Masanori Takeda ,m.takeda@dc.tohoku.ac.jp ,(None) ,Japan , ,Not Presenting[3]

Prof. Kaoru Sato ,kaoru@eps.s.u-tokyo.ac.jp ,(Professor) ,Japan ,Tokyo ,Not Presenting[2]

1 - Japan 2 - The University of Tokyo 3 - Tohoku University 4 - The University of Tokyo

An intensive balloon observation was performed at Antarctic Syowa Station (69.0S, 39.6E) in July 2016 using 7 Cryogenic Frostpoint Hygrometers (CFH) and 24 ECC ozonesondes. It aims at examining a fine vertical structure at the Antarctic tropopause and its relationship with the stratosphere-troposphere exchange (STE). While all of ozone, water vapor, and buoyancy frequency showed a clear distinction between troposphere and stratosphere, low water vapor mixing ratio was observed below the tropopause on 24th July. A potential vorticity analysis suggests an intrusion of low latitude air around the tropopause over Syowa. Three-dimensional wind observations were also performed in July using the PANSY radar (i.e., the first MST/IS radar in the Antarctic). It often observed strong vertical wind disturbances in the troposphere and the lower stratosphere. Effects of strong vertical wind on the vertical structure at the tropopause and STE will be also discussed in our presentation.

A synoptic wave-pulse view of the influence of planetary waves on the stratospheric vortex, polar ozone, the midlatitude effect of the QBO, and ozone waves.

Abstract ID : 1235

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Nili Harnik ,harnik@post.tau.ac.il ,(None) ,Israel , ,Not Presenting[1]

Ms. Vered Silverman ,vered.silverman@gmail.com ,(None) ,Israel , ,Not Presenting[2]

Mr. Sandro Lubis ,slubis@uchicago.edu ,(None) ,United States , ,Not Presenting[3]

Prof. Katja Matthes ,kmatthes@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[4]

Mr. Nour-Eddine Omrani ,Noureddine.Omrani@uib.no ,(None) ,Norway , ,Not Presenting[5]

Mr. Sebastian Wahl ,swahl@geomar.de ,(None) ,Germany , ,Not Presenting[6]

1 - University of Tel Aviv 2 - tel aviv university 3 - University of Chicago 4 - GEOMAR Helmholtz Centre for Ocean Research Kiel 5 - University of Bergen 6 - GEOMAR

The basic wave coupling between the troposphere and stratosphere involves upward pulses of wave activity, which influence the flow by decelerating it and inducing a mean meridional circulation. The net effect of these wave effects depends on the degree of their reversibility over the life cycle of the wave. We will present two implications of such reversibility, on polar ozone and on the midlatitude effect of the QBO and ozone waves.
Studies have shown that the radiative effects induced by ozone zonal asymmetries can significantly affect the polar vortex wind and temperature, but it is not clear how how the small radiative effect of ozone waves, which is strongest in fall, amplifiy to affect the mid-winter circulation. We find that the effect of ozone waves depends on phase of the QBO and show a chain of events which leads from an early winter direct radiative effect on wave-mean flow interaction, to a dynamical modulation of the polar vortex, via a modulation of the stratospheric evolution of early winter upward wave pulses and their reversibility.
It is well established that variable wintertime planetary wave forcing controls the variability of Arctic stratospheric ozone through changes in the strength of the polar vortex and the residual circulation. Previous studies
focused on the variations in upward wave flux entering the lower stratosphere. Here we examine the effects of the reversibility which follows downward planetary wave reflection, both by directly affecting ozone advection and by indirectly affecting its destruction during spring via the polar temperature.

Rossby wave breaking in the Southern Hemisphere dynamical tropopause: Variability, ozone depletion impact and links to cut off low pressure systems

Abstract ID : 1357

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Thando Ndarana ,thando.ndarana@up.ac.za ,(None) ,South Africa , ,Not Presenting[1]

Prof. Darryn Waugh ,waugh@jhu.edu ,(None) ,United States , ,Not Presenting[2]

1 - University of Pretoria 2 - Johns Hopkins University

First, a thirty-year climatology of Rossby wave breaking (RWB) on the Southern Hemisphere (SH) tropopause is formed using thirty years of reanalyses. RWB events are broadly categorized into anticyclonic wave breaking (AWB) and cyclonic wave breaking (CWB). AWB is more common than CWB, except on the lower isentrope examined (320 K). Seasonal variations vary with latitude with maximum (minimum) frequency in summer (winter) in the subtropics. In midlatitude the maximum frequencies occur during the equinox seasons and minimum during the solstice seasons. The seasonal variations of the tropospheric jets are consistent with the RWB seasonality.

The climatological link between cut-off low (COL) pressure systems and RWB is examined. 89% (11%) of COLs are associated with RWB (Potential vorticity (PV) intrusions). The RWB events occur upstream, on or before the day of the COL formation. The evolution of the PV, geopotential heights, static stability, absolute vorticity and temperature advection fields during the COLs are consistent with the formation of high PV anomalies. RWB plays a key role in producing the split flow associated with COLs, which in turn produces absolute vorticity anomalies by shear-curvature vorticity conversion, and creates static stability anomalies. The COLs associated with RWB at 330 K are deeper and more persistent than those associated with 350 K RWB and surface processes differ depending on the isentropic surface on which the associated RWB occur. The seasonality of the RWB and COLs are similar, and is linked to the seasonal march of the westerly jets.

The connection between the ozone hole and RWB and COLs is examined in reanalyses and time slice simulations. The reanalyses show an increase in the occurrence of RWB and COLs in middle latitudes during southern summer over the last thirty years. Consistent changes in RWB and COLs are found in time-slice simulations whose stratospheric ozone distributions differ between 1960 and 2000, but not in simulations that differ only in their greenhouse gas concentrations and sea surface temperatures. This supports the hypothesis that the observed increases in RWB and COL are due to the formation of the stratospheric ozone hole.

The importance of coupling between circulation, temperature, and radiative species for the tropical lower stratosphere

Abstract ID : 1474

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Amanda Maycock ,a.c.maycock@leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Alison Ming ,adk33@cam.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Peter Hitchcock ,phitch@ucar.edu ,(None) ,United States , ,Not Presenting[3]

Prof. Peter Haynes ,phh@damtp.cam.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - University of Leeds 2 - University of Cambridge 3 - NCAR 4 - University of Cambridge

There exists a tight coupling between circulation, temperature and radiatively active species in the tropical lower stratosphere. This talk will summarise a number of recent studies demonstrating the importance of this coupling for the tropical lower stratosphere on annual, interannual and centennial timescales. The annual cycles in ozone and water vapour in the tropical upper troposphere/lower stratosphere (UTLS), which are strongly influenced by circulation, are shown to make a significant contribution of around 30% to the observed 8 K peak-to-peak annual cycle in tropical average temperatures at 70hPa. On centennial timescales, climate models consistently simulate an increase in the strength of the tropical lower stratospheric circulation in response to increases in greenhouse gases. Data from an ensemble of global models show that the increase in tropical lower stratospheric upwelling over the 21st century is strongly correlated with the magnitude of tropical tropospheric warming. However, the strength of this relationship differs by up to a factor of 6 across models. This simple "dynamical sensitivity" scaling describes a large fraction of the quantitative differences in future tropical upwelling trends across models, and is useful for constraining trends in UTLS ozone and stratospheric water vapour, which have been highlighted as important climate feedback mechanisms. The strong relationship between tropospheric warming and the change in tropical upwelling offers insights into the possible underlying mechanisms.

M014 - Vertical Atmospheric Coupling the Polar Atmosphere

Observation of OH–airglow from ground, aircraft, and satellite: investigation of different wave types

Abstract ID : 483

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sabine Wüst ,sabine.wuest@dlr.de ,(Scientist) ,Germany ,Wessling ,Presenting[1]

Mr. Carsten Schmidt ,carsten.schmidt@dlr.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Patrick Hannawald ,patrick.hannawald@dlr.de ,(None) ,Germany , ,Not Presenting[3]

Mr. Thomas Offenwanger ,thomas.offenwanger@gmail.com ,(None) ,Germany , ,Not Presenting[3]

Mr. René Sedlak ,rene.sedlak@dlr.de ,(None) ,Germany , ,Not Presenting[3]

Prof. Michael Bittner ,michael.bittner@dlr.de ,(Professor for Atmospheric Remote Sensing at the University of Augsburg, Physics Department Head of Department "Atmosphere" at DLR-DFD, Oberpfaffenhofen) ,Germany ,Wessling ,Not Presenting[6]

Mr. Jeng-Hwa Yee ,Sam.Yee@jhuapl.edu ,(None) ,United States , ,Not Presenting[7]

Dr. Marty Mlynczak ,m.g.mlynczak@nasa.gov ,(None) ,United States , ,Not Presenting[8]

Dr. James Russel III ,JAMES.RUSSELL@hamptonu.edu ,(None) ,United States , ,Not Presenting[9]

1 - DLR 2 - DLR 3 - University of Augsburg 4 - University of Augsburg 5 - University of Augsburg 6 - DLR-DFD and University of Augsburg 7 - Johns Hopkins University 8 - NASA Langley Research Center 9 - Hampton University

From January to February 2016, we operated four instruments in Northern Scandinavia: two ground-based OH* IR-spectrometers (scanning and non-scanning mode at ALOMAR (69°N), Norway, and Kiruna (68°N), Sweden) and one ground-based OH* IR all-sky camera (at Kiruna) as well as one OH* IR-camera on board the research aircraft FALCON (field of view ca. 30°, spatial resolution 150 m x 150 m). Due to the differing spatial and temporal resolution of the instruments, this equipment allows the investigation of temporal and spatial gravity wave parameters in a wide spectral range. The flights of the research aircraft provide the opportunity to investigate gravity waves in between both measurement sites.
During the campaign period, the dynamical situation changed due to a minor stratospheric warming. The effect of this warming on the OH*-layer is investigated using TIMED-SABER data.
We provide an overview of the development of planetary and gravity wave parameters and energy density at mesopause height during the campaign period and present first results of the airborne

measurements. We discuss possible wave sources, e.g. flow over mountains and compare the results to the ones achieved with similar equipment in the Alpine region. Finally, we focus on the influence of the stratospheric warming on wave parameters, and propagation.

The work presented here is funded by the Bavarian state ministry for environment and consumer protection (LUDWIG) and the German federal ministry for education and research (GW-LCYCLE).

Understanding interhemispheric differences in NLC variability

Abstract ID : 488

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Maartje Kuilman ,maartje.kuilman@misu.su.se ,(PhD student) ,Sweden ,Stockholm ,Not Presenting[1]

Dr. Bodil Karlsson ,bodil@misu.su.se ,(Department of Meteorology Stockholm University) ,Sweden ,Stockholm ,Not Presenting[2]

1 - Stockholm university 2 - Stockholm University

Polar summer mesospheric noctilucent clouds vary in time and in space. In the southern hemisphere, the noctilucent cloud variability is particularly large, both in the onset of the phenomenon as in mid-season occurrence frequency. In the northern hemisphere there are, however, more noctilucent clouds than in the southern hemisphere, which also extend to lower latitudes. In this study we investigate these interhemispheric differences.
Noctilucent cloud variability is driven by various atmospheric processes, such as the solar cycle, gravity waves and planetary waves. Various other phenomena in the troposphere and stratosphere have shown to have an influence on the NLCs by perturbing the gravity wave filtering, such as the quasi-biennial oscillation and the El Niño-Southern Oscillation. Another important mechanism influencing the noctilucent cloud variability is interhemispheric coupling. In a recent study carried out with the Kühlungsborn Mechanistic general Circulation Model (KMCM), it was shown this mechanism leads to a net cooling in the summer polar mesospheres. The comprehensive Whole Atmosphere Community Climate Model (WACCM) has been used to reconfirm the hypothesis that the summer polar mesosphere will be much warmer without a gravity wave driven residual circulation in the winter. It is also seen that the northern hemisphere summer polar mesosphere is most affected by the winter hemisphere. A parameterization of noctilucent clouds is made in WACCM. It is seen that without a residual circulation southern winter mesosphere, there are less clouds in the northern hemisphere summer mesopause. For noctilucent clouds in the southern hemisphere the effect is less clear, as expected.

Turbulence measurements with LITOS during a multi scale gravity wave event at polar latitudes

Abstract ID : 644

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Jens Söder ,soeder@iap-kborn.de ,(Phd student) ,Germany ,Kühlungsborn ,Not Presenting[1]

Dr. Michael Gerding ,gerding@iap-kborn.de ,(None) ,Germany ,Kuehlungsborn ,Presenting[1]

Mr. Johannes Wagner ,Johannes.Wagner@dlr.de ,(None) ,Germany , ,Not Presenting[3]

Prof. Franz-Josef Lübken ,luebken@iap-kborn.de ,(None) ,Germany , ,Not Presenting[1]

1 - Leibniz-Institute of Atmospheric Physics 2 - Leibniz-Institute of Atmospheric Physics 3 - German Aerospace Center, Institute of Atmospheric Physics 4 - Leibniz-Institute of Atmospheric Physics

In the course of a corporate campaign of the German research Programmes METROSI and GWLCYCLE (January 2016, Northern Scandinavia), we found evidence for turbulence generation by wave saturation in the lower stratosphere. The turbulence measurements have been performed with a light weight version of the balloon-borne LITOS instrument (Leibniz-Institute Turbulence Observations in the Stratosphere) reaching altitudes of up to ~30 km. LITOS infers energy dissipation rates as a measure for turbulence strength by resolving the Kolmogorov microscale of turbulence. These measurements are combined with a series of radiosonde launches each that monitor the time evolution of the gravity wave event. During that campaign, some radiosonde observations show ambiguous vertical and horizontal wave parameters due to small horizontal wave scales and large vertical amplitudes. Therefore we utilise WRF simulations and ECMWF analyses to further investigate the wave field.
During a particular time slot on 29 Jan 2016, we observed with our unique suite of instruments turbulent patches directly related to certain wave phases of a multi scale gravity wave event. We found turbulence to be confined to certain regions in the downward phase of a small scale mountain wave that was influenced by another larger scale wave. The mountain wave was also strongly affected by the polar stratospheric jet at the onset of a minor Sudden Stratospheric Warming, which makes this an interesting measurement study into influences on vertical coupling at polar latitudes.

The South Georgia Gravity Wave Experiment (SG-WEX): investigating the small island problem

Abstract ID : 681

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Tracy Moffat-Griffin ,tmof@bas.ac.uk ,(Scientist) ,United Kingdom ,Cambridge ,Not Presenting[1]

Dr. Corwin Wright ,c.wright@bath.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Prof. Nicholas Mitchell ,N.J.Mitchell@bath.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. John King ,jcki@bas.a.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr. Steve Colwell ,src@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Andrew Moss ,andrew.moss@bath.edu ,(None) ,United Kingdom , ,Not Presenting[2]

1 - British Antarctic Survey 2 - Bath University 3 - Bath University 4 - British Antarctic Survey 5 - British Antarctic Survey 6 - Bath University

Recent studies have shown that isolated mountainous islands in regions of strong winds can be intense sources of gravity waves that can have climatologically-significant effects on atmospheric circulation. However, most climate and numerical weather prediction models cannot accurately model waves from such small, intense island sources because the islands are too small compared to the resolution of the models - this is the "small island problem".

The South Georgia Gravity Wave Experiment (SG-WEX) is a NERC funded observational and modelling experiment to determine the nature and impacts of gravity waves generated by South Georgia (a small mountainous island in the Southern Ocean). It is a collaboration between Bath University, BAS, Leeds University and the Met Office.
Two month-long radiosonde campaigns were conducted from South Georgia in 2016 to examine the gravity wave field in the troposphere and lower stratosphere. The results from these two campaigns are presented in this talk alongside model results.
The radiosonde results show a marked increase in gravity wave activity in the wintertime compared to summertime in terms of gravity wave energy density and momentum fluxes. There is also a marked difference in the proportion of upward and downward propagating waves seen in the two campaigns. The reasons for these differences are explored and the results explained in reference to the likely different sources for gravity waves in these two seasons.

Comparison of Mesospheric Wave Activities at South Pole, and ALOMAR, Norway (69N)

Abstract ID : 1200

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yucheng Zhao ,yu.cheng@usu.edu ,(UT) ,United States ,Logan ,Not Presenting[1]

1 - Utah State University

As part of the Antarctica Gravity Wave Instrument Network (ANGWIN) program, the Utah State University (USU) Advanced Mesospheric Temperature Mapper (AMTM) has been operated at the Amundsen-Scott South Pole Station (90°S), Antarctica since 2011. Six years of Austral winter-time (April to August) high-precision measurements of the IR (1.5 micron) OH (3, 1) rotational temperature (1K precision) and band intensity have now been obtained. During the same period, a second USU AMTM has been taking similar winter-time measurements (November to March) at the ALOMAR Arctic Observatory (69°N), Norway. The locations of these two high-latitude sites relative to the winter polar vortex are unique with the South Pole Station located deep inside the polar vortex.
Spectral analysis of the zenith temperature and intensity data from both of these polar sites have revealed a rich spectrum of gravity waves and planetary waves, with minimal tidal activity at the pole. In this paper, we compare the winter-time wave activities from these two sites using the 6-years of temperature and OH band intensity measurements. In particular, we focus on the similarities and differences in the intra-seasonal variations of the gravity waves and planetary waves, and their year-to-year variability as measured at these two geophysically distinct sites. Our goal is to gain new knowledge on the impact of the vortex on waves in the upper mesosphere.

Variability of wind and airglow irradiance above Eureka, Nunavut

Abstract ID : 1467

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. William Ward ,wward@unb.ca ,(None) ,Canada ,Fredericton ,Not Presenting[1]

Mr. Sam Kristoffersen ,Samuel.Kristoffersen@UNB.ca ,(None) ,Canada , ,Not Presenting[1]

Mr. Chris Vail ,c.w.vail@unb.ca ,(None) ,Canada , ,Not Presenting[1]

1 - University of New Brunswick 2 - University of New Brunswick 3 - University of New Brunswick

The PEARL All Sky Imager (PASI, airglow images)) and the E-Region Wind Interferometer II (ERWIN2, wind, airglow irradiance and temperature) are co-located at the Polar Environment Atmospheric Research Laboratory (PEARL)in Eureka, Nunavut (80 N, 85 W). These instruments view the wind and airglow irradiance of hydroxyl (both) O2 (ERWIN2), sodium (PASI), and oxygen green line (both) in the meospause region. Variability in the wind and irradiance occur over a large range of scales. Some of this variability can be directly associated with waves. Some is less coherent. In this paper, this variability is characterized as a function of time (during polar winter) and spatial and temporal scale. Of interest is whether air masses of enhanced airglow advected horizontally (as opposed to vertical advection associated with waves) is contributing to this variability. Correlations in periodicities between wind and airglow features are used to assist in this analysis. This paper will present some initial results in this study.

M015 - Energy balance of the Earth

Variations in the Earth color and brightness as observed by DSCOVR/EPIC

Abstract ID : 210

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Alexander Marshak ,alexander.marshak@nasa.gov ,(scientist) ,United States ,Greenbelt ,Presenting[1]

Dr. Tamas Varnai ,tamas.varnai@nasa.gov ,(None) ,United States , ,Not Presenting[2]

Dr. Weidong Yang ,weidong.yang@nasa.gov ,(None) ,United States , ,Not Presenting[3]

1 - NASA 2 - UMBC 3 - USRA

In contrast to low orbit and geostationary satellites, the EPIC instrument on board the DSCOVR satellite provides multispectral images of the sunlit side of the Earth every hour or two. EPIC's 10 narrowband channels span from UV to visible and near IR. The spectral observations reveal a strong daily cycle and seasonal variations in the average brightness of the planet, especially at longer wavelengths. By combining EPIC observations taken at different wavelengths, this study examines the way the brightness and the color of our planet has varied since the launch of the DSCOVR satellite in mid-2015. A special attention has been paid to the spectral daily and monthly variability of the EPIC observations. In order to better understand the observed variability, the study also analyzes the influence of factors such as variations in the observed size of land and ocean, in ice and snow covered areas, as well as in cloud cover.

First light measurements of the Total Solar Irradiance experiment CLARA on NORSAT-1

Abstract ID : 502

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Werner Schmutz ,werner.schmutz@pmodwrc.ch ,(Director) ,Switzerland ,Davos Dorf ,Presenting[1]

Dr. Bo Andersen ,bo.andersen@spacecentre.no ,(None) ,Norway , ,Not Presenting[2]

Dr. Finsterle Wolfgang ,Wolfgang.Finsterle@pmodwrc.ch ,(None) ,Switzerland , ,Not Presenting[1]

Dr. Greg Kopp ,greg.kopp@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Walter Benjamin ,benjamin.walter@pmodwrc.ch ,(None) ,Switzerland , ,Not Presenting[1]

1 - PMOD/WRC 2 - Norsk Romsentre 3 - PMOD/WRC 4 - Laboratory for Atmospheric and Space Physics 5 - PMOD/WRC

NORSAT-1 is a Norwegian micro-satellite to be launched June 29, 2017. The satellite carries two scientific instruments and an AIS receiver aimed at ship detection from space. One scientific experiment is the Compact Light-weight Absolute RAdiometer, termed CLARA, and the other is comprising four a Langmuir probes mounted on booms. The latter experiment will measure electron density and the platform's floating potential along the orbit and is provided by University of Oslo. The radiometer experiment CLARA has been built by PMOD/WRC funded through the Swiss PRODEX program. It will measure Total Solar Irradiance with a novel instrument design that is optimized for minimizing mass and size but still ensuring highest measuring accuracy and thermal stability. The three radiometer-channels of CLARA have been fully characterized as well as calibrated at the TRF facility. The absolute uncertainty of one channel is 500 ppm or 0.7 W/m^2. However, it is expected that by relative comparison to the PREMOS/PICARD value of 2010 and TCTE measurement of 2014, which both are TRF calibrated, the TSI composite can be probed on a tighter uncertainty margin. The presentation will give an overview of the CLARA instrument and its calibration. It is expected that at the time of the conference the first light TSI value of CLARA/NORSAT-1 is ready for publication.

Climate Monitoring from the International Space Station: TSIS and CLARREO Pathfinder

Abstract ID : 519

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Peter Pilewskie ,peter.pilewskie@lasp.colorado.edu ,(None) ,United States ,Boulder, CO ,Not Presenting[1]

1 - University of Colorado

The Total and Spectral Solar Irradiance Sensor (TSIS), first selected in 1998 for the National Polar-orbiting Operational Environmental Satellite System (NPOESS), re-manifested in 2010 on the NOAA-NASA Joint Polar Satellite System (JPSS), then the NOAA Polar Free Flyer, is now scheduled for deployment in 2017 on the International Space Station (ISS). The TSIS will acquire measurements of total and spectral solar irradiance. I will summarize the importance of highly accurate and stable observations of solar irradiance in understanding the present climate epoch and for predicting future climate; why continuity in the solar irradiance data record is required; improvements in the TSIS Total and Spectral Irradiance Monitors, including verification of their calibration using ground-based NIST-traceable cryogenic standards; and how these improvements will impact Sun-climate studies in the near future.

The CLARREO Pathfinder mission, in some ways an Earth-viewing analog to TSIS, is also set to deploy on ISS in 2020. The improved accuracy of the Reflected Solar spectrometer on CLARREO provides reference inter-calibration for other on-orbit assets, for example CERES and VIIRS, and sets the stage to dramatically reduce time-to-detection of climate trends. The goals of CLARREO Pathfinder are to demonstrate improved radiometric accuracy beyond current capabilities, and to demonstrate the ability to improve the accuracy of other sensors through inter-calibration.

Radiative impacts of the seasonal variability of clouds over the Amazon Basin

Abstract ID : 543

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Elisa Sena ,elisatsena@gmail.com ,(None) ,Brazil , ,Not Presenting[1]

Prof. Maria Assunção Faus da Silva Dias ,massuncao.dias@gmail.com ,(None) ,Brazil , ,Not Presenting[2]

Prof. Alex Correia ,acorreia@if.usp.br ,(Professor) ,Brazil ,Sao Paulo ,Not Presenting[1]

1 - University of Sao Paulo 2 - University of São Paulo 3 - University of Sao Paulo

Changes in cloud cover, its life cycle and albedo significantly impact the global radiative balance and the hydrological cycle. These changes could be particularly harmful in key environments, such as the Amazon, that works as a pump of heat and moisture from the tropics to temperate zones of South America. Variations in the seasonal cycle of clouds, associated with a delay in the onset of the rainy season, in the Amazon Basin have already been reported (eg., Butt et al., 2009, Fu et al., 2013). The physical mechanisms that trigger these modifications are still unclear.

In this work long-term observations are used to investigate the association between the seasonal cycle of convection and radiation in the Amazon Basin. Approximately 26 years of cloud properties retrieved by geostationary satellites were analyzed. A methodology to infer the onset and end of the wet season using cloud fraction observations is proposed. Meteorological indices related to sea surface temperature and teleconnection patterns were analyzed to understand the influence of ocean-atmosphere interactions on cloudiness. A radiative transfer model was used to estimate the contribution of the different drivers of convection to the energy balance.

The results show that cloud cover has significantly decreased over the last decades, at a rate of up to -0.6%/year over Central and Eastern Amazon. A significant trend of delay in the onset of the rainy season and a decrease in its duration are also observed. Correlation analysis indicate that cloud development is dominated by oscillation modes that occur in the Atlantic Ocean. Fewer clouds are observed over the Amazon when the Atlantic Multi-decadal Oscillation and the North Atlantic Tripole are in their positive phase. El Niño presents a smaller but significant influence on cloudiness, causing an earlier demise of the wet season. The decrease in cloud fraction over the Amazon Basin reduces the amount of solar radiation reflected back to space, while increasing irradiance at the surface. This local warming alters the atmospheric thermodynamic profile further modifying cloud formation and development.

Butt, N., et al., 2009, JGR, *114*(D21).
Fu, R., et al., 2013, PNAS, *110*(45), 18110-18115.

Influence of the land-atmosphere coupling on cloud development and precipitation over Southeastern Brazil

Abstract ID : 682

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Daniela Rodrigues ,daniela.rodrigues@cptec.inpe.br ,(Scientist) ,Brazil ,Cachoeira Paulista ,Not Presenting[1]

Ms. Sin Chan Chou ,chou.sinchan@gmail.com ,(None) ,Brazil , ,Not Presenting[1]

1 - INPE 2 - INPE

The processes of interaction between the land surface and the atmosphere may play an important role in mesoscale convection and precipitation. Numerical weather and climate prediction models still do not correctly represent surface-to-atmosphere changes. The objective of this study is to investigate the influence of the land surface-to-atmosphere coupling on cloud development and convective precipitation over the Southeast region of Brazil. The effects of the land-atmosphere coupling are analyzed through simulations with the Eta regional model in very high spatial resolution (1 km), using the Noah surface scheme. Different values were tested for the Zilitinkevich coefficient (Czil) which partitions the heat/moisture and momentum roughness lengths and indirectly determine the coupling force between the land surface and the atmosphere. The results showed that improvements in the precipitation simulation can be obtained by changing the value of the surface-to-atmosphere exchange coefficient. Changes in parameter values impact partitioning of surface flows resulting in changes in atmospheric fields near the surface. We have found that in general the increase in Czil leads to a decrease in latent and sensitive heat fluxes and, consequently, causes an increase in surface temperature. A decrease in surface temperature was observed in tropical forest areas when the value of the Czil coefficient was dynamically varied as a function of the height of the vegetation. The substitution of the default value (0.2) for the value of 0.8 and values that vary dynamically due to the roughness of the vegetation cover showed the best results in the simulation of the precipitation event. These values decreased precipitation overestimates and increased their amount in regions where it was underestimated. Improvements in the simulation of surface fluxes and in the atmospheric field were obtained by adopting the dynamic coupling coefficient. The tests need to be analyzed for other regions. The results support the use of a dynamic coupling formulation, but caution about complex terrain should be taken. Overall, these results point out that the evaluation and enhancement of the land-to-atmosphere coupling could potentially improve the performance of the model in simulation of convective clouds and precipitation.

The contribution of greenhouse gases to the recent slowdown in global mean temperature trends

Abstract ID : 867

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Michaela Hegglin ,m.i.hegglin@reading.ac.uk ,(Lecturer in Atmospheric Chemistry) ,United Kingdom ,Reading ,Not Presenting[1]

Dr. Ramiro Checa-Garcia ,r.checa-garcia@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Keith P. Shine ,k.p.shine@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Reading 2 - University of Reading 3 - University of Reading

The recent slowdown in the rate of increase in global-mean surface temperature has generated extensive discussion, but little attention has been given to the contribution of time-varying trends in greenhouse gas concentrations. We use a simple model approach to quantify this contribution and show that between 1985 and 2003, greenhouse gases caused a reduction in GMST trend of around 0.03-0.05 K decade^{-1} which is around 18%-25% of the observed trend over that period. We discuss the relative contributions of different greenhouse gases (CO_2, N_2O, CH_4, stratospheric and tropospheric O_3, stratospheric H_2O, and ODSs). We highlight the result that trends in non-CO_2 greenhouse gases can make significant positive or negative contributions to changes in the rate of warming that need to be considered when analyzing causes of temperature trend variations. We then also explore the response of our result when taking into account a recently updated value for the radiative forcing of methane.

Effects of aerosol and clouds on the atmospheric energy budget

Abstract ID : 919

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. stefan kinne ,stefan.kinne@mpimet.mpg.de ,(None) ,Germany ,Hamburg ,Not Presenting[1]

Mr. Piet Stammes ,piet.stammes@knmi.nl ,(None) ,Netherlands , ,Presenting[2]

Mr. Ehrhard Raschke ,drraschke@aol.com ,(None) ,Germany , ,Not Presenting[3]

1 - MPI-meteorology 2 - KMNI 3 - University of Hamburg

Global distributions of optical and microphysical properties for clouds (SRB, CERES, ISCCP) and aerosol (MAC aerosol climatology) are applied in an off-line radiative transfer model to illustrate (average as well as spatial and seasonal context of) impacts of (all, high, mid and low altitude) clouds and of (total, natural and anthropogenic) aerosol on atmospheric energy budgets at the top of the atmosphere, at the Earth's surface and for the atmosphere. A particular focus will be given impacts linked to (anthropogenic) changes in aerosol since pre-industrial times, including estimates for aerosol (extra nuclei microphysical) impacts on low altitude clouds.

ASSESSMENT OF THE DIRECT RADIATIVE EFFECT OF THE 2017 CHILEAN WILDFIRE SMOKE PLUME

Abstract ID : 1127

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Piet Stammes ,stammes@knmi.nl ,(Senior scientist) ,Netherlands ,De Bilt ,Not Presenting[1]

Dr. Martin de Graaf ,graafdem@knmi.nl ,(None) ,Netherlands , ,Not Presenting[1]

Mr. Maurits Kooreman ,kooreman@knmi.nl ,(None) ,Netherlands , ,Not Presenting[1]

Miss. Jiyunting Sun ,jiyunting.sun@knmi.nl ,(None) ,Netherlands , ,Not Presenting[1]

Dr. J. Pepijn Veefkind ,veefkind@knmi.nl ,(None) ,Netherlands , ,Not Presenting[1]

Dr. Peter van Velthoven ,velthove@knmi.nl ,(None) ,Netherlands , ,Not Presenting[1]

1 - KNMI 2 - KNMI 3 - KNMI 4 - KNMI 5 - KNMI 6 - KNMI

In January and February 2017 wildfires raged in Central Chile, due to drought conditions and high temperatures. A number of people were killed and many lost their homes. Smoke plumes arising from the fires were drifting over the Pacific Ocean for hundreds to thousands of kilometers. The smoke was partly drifting over clouds and partly over cloud-free ocean.

Absorption of solar radiation by smoke consisting of biomass burning aerosols (BBA) may lead to strong atmospheric warming and surface cooling. At top-of-atmosphere the direct radiative effect (DRE) of smoke depends on the albedo of the underlying surface, i.e. dark ocean or bright clouds. To estimate the direct radiative effect of the smoke plumes we analysed available satellite measurements in the period 20 January - 5 February 2017.

We used the UV absorbing aerosol index (AAI) from the GOME-2 instrument on the Metop-A and B satellites to detect the smoke plume in both cloud-free and cloudy scenes. For smoke in cloud-free scenes we employed the aerosol optical thickness (AOT) from MODIS/Aqua, and with this AOT as input we calculated the DRE at top-of-atmosphere and inside the atmosphere with a spectrally resolved radiative transfer model. For smoke in cloudy scenes we used the OMI/Aura and MODIS/Aqua multi-spectral radiances and determined the DRE at top-of-atmosphere using the novel Differential Aerosol Absorption method (De Graaf et al., JGR, 2012). With this method, the DRE can be determined without determining the aerosol properties, only requiring vanishing AOT at long wavelengths. In this way we could make a comprehensive assessment of the DRE of the Chilean smoke plumes.

Additionally, simulations of the smoke plume were performed using the chemical transport model TM5, through which the aerosol profiles and optical properties were provided. Then the radiative transfer model DISAMAR was employed to calculate the AAI and AOT, which were further compared to the satellite observations.

Impact of biomass burning aerosol layers on the underlying cloud radiative effects in the South East Atlantic

Abstract ID : 1188

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Samuel LeBlanc ,samuel.leblanc@nasa.gov ,(Scientist) ,United States ,Moffett Field ,Presenting[1]

Dr. Yohei Shinozuka ,yohei.shinozuka@nasa.gov ,(None) ,United States , ,Not Presenting[1]

Dr. Jens Redemann ,jens.redemann-1@nasa.gov ,(None) ,United States , ,Not Presenting[3]

Dr. Connor Flynn ,connor.flynn@pnnl.gov ,(None) ,United States , ,Not Presenting[4]

Dr. Michal Segal-Rosenheimer ,michal.segalrozenhaimer@nasa.gov ,(None) ,United States , ,Not Presenting[1]

Dr. Meloë Kacenelenbogen ,meloe.s.kacenelenbogen@nasa.gov ,(None) ,United States , ,Not Presenting[6]

Dr. Kristina Pistone ,kristina.pistone@nasa.gov ,(None) ,United States , ,Not Presenting[7]

Dr. Yana Karol ,yana.karol@nasa.gov ,(None) ,United States , ,Not Presenting[7]

Dr. K. Sebastian Schmidt ,Sebastian.Schmidt@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[9]

Ms. Sabrina Cochrane ,Sabrina.Cochrane@colorado.edu ,(None) ,United States , ,Not Presenting[9]

1 - BAER/NASA Ames Research Center 2 - BAER/NASA Ames Research Center 3 - NASA Ames Research Center 4 - Pacific Northwest National Laboratory 5 - BAER/NASA Ames Research Center 6 - BAER/NASA Ames Research Cneter 7 - USRA/NASA Ames Research Center 8 - USRA/NASA Ames Research Center 9 - University of Colorado 10 - University of Colorado

We present early results from the NASA ObseRvations of CLouds above Aerosols and their intEractionS (ORACLES) field campaign, focused on the South East Atlantic seasonal biomass burning aerosol layers which overlie semi-permanent marine stratocumulus clouds. We present results from airborne measurements by the Spectrometer for Sky-Scanning, Sun-Tracking Atmospheric Research (4STAR), in conjunction with measurements from the Solar Spectral Flux Radiometers (SSFR). During this field campaign, 4STAR sampled cloud-transmitted solar light via zenith measurements, while SSFR characterized the flight level albedo. We present calculated cloud radiative effects (CRE) based on (i) retrieved cloud optical thickness, effective radius, and thermodynamic phase from zenith-viewing scattered light measurements under stratocumulus clouds and (ii) measured properties of the overlying aerosol layer. Typical remotely sensed cloud properties are based on reflected light, but here we use transmitted light to retrieve cloud properties, taking advantage of a hyperspectral retrieval technique. For cases where there is an overlying aerosol layer, cloud top reflected light may cause some biases in retrieved cloud properties. In contrast, an opposite bias in retrievals based on light transmitted through clouds is expected. To account for any biases, we use accurate measurements and retrievals of the overlying aerosol optical properties (aerosol optical depth, single scattering albedo, and asymmetry parameter) in addition to cloud-transmitted light to

calculate the CRE below cloud. We have observed that the overlying aerosol layer acts to reduce the top of atmosphere and surface CRE by the simply reducing the cloud-incident radiative energy, i.e. casting a shadow on the cloud. We present an early estimate of the CRE based on measured values and calculate the impact of to the presence of aerosol on calculated CRE.

M016 - Resilience: The science of Adapting to Climate Change

Challenges in building climate resilient quality energy infrastructure in Africa

Abstract ID : 67

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ashbindu Singh ,ashbindu@gmail.com ,(President) ,United States ,Centreville ,Not Presenting[1]

1 - Environmental Pulse Institute

Africa is rich in energy resources but poor in its capability to exploit and use them. Many African countries face an energy crisis. Power is inaccessible, unaffordable and unreliable for most people, trapping them in poverty. Power is, by far, Africa's biggest infrastructure challenge. Whether measured in generation capacity or electricity consumption, Africa's power infrastructure delivers only a fraction of the services found in other parts of the world. There are solutions, however, including the following: significant investment in energy infrastructure; technology transfers; improving access to electricity on a large scale; boosting cross-border power trade; improving the performance of existing utility companies; and helping countries chart low-carbon growth paths.
While increasing funding for infrastructure development is important, this must be accompanied by improvements to the quality and sustainability of infrastructure. Providing infrastructure that is economically efficient, socially inclusive, safe, resilient and sustainable requires building-in concepts of quality throughout the project life-cycle, from feasibility planning and design, through to appropriate technology, operation and maintenance.
Furthermore, Africa is likely to be significantly impacted by climate change, through increased weather events (both droughts and storms) and rising sea levels. Ensuring climate resilience implies additional investment costs, probably of between 10% and 15%. However, there would be later benefits, both financial and societal. So scientifically credible information is needed for building a climate resilient energy infrastructure. However, due to uncertainty associated with the current knowledge of climate adaptation, it is rather difficult for decision makers to justify additional investments when they are faced with allocation of limited financial resources among competing priorities.

Enhancing The Resilience of Farmers In Dryland Ecosystem Against Water Droughts And Land Degradation In Semi-Arid Region Of Pakistan

Abstract ID : 73

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Sahibzada Irfanullah Khan ,sirfanullah@hotmail.com ,(Provincial Programme Coordinator, Sustainable Land Management Programme) ,Pakistan ,Peshawar ,Not Presenting[1]

1 - Sustainable Land Management Programme

There are more than 3 billion people globally living in drylands that cover 40% of earth's surface; ROBIN (2002). In Pakistan, the situation is severe with 75% of the country's area receiving less than 250 mm of annual rainfall; PMD (1998). Drylands in southern Pakistan are home to communities living in poverty and depending on livestock rearing for their livelihood. The subsistence agriculture is losing its importance under the effects of climate change i.e. uncertain rainfall and very low productivity. To fill the livelihood gap, local communities are increasing their livestock herds. Thus pressure on silvo-pastures is increasing resulting in degradation of natural resources and loss of soil fertility, a fact that adversely affects the livelihood of communities.

The Farm Forestry Support Project (FFSP) of the Intercooperation (IC) and Swiss Agency for Development & Cooperation (SDC), initiated collaboration with local pastoral communities to pilot adaptation measures in 2010 in extreme dry region of Karak. Major elements of these measures included the strengthening of the silvo-pastoral system using hillside ditches and sand dune stabilization techniques. The objective was to harvest, conserve and use rain water for recovering vegetation and increase productivity of the area with minimum cost and hence support livelihoods. The results recorded in 2015 showed a profuse plant growth in terms of trees, shrubs and grasses with a potential to provide timber, fuel wood and fodder for livestock. Maximum harvesting of rainwater and conservation of moisture also resulted in growth of natural grasses and shrubs. Within a short period of 5 years, plant growth in height and diameter of 6 meters and 20 centimeters respectively was recorded. The average vegetation cover of 45% and increase in soil organic matter and nitrogen content was also recorded. All this happened with a minimum cost of US$ 82 per hectare. The rejuvenation of wells in few cases was an additional positive affect of the activity. On the other hand, an annual income of US$ 735 per hectare from *Saccharum spontaneum* planted in sand dunes was a real benefit to farmers against other land-uses in sand dunes.

Loss and Damage and Limits to Adaptation: Case Study from the Philippines

Abstract ID : 122

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ebinezer Florano ,efloranoy@yahoo.com ,(Associate Professor & Director) ,Philippines ,Quezon City ,Not Presenting[1]

1 - University of the Philippines-National College of Public Administration and Governance

This paper aims to rapidly assess the legal and institutional frameworks in the Philippines used in determining the L&D caused by recent disasters. The research questions are: Can the Philippines make a claim about L&D from CC? Are there legal and institutional frameworks to determine L&D in the Philippines? Are they attuned for CC-induced disasters? How can they be improved? The Philippines has legal and institutional frameworks for CC and disaster risk reduction (DRR). It is not known, however, if they could help in determining L&D specifically for CC for the country. There are two laws dedicated to CC and DRR, namely: (1) the Climate Change Act of 2009 (Republic Act 9729), and (2) the Philippine Disaster Risk Reduction and Management Act of 2010 (Republic Act 10121). The former only mentions about "damage to ecosystems", and "biodiversity loss", but silent on the accounting methods. The latter, on the other hand, has a full accounting system for "loss of lives" and "damage to property" due to its long history of experiences dealing with man-made disasters. At the institutional and operational levels, L&D are inventoried by various government agencies through the use of the Post-Disaster Needs Analysis (PDNA) methods. It is not clear, however, if the PDNA methods and levels of analysis are applicable to CC-induced disasters. In the short run, it could be useful for national accounting of post-disaster damages. However, it might have to go beyond reporting L&D using the PDNA way. The Philippine government might have to consider attributing the hazards and disasters to CC, and if such could have been prevented had responsible parties (including the Philippines) contributed their shares in mitigating global GHG emissions. Unfortunately, the science of attribution is also not clear on this.

California: It's Complicated: A Case Study of the San Joaquin Valley

Abstract ID : 195

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Gillisann Harootunian ,gharootunian@csufresno.edu ,(Director, University Initiatives) ,United States ,Fresno ,Not Presenting[1]

1 - California State University, Fresno

From 2012-2016, California experienced the most severe drought conditions in its recorded history. California has both the largest population in the U.S. and the most significant agricultural industry. The impacts of the drought have been severe, and the response complicated.
This case study tackles that complicated scenario by reviewing five factors:

1. Scientific evidence suggests links between anthropogenic warming and an increase in the occurrence, strength, and length of droughts in California.
2. Two ecosystems (surface water and groundwater) were severely impacted by the drought. These ecosystems provide two services?drinking water and agricultural irrigation?that are increasingly threatened in the face of unchecked climate change heralding mega-droughts. Agribusiness has mined aquifers to the point some may never recover. Farmworker communities have found their domestic wells run dry or become contaminated by an increasing concentration of pollutants, such as nitrates (from agricultural fertilizers).
3. California government experienced growing pressure from the drinking water crisis. How to bring municipal-type water infrastructure and services to farmworker communities? The community-based adaptation is a joint powers agreement forming a "Drinking Water Authority" that legally empowers multiple stakeholders to build a regional surface water treatment plant to provide drinking water to the communities.
4. A fiscal response is necessary, however, to realize the proposed solution. The farmworker communities cannot afford to build the regional water treatment plant. Moreover, post-construction costs include an on-going monthly household service fee. Should agribusiness as a key responsible party pay some of that fee? The estimated service fee is $33.889 per household, and the average annual Total Crop Value per acre $13,823.82.
5. Californians complain of being "fee-ed to death," but the reason is an unsustainable state fiscal structure. Assessed property values are divorced from actual market value in California. To meet chronic fiscal shortfalls from a shrunken tax base, California deploys a labyrinth system of use taxes and impact fees. With projected population growth in California, demand for water will increase, and the local communities will have little capital to build infrastructure or pay on-going service fees.

The progression of climate change, human rights and human mobility

Abstract ID : 335

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Cosmin Corendea ,corendea@ehs.unu.edu ,(Academic Officer/ Legal Expert) ,Germany ,Bonn ,Not Presenting[1]

1 - United Nations University

The preliminary findings Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR5) Chapter 19 recognizes the emergent risk and key vulnerabilities related to climate change and migration. Climate change will bear significant consequences for human migration flows "at particular times and places", creating risks as well as benefits for migrants and for sending and receiving regions and states (*high confidence*) [19.4.2.1].
The international community is already developing solutions and approaches to the impacts of migration related to climate change. However, this long-term process requires global comprehensive and sustainable solutions with the support of a human rights frameworks.
The human rights and migration relation needs to be brought into the climate change process at the local, national and regional/ international level in order to protect rights, reduce risks, build resilience and empower people. This is particularly important in the context of the Paris Agreement's implementation period, as it will inform the domestic frameworks dealing with environmental risks.
Based on the AXA research project in the Pacific, which analyses *inter alia*, the risks associated with international climate policies implementation into domestic climate change frameworks, this paper aims to address the interrelation and interconnection between climate change, human rights and human mobility with a strong emphasize on regionalism (bottom up approach) and the rights-based approach.

Managing flood risk in the Thames Estuary: The Thames Estuary 2100 (TE2100) project, putting climate change adaptation into practice

Abstract ID : 362

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Darren Lumbroso ,d.lumbroso@hrwallingford.com ,(Technical Director) ,United Kingdom ,Wallingford ,Not Presenting[1]

Mr. David Ramsbottom ,d.ramsbottom@hrwallingford.com ,(None) ,United Kingdom , ,Not Presenting[1]

1 - HR Wallingford 2 - HR Wallingford

There are billions of pounds worth of assets at risk of flooding in the Thames Estuary and London. This infrastructure benefits from a system of measures protecting them from floods with a return period up to 1 in 1,000 years. However, owing to climate change, sea levels are rising, and there is a long-term lowering of ground levels in south-east England following the melting of the ice sheets at the end of the most recent Ice Age. These factors coupled with increasing development in the Thames Estuary's floodplain means that the risk of flooding is increasing and that flood defences, including the Thames Barrier, need to be upgraded, if the same level of protection is to be provided in the future.

In 2002, the Environment Agency, (the organisation responsible for flood risk management in England), established the Thames Estuary 2100 project (TE2100) with the objective of developing a strategic flood risk management plan for London and the Thames estuary through to the end of the century. Over a six year period studies were undertaken to gain a thorough understanding of how flood risk is managed today and the options that could manage flooding through to 2100. TE2100 was the first major flood risk project in the UK to have put climate change adaptation at its core.

As part of TE2100 an approach to adaptation was developed that takes account of the impacts of climate change, lowering ground levels and deterioration of the existing flood defence system. The approach was based on a number of flood risk management thresholds including flood defence crest levels in different parts of the estuary and the frequency of flood barrier closures. Strategic options were developed that consisted of sequences of interventions to be implemented when each threshold is reached. The options were tested for a range of future scenarios to demonstrate that the TE2100 plan is robust to a wide range of future conditions. Indicators of change are monitored and used to update the dates when the thresholds will be reached and therefore the interventions will be needed.

Climate Resilient City: Assessing the Adaptive Capacity of Coastal Communities of India

Abstract ID : 795

Conflict Declaration : None

Content Motivation : Very Strong Motivation for attending this 2017 Joint IAPSO-IAMAS-IAGA Assembly in Cape Town, South Africa.

Additional Information : None

Mr. Shailendra Kumar Mandal ,shailendra@nitp.ac.in ,(Research Scholar and Assistant Professor) ,India ,Patna ,Not Presenting[1]

1 - National Institute of Technology Patna, India

Vulnerability of coastal areas to climate change is a key issue, which has gained attention recently. Coastal areas face multiple risks and stresses related to climate change and variability (IPCC 2007a). "Thirteen of the world's 20 largest cities are located on the coast, and more than a third of the world's people live within 100 miles of a shoreline" (World Bank 2010).
Altered frequencies and intensities of extreme weather, combined with sea level rise, are expected to have mostly adverse effects on natural and human systems. Coastal communities are highly vulnerable to global change impacts, mainly because of three reasons, high resource dependency, high exposure and limited adaptive capacity. India has a 7,517 km long coastline with many low-lying and densely populated areas with nearly 260 million people living within 50 km of the seacoast.
The report on coastal mega cities (World Bank 2010) states that about 2 per cent of the world's land area is represented by low-lying coastal areas. This 2 per cent coastal land area contains 13 per cent of the urban population (McGranahan et al., 2007). These highly vulnerable areas house a network of infrastructures. It is highly pertinent to start climate proofing infrastructure and services, given the climate sensitive nature of the existing infrastructure systems in the urban area. It could be maintained and managed in such a way that it is prepared to withstand climate impacts that it may be subjected to during its operational lifetime. Although the focus on urban adaptation has emerged more recently than earlier adaptation research that tended to focus on sectors such as agriculture, coasts or biodiversity, cities are catching up and developing adaptation responses (GLA 2010, Storch et al. 2009, Bloomberg et al. 2010).
This paper discusses on adaptive approaches that can increase resilience of infrastructure and the services in coastal urban areas of developing nations. It also highlights the Identification of vulnerable hot spots in the coastal urban area, recommendations for climate resilient infrastructure and services and methodology for vulnerability assessment of coastal cities to climate variability and sea-level rise.

The Science of Adaptation to Extreme Heat

Abstract ID : 809

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Ethan Coffel ,ec2959@columbia.edu ,(PhD Student) ,United States ,New York ,Not Presenting[1]

Dr. Alex de Sherbinin ,adesherbinin@ciesin.columbia.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Stuart Gaffin ,srg43@columbia.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Radley Horton ,rh142@columbia.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Stefan Kienberger ,stefan.kienberger@sbg.ac.at ,(None) ,Austria , ,Not Presenting[5]

Dr. Kate Lane ,klane1@health.nyc.gov ,(None) ,United States , ,Not Presenting[6]

Dr. Olga Wilhelmi ,olgaw@ucar.edu ,(None) ,United States , ,Not Presenting[7]

1 - Columbia University of New York 2 - Columbia University 3 - Columbia University 4 - Columbia University 5 - University of Salzburg 6 - NYC Department of Public Health 7 - UCAR

Heat is the number-one weather-related cause of death globally. Recent heat waves have been responsible for tens of thousands of excess deaths, damage to infrastructure, crop losses, and economic disruption. Many of these events have been in part attributed to climate change and in coming decades the frequency, magnitude, and duration of extreme heat waves are very likely to rise across the world. Given the high probability of increasingly severe temperatures and their moderate to high impact on human health, heat impacts are projected to expand dramatically. This chapter examines the state of the science concerning heat stress, the urban heat island, and heat adaptation strategies in both the developing and the developed world, and considers how adaptation can be guided by evidence to yield improved results. Adaptation solutions based on sound science -physical, social, and behavioral - are essential to target the most vulnerable populations and decrease impacts on human health and wellbeing.

Climate change, climate extremes and global food production – the need for adaptation in the agricultural sector

Abstract ID : 853

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Elisabeth Vogel ,elisabeth.vogel@climate-energy-college.org ,(PhD student) ,Australia ,Melbourne ,Not Presenting[1]

1 - University of Melbourne

This presentation summarises the main impacts of climate change and extreme events on the global food system, based on a review of the literature and own research, and highlights the need for adaptation in the agricultural sector.
Climate change poses major risks for the world agriculture in the 21st century, with implications for the livelihoods of farmers and the food security of communities worldwide. The agricultural sector employs close to 1 billion people worldwide - or about 1/3 of the global workforce (ILOSTAT, 2016). In developing countries, the share of people who depend on agriculture for their livelihoods is even higher, putting the greatest risks on the most vulnerable. At the same time, the global food system is faced with increasing pressures from demographic change - by 2050, the world population is estimated to reach 9.7 billion people (UN, 2015) and rising income and urbanisation levels will lead to higher per capita consumption and increasing demands for animal products. The UN Food and Agriculture Organization estimates that food production has to increase by 70% until 2050 to meet future demands (FAO, 2009), while mitigating climate change and adapting to the effects of it.
Food producers have to adapt to climate change related shifts in mean climate and changes in the variability of climate variables (e.g. precipitation, temperature). Further, certain types of extremes, such as droughts and heatwaves, are projected to increase and/or become more severe in many regions worldwide (IPCC, 2012). Food production is affected in a number of ways - through, for example, direct impacts on crop yields, effects on irrigation water availability, crop pests, declines in the nutritional value of some food products and impacts on livestock. Furthermore, due to the growing interconnectedness of the food system, production shocks in one region can lead to cascading effects and impact communities in other parts of the world (GFSP, 2015).
It is therefore critical to improve the resilience of the global food system to climate change and particularly extreme events to secure the livelihood of communities depending on agriculture for their living and to ensure the sustainable production of food in a changing world.

State of Climate Change Adaptation Policies and Negotiations

Abstract ID : 869

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Saleem Huq ,saleemul.huq@iied.org ,(None) ,Bangladesh , ,Not Presenting[1]

Mr. Yousuf Mahid ,mahid.buet06@gmail.com ,(Coordinator: Policy Support Programme) ,Bangladesh ,Dhaka ,Presenting[1]

Ms. Nadine Suliman ,nadinesuliman@trentu.ca ,(None) ,Bangladesh , ,Not Presenting[1]

1 - International Centre for Climate Change and Development (ICCCAD) 2 - International Centre for Climate Change and Development (ICCCAD) 3 - International Centre for Climate Change and Development (ICCCAD)

Adaptation has been spearheading international negotiations as scientific predictions continue to reaffirm that mitigation as the only response to climate change is insufficient. In theory, adaptation is described on a gradient of impact from reactive to proactive measures of response to climatic variability and its socio-economic repercussions. Discussions occur at global, national, and local scales, with the UNFCCC as the main correspondent. Initiated through the Marrakech Accords in COP7 (2001), adaptation negotiations continue to develop year by year. This chapter discusses the evolution of conventional adaptation policies and negotiations across governance scales, under the UNFCCC umbrella and elsewhere; highlighting different programmes, plans, and frameworks that govern action and any gaps or discrepancies herein. Through a critical analysis lens, climate change adaptation policies are evaluated in comparison with discussions/ action in the South versus the North. In conclusion, recommendations for potential South-North and South-South collaboration on adaptation policies are stated.

Climate Resilient Development in Fragile Contexts

Abstract ID : 926

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sarah Henly-Shepard ,shenlyshepard@mercycorps.org ,(Senior Advisor, Climate Change & Resilience) ,United States ,Washington ,Not Presenting[1]

Dr. Zinta Zommers ,Zinta.Zommers@unep.org ,(Programme Officer) ,United States ,Washington ,Not Presenting[2]

Mr. David Nicholson ,dnicholson@mercycorps.org ,(None) ,United States , ,Not Presenting[1]

1 - Mercy Corps 2 - United Nations 3 - Mercy Corps

This chapter will explore the need for climate resilient development in fragile states, including contexts of extreme poverty, post-disaster and conflict. Climate change is increasing the frequency, intensity and unpredictability of shock and stressor hydro meteorological events, rendering particularly negative impacts upon societies highly dependent upon natural resources, and exacerbating underlying vulnerabilities. Most climate change adaptation and resilience research efforts focus primarily on stable-states, in rural areas and politically stable states. However, an increasing number of people are migrating, moving to or residing in urban and per-urban areas, and face conflict and displacement from ecological degradation, war and disasters. Many of these people are particularly vulnerable to the impacts of climate change. In addition, many development and humanitarian response programs fail to adequately reduce underlying causes of vulnerability and exposure to conflict and disaster, nor build adequate capacities of people to cope, adapt and transform amidst these challenges. In order to adapt to 21st century trends and demands, humanitarian development will need to comprehensively address dynamic and complex socio-ecological systems, including in fragile states, urban areas and amidst migrating populations. It is critical to integrate climate change adaptive measures within resilience frameworks for humanitarian development. As illustrated in the Sendai Framework for Disaster Risk Reduction, the Sustainable Development Goals and the Paris Agreement, clear linkages between climate change, resilience humanitarian aid demand have been established at a scientific, programmatic and policy level. However, linking these policies with localized, appropriate indicators and programming has proven difficult, due to financial, programmatic and political barriers. Gaps in research, policy and programming will be reviewed, to highlight challenges and opportunities in bridging adaptation and resilience thinking within humanitarian development in high-risk conflict and disaster-prone systems. A suite of case studies presenting adapted methodologies and tools, new evidence and innovative approaches to adaptation and resilience in fragile states affected by conflict, will be evaluated, offering a cross-section of different geographical, ecological, political and social perspectives.

The Need for Evidence and Intelligent Tinkering in Climate Change Adaptation

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Content Motivation : None

Additional Information : None

Dr. Zinta Zommers ,Zinta.Zommers@unep.org ,(Programme Officer) ,United States ,Washington ,Presenting[1]

Dr. Anand Patwardhan ,apat@umd.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Keith Alverson ,keith.alverson@unep.org ,(None) ,Japan ,None ,Not Presenting[3]

Ms. Aki Yamaguchi ,aki.yamaguchi.affiliate@unep.org ,(None) ,Japan , ,Not Presenting[3]

1 - United Nations 2 - School of Public Policy, University of Maryland 3 - International Environmental Technology Center, UNEP 4 - International Environmental Technology Center, UNEP

The Paris Agreement marks a significant acceleration in the adaptation agenda, by creating a global goal for adaptation; by enabling countries to include adaptation and resilience goals in their NDC's; and, by placing equal emphasis on adaptation and mitigation with regard to the provision of climate finance. Validation is critical to ensure equitable, efficient adaption outcomes arise from adaptation actions. However methodologies to validate progress are still nascent and thus the evidence base for what works is limited. As a result, there is a significant risk that actions may lead to maladaptation - adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare. To avoid unintended negative consequences it is critical that adaptation efforts adopt experimental design approaches to validate interventions. Indeed, medicine, development economics, conservation biology and other fields of practice commonly use techniques such as systematic reviews and randomized trails.

Moreover, it is critical to develop an approach based on adaptive management, in which implementation itself includes a strong learning component, i.e. learning by doing. Traditionally, learning and research is conducted before and after implementation. Pilots are implemented, validated and then, if successful, scaled up. However, given the magnitude and immediacy of climate change, in both the long-term and short-term, and the myriad local contexts and constraints that vex simplistic attempts to scale up solutions, there is an urgent need for this approach to be revised. "Intelligent tinkering" -from small, rapid experiments to large, long-term experiments-needs to be planned into projects themselves (Mills et al. 2015).

This paper will highlight some examples of intelligent tinkering including the use of mechanisms such as "refine and implement" and "shock response". It will suggest how science, practice and policy may need to change to embed learning and facilitate effective adaptive management.

Forecast Based Financing and Climate Change Adaptation: exploring lessons learnt from Uganda

Abstract ID : 993

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Wasswa Eddie Jjemba ,jjemba@climatecentre.org ,(Programme Officer) ,Uganda ,Kampala ,Not Presenting[1]

1 - Red Cross Red Crescent Climate Centre

Humanitarian organizations and development partners are increasingly searching for ways of reducing human suffering at affordable and sustainable costs. This in part explains the growing investment and interest in early action based on sound science. The Forecast based Financing (FbF) approach piloted in northeastern Uganda seeks to contribute to this effort. This approach involves an iterative process of matching forecasts with appropriate actions compiled into Standard Operating Procedures (SOPs). In the Uganda pilot, the SOPs focused on three areas that reduce the impact of floods; enhancing water purification and storage to minimize diarrheal infections, encouraging food storage to minimize post-harvest losses, and digging drainage channels (trenches) to reduce damage to houses and gardens. There were two activations in November 2015 and April 2016 that provided an opportunity to experience a realized forecast and a false alarm. An evaluation and community consultation conducted later on generated lessons that can inform subsequent programming. Uganda Red Cross' experience in piloting the Forecast Based Finance approach shows that the approach has great potential to enhance climate change adaptation by strengthening early warning systems and disaster financing in developing countries.

Urban landscapes: How urbanization, climate change and the urban environment are shaping the Earth

Abstract ID : 1008

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Julie Greenwalt ,jgreenwalt@citiesalliance.org ,(Urban Environment Specialist) ,Belgium ,Brussels ,Presenting[1]

Dr. Keith Alverson ,keith.alverson@unep.org ,(None) ,Japan ,None ,Not Presenting[2]

Ms. Nina Raasakka ,nina.raasakka@unep.org ,(None) ,Finland , ,Not Presenting[3]

1 - Cities Alliance 2 - International Environmental Technology Center, UNEP 3 - UN Environment

Climate change and urbanization are increasingly defining the planet yet they are both characterized by inequitable impacts and inadequate responses.
Despite variability in the definition of cities, it is well recognized that more than half of the world's population now living in cities and this is expected to increase in the next decades. Conversely it is well documented and yet less recognized that human-induced climate change is occurring and threatens to increase in the next decades. The people, businesses and buildings within cities are responsible for consuming 75% of the world's natural resources and an estimated 75% of global emissions, but much of this is concentrated in the developed world. Whereas the need for adaptation is arguably higher in the cities of developing countries given the high levels of vulnerability. Urbanization has enhanced economic development and improved the lives of many people in the past few decades, however basic living conditions still elude millions of urban residents around the world. The Fifth Assessment of the IPCC made it clear that there are many climate change-related risks for urban areas and they are on the rise. The risks include: rising sea levels, storm surges, heat stress, extreme precipitation, inland and coast flooding, landslides, drought, increased aridity, water scarcity, and air pollution. These risks are heightened for those living in informal settlements, lacking housing, services and infrastructure.
Assessing the responses to climate change and urbanization reveal that there has been a proliferation of global agreements and support generated from the international level, however there is a pervasive lack of capacity, data and finance at the city level to effectuate change. Solutions vary by city, country and region. In high income countries, improving urban spaces is critical for reducing GHG emissions and there is great potential for multiple benefits from upgrading urban areas - increased mobility, more reliable energy sources, reducing vulnerabilities to disaster while transitioning to a low-carbon economy powered by cities. In developing countries, ecosystem-based approaches to adaptation in urban and peri-urban areas have the potential to attain sustainable development for cities.

What constitutes "success" in adaptation?

Abstract ID : 1269

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Anand Patwardhan ,apat@umd.edu ,(None) ,United States , ,Not Presenting[1]

1 - School of Public Policy, University of Maryland

Measuring, monitoring and evaluating adaptation poses conceptual, methodological and practical challenges - starting with the difficulty of defining "success" - as the long-term nature of climate change makes the success of adaptation efforts only apparent over time and in retrospect, creating difficulties for current- and near-term assessments of progress. Further, adaptation interventions occur against the background of evolving climate, environmental and developmental baselines - posing challenges for attribution and evaluation - including the lack of counterfactuals.
Adaptation is increasingly seen as a process of iterative risk management that is put into practice through mainstreaming. This often requires systemic interventions and institutional and structural changes with regard to aspects such as planning, coordination, finance, capacity and the science-policy interface. Consequently, measuring and tracking progress requires us to monitor and track process and capability outcomes with appropriate indicators and with an appropriate balance between the need for comparability and aggregation and the need to preserve contextual richness and detail. Continued progress and action may thus be the most feasible and appropriate metric for success.

Social capital as a determinant of resilience: Implications for adaptation policy

Abstract ID : 1318

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Siobhan Kerr ,siokerr@umd.edu ,(PhD Student) ,United States ,Silver Spring ,Not Presenting[1]

Dr. Anand Patwardhan ,apat@umd.edu ,(None) ,United States , ,Not Presenting[1]

1 - School of Public Policy, University of Maryland 2 - School of Public Policy, University of Maryland

This chapter examines the role of social capital as an important determinant of resilience. Social capital refers to the linkages between individuals and groups, and the norms, common values and understanding that strengthen them. It manifests either by *bonding* with those inside the group or *bridging* outside connections. Research has shown that social capital, and in particular bridging social capital, is a strong predictor of a community's post-disaster recovery. It can explain divergent outcomes in cases where many of the more frequently cited determinants, such as income of residents, governance, aid, disaster severity, or population density fail. While social capita can be used to build resilience and recovery, its impacts within communities are not uniformly beneficial. It often excludes community outsiders, such as religious and ethnic minorities and other vulnerable groups, thereby reinforcing their vulnerability and leaving them even worse off. Adaptation policies and interventions need to consider and incorporate social capital issues.
Keywords: Social capital; resilience; recovery; community; adaptation

Promoting innovative dialogue for Resilience: Evidence and Learning from BRACED

Abstract ID : 1368

Conflict Declaration : None

Content Motivation : None

Additional Information : We are also invited by Zinta Zommers to contribute this paper in an expanded version as a book chapter.

Ms. Bettina Koelle ,koelle@climatecentre.org ,(Senior Learning Specialist) ,South Africa ,Nieuwoudtville ,Not Presenting[1]

Dr. Maarten Van Aalst ,vanaalst@climatecentre.org ,(None) ,Netherlands , ,Not Presenting[1]

1 - Red Cross Red Crescent Climate Centre 2 - Red Cross Red Crescent Climate Centre

The BRACED programme aims to support vulnerable people to become more resilient to climate extremes in South and Southeast Asia and in the African Sahel and its neighboring countries. In its work to improve the integration of disaster risk reduction and climate adaptation methods into development approaches, BRACED seeks to influence policies and practices at the local, national and international level. In order to achieve this ambition, innovative approaches for facilitating dialogue linking science to practice have been applied and tested.

In this paper, the opportunities and challenges of facilitating dialogue, co -producing strategies and joint exploration of possible solutions are explored, drawing on the rich experience over the past 2 years of the BRACED programme.

This paper specifically explores lessons learnt on knowledge management in large programmes and suggests various avenues for effectively facilitating learning and uptake of lessons from the ground, linking practice, science and policy to effectively increase resilience and foster effective adaptation.

Links between quality of housing, community based adaptation and climate change

Abstract ID : 1409

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Runyararo Newton Matandirotya ,runyamore@gmail.com ,(PHD Student) ,South Africa ,Potchefstroom ,Not Presenting[1]

Mr. Dirk Cilliers ,dirk.cilliers@nwu.ac.za ,(None) ,South Africa , ,Not Presenting[2]

Dr. Roelof Burger ,roelof.burger@nwu.ac.za ,(Senior Lecturer) ,South Africa ,Potchefstroom ,Not Presenting[3]

1 - North West University 2 - North-West University 3 - NWU

Energy use is one of the main drivers of anthropogenic climate change. Low-income communities in the developing world rely heavily on solid fuels as energy source for cooking and heating purposes. Many houses in low-income communities are poorly insulated, with a low thermal efficiency, due to the poor quality of the houses, resulting in higher levels of solid fuel burning for heating purposes. This affects the adaptive capacity of households in low-income communities as they are exposed to high levels of indoor pollution resulting from their exposure to temperature extremes due to the poor quality of houses. This paper explores the thermal efficiency of houses in low-income settlements in the high altitude areas (Highveld region) of South Africa using a combination of in situ (ambient and indoor measurements) and remote sensing (thermal infrared imagery) measurements. This region is characterized by cold winters with minimum temperatures often dropping below freezing point. Poor quality of housing, however presents an opportunity to devise mitigatory interventions and increase adaptive capacity of the urban poor. The study's findings were that structures in low-income settlements in high altitude experience very low indoor temperature, have poor thermal efficiency and prefer solid fuels for heating purposes. Improving the quality of housing and thermal efficiency of structures in low income settlements provides tangible opportunities to enhance community based adaptation to climate change and variability.

Environmental, Agricultural and Health Impacts of Solar Geoengineering

Abstract ID : 1420

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Christopher Trisos ,ctrisos@sesync.org ,(Postdoctoral Fellow) ,United States ,Annapolis ,Not Presenting[1]

Dr. Lili Xia ,lilixia@envsci.rutgers.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Corey Gabriel ,cjgabriel7@gmail.com ,(None) ,United States , ,Not Presenting[2]

Prof. Alan Robock ,robock@envsci.rutgers.edu ,(None) ,United States , ,Not Presenting[2]

1 - National Socio-Environmental Synthesis Center (SESYNC) 2 - Rutgers University 3 - Rutgers University 4 - Rutgers University

Slow progress reducing greenhouse gas emissions has increased attention on whether solar radiation management (SRM) geoengineering is a feasible and affordable tool to cool Earth, buying time for additional adaptation and mitigation efforts. Climate responses to several idealised SRM simulations have been studied in detail. In contrast, evaluating the plausibility of different SRM scenarios remains difficult and more collaboration between natural and social scientists is required. Moreover, the environmental and social impacts remain essentially unknown. We review evidence on impacts across multiple SRM technologies and scenarios. Rapid SRM implementation and termination, resulting in rapid climate change, would significantly increase threats to global biodiversity and ecosystems from climate change, especially in the tropics. In contrast, more measured use of SRM combined with emissions cuts could reduce some climate risks, but further research is needed. Agricultural impacts from geoengineering are predicted to be complicated. In general, cooling from SRM benefits most crops, while the reduction of precipitation from certain SRM scenarios would have negative impacts on rice and groundnuts in Asia. SRM strategies may also have complicated impacts on human health. For example, surface ozone concentration has a negative response to sulphate injection geoengineering, but increases under solar constant reduction geoengineering. Geoengineering simulations produce distinct regional climates that differ from a simple return to pre-industrial climate, with the potential for particular countries to benefit disproportionately. As the potential benefits and effectiveness of geoengineering increase with more severe warming the interaction of geoengineering impacts with ongoing climate adaptation efforts is expected to generate complex governance challenges were geoengineering ever implemented.

Urban heat island and adaptation on climate change

Abstract ID : 1453

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Tomas Halenka ,tomas.halenka@mff.cuni.cz ,(Associate Professor) ,Czech Republic ,Prague ,Presenting[1]

Mr. Peter Huszar ,peter.huszar@mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

Mr. Michal Belda ,michal.belda@mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

Mr. Jan Karlicky ,jan.karlicky@mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

1 - Charles University 2 - Charles University 3 - Charles University 4 - Charles University

To assess the impact of cities and urban surfaces on climate, the modeling approach is often used with inclusion of urban parameterization in land-surface interactions. This is especially important when going to higher resolution, which is common trend both in operational weather prediction and regional climate modelling. Model descriptions of urban canopy related meteorological effects can, however, differ largely given the odds in the driving models, the underlying surface models and the urban canopy parameterizations, representing a certain uncertainty. To assess this uncertainity is important for adaptation and mitigation measures often applied in the big cities, especially in connection to climate change.

In this study we contribute to the estimation of this uncertainty by performing numerous experiments to assess the urban canopy meteorological forcing over central Europe on climate for the decade 2001-2010, using two driving models (RegCM4 and WRF) in 10 km resolution driven by ERA-Interim reanalyses, three surface schemes (BATS and CLM4.5 for RegCM4 and Noah for WRF) and five urban canopy parameterizations available: one bulk urban scheme, three single layer and a multilayer urban scheme.

Effects of cities on urban and rural areas were evaluated. There are some differences in sensitivity of individual canopy model implementations to the UHI effects, depending on season and size of the city as well. Effect of reducing diurnal temperature range in cities (around 2 °C in summer) is noticeable in all simulation, independent to urban parameterization type and model. Also well-known warmer summer city nights appear in all simulations. For the adaptation and mitigation purposes, rather than the average temperature increase the distribution of it is more important providing the information on extreme UHI effects, e.g. during heat waves. We demonstrate that even for not so big central European cities these extremes can approach more than 5°C.

Ethics, Social Capital and Climate Resilience

Abstract ID : 1520

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Kerry Bowman ,kwjbowman@gmail.com ,(None) ,Canada ,None ,Not Presenting[1]

Mr. Alan Warner ,alan.warner@utoronto.ca ,(None) ,Canada , ,Not Presenting[2]

1 - Mount Sinai Hospital 2 - University of Toronto

Building resilience for climate change is not just a complex scientific challenge it is also a social, cultural and ethical challenge. Although the impacts of climate variability and change affects everyone, ethical challenges are raised as changes disproportionately affect vulnerable populations, as they are the ones with the least resources and in turn resilience to prepare, adapt and recover from impacts. Through case analysis this chapter looks at community based initiatives and ethical arguments that build "social capital" and examines what practical and ethical arguments lead to effective community engagement. Case studies will highlight ethical concepts important to strengthening both environmental resilience and public health by mobilizing community partnerships and knowledge toward advancing social capital. The Ethics of the precautionary principle is examined in relation to climate adaptation and public health.

M017 - High-impact Weather and Climate Extremes

Influence of quasi-biennial oscillation on the drought conditions and cereal crop yields in Ukraine

Abstract ID : 19

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Inna Semenova ,innas.od@gmail.com ,(Professor of Department of meteorology and climatology) ,Ukraine ,None ,Not Presenting[1]

1 - Odessa State Environmental University

Ukraine is main of producers for cereal crops in East Europe, therefore the identification of physical mechanisms of drought development on its territory is an important objective for agrometeorological forecasting.
It is known that the quasi-biennial oscillation (QBO) of global atmospheric processes affects the atmospheric circulation in the middle latitudes. In the study the QBO phases were defined from April to June of 1948-2013. The values of standardized precipitation index (SPI) on 3 month time scale and the crop yields of winter wheat and spring barley were separated according to the QBO phases. Comparison between data of SPI and the QBO phases showed that in years with severe spring-summer drought at least in two agroclimatic zones in Ukraine, observed the phase E. Since 1995 most intense droughts occurred in vegetation period, when the negative phase of the QBO predominated. A preliminary analysis shows that the most intensive and prolonged drought happens, if it beginning coincides to the middle of the negative phase.
Assessment of the regional atmospheric circulation over Europe in different QBO phases using author's European continental blocking index (ECBI) showed that within the negative phase prevails the blocking of zonal flow (54%). This fact explains higher frequency of drought in phase E. Within the positive phase the west-east flow dominates (53%).
It was found that for the crop yields of winter wheat and spring barley observed exceeding of the average yields in the phase W comparing to phase E. Most of the excess fixed in the Steppe zone - more than 22% for both crops. In northern areas the excess is reduced to 14% for winter wheat and 10% for spring barley. Values of s.d. indicate that interannual variability of crop yields is higher in the phase E. Moreover, under the negative phase prevails the crop losses, probably due to unfavorable weather conditions.
The obtained results clearly demonstrate the relationship between the QBO phases and crop yields fluctuations, which occur because changes of the regional atmospheric processes that lead to drought formation.

Dominant Role of Subtropical Pacific Warming in Extreme Eastern Pacific Hurricane Seasons: 2015 and the Future

Abstract ID : 167

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Hiroyuki Murakami ,Hiroyuki.Murakami@noaa.gov ,(Associate Research Scholar) ,United States ,Princeton ,Not Presenting[1]

1 - None

The 2015 hurricane season in the eastern and central Pacific Ocean (EPO and CPO), particularly around Hawaii, was extremely active, including a record number of tropical cyclones (TCs) and the first instance of three simultaneous category-4 hurricanes in the EPO and CPO. A strong El Niño developed during the 2015 boreal summer season and was attributed by some to be the cause of the extreme number of TCs. However, according to a suite of targeted high-resolution model experiments, the extreme 2015 EPO and CPO hurricane season was not primarily induced by the 2015 El Niño tropical Pacific warming, but by warming in the subtropical Pacific Ocean. This warming is not typical of El Niño, but rather of the Pacific meridional mode (PMM) superimposed on long-term anthropogenic warming. Although the likelihood of such an extreme year depends on the phase of natural variability, the coupled GCM projects an increase in the frequency of such extremely active TC years over the next few decades for EPO, CPO, and Hawaii as a result of enhanced subtropical Pacific warming from anthropogenic greenhouse gas forcing.

Planetary and synoptic drivers of warm and cold wintertime extremes in the High Arctic

Abstract ID : 233

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Gabriele Messori ,gabriele.messori@misu.su.se ,(Research Scientist) ,Sweden ,Stockholm ,Not Presenting[1]

Dr. Cian Woods ,cian@misu.su.se ,(None) ,Sweden , ,Not Presenting[1]

Prof. Rodrigo Caballero ,rodrigo@misu.su.se ,(None) ,Sweden , ,Not Presenting[1]

Dr. Joy Monteiro ,joy.monteiro@misu.su.se ,(None) ,Sweden , ,Not Presenting[1]

1 - Stockholm University 2 - Stockholm University 3 - Stockholm University 4 - Stockholm University

The quick rise in Arctic temperatures over the last 1-2 decades has received ample coverage in both mainstream media and scientific publications. This has largely focussed on the causes and impacts of rapid sea-ice melt. The atmospheric drivers of warm and cold wintertime temperature extremes on daily to weekly timescales have received comparatively less attention. In this paper we analyse both the large-scale and synoptic-scale circulation patterns associated with wintertime temperature extremes in the high Arctic. We find that warm extremes are systematically associated with a meridionally-oriented large-scale circulation, characterised by a persistent anomalous low pressure extending from Iceland to Northern Greenland and Canada and a northward extension of the Siberian High. This favours large moisture intrusions from the Atlantic, associated with cyclones crossing the Nordic seas. The cold extremes are instead associated with weaker large-scale anomalies, mostly limited to a southward shift of the Siberian High and an intensification of the climatological high-latitude westerlies. This results in below-average penetration of Atlantic airmasses and in an intense radiative cooling. These findings lay the bases for an improved understanding of how the daily to weekly temperature variability in the Arctic may evolve in future climates.

HIWeather – predicting and warning weather-related hazards

Abstract ID : 235

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Brian Golding ,brian.golding@metoffice.gov.uk ,(Fellow in Weather Impacts) ,United Kingdom ,Exeter ,Not Presenting[1]

Dr. Paolo Ruti ,pruti@wmo.int ,(None) ,Switzerland , ,Not Presenting[2]

Prof. David Johnston ,david.johnston@gns.cri.nz ,(None) ,New Zealand , ,Not Presenting[3]

1 - Met Office 2 - World Meteorological Organisation 3 - GNS Science

The World Meteorological Organisation's High impact Weather project (HIWeather) aims to build global resilience to weather-related disasters by pushing forward research into key areas of weakness in the forecasting and warning production and delivery chain. Focused primarily on short duration, mesoscale weather, the project has five main research pillars in weather processes, hazard modelling, impact modelling, warning communication, and evaluation. My talk will set the scope of the weather processes and modelling research in the context of the requirements of decision makers for warning information. It will then go on to describe some HIWeather research activities in these areas, before concluding with an overview of plans for bringing the research together in end-to-end demonstration projects.

Cloud Resolving Ensemble Simulation of a Local Heavy Rainfall Event on 26 August 2011 Observed in TOMACS

Abstract ID : 294

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Kazuo Saito ,ksaito@mri-jma.go.jp ,(Senior Director for Research Affairs) ,Japan ,Tsukuba ,Not Presenting[1]

Mr. Kentaro Araki ,araki@mri-jma.go.jp ,(None) ,Japan , ,Not Presenting[1]

Mr. Masaru Kunii ,mkunii@mri-jma.go.jp ,(None) ,Japan , ,Not Presenting[1]

1 - Meteorological Research Institute 2 - Meteorological Research Institute 3 - Meteorological Research Institute

Local heavy rainfall about 100 mm/h occurred at Tokyo metropolitan area on 26 August 2011. This rain was brought by a mesoscale convective system (MCS) developed in the south of a stationary front In the analysis using geostationary multi-purpose satellite images and dense automated weather station networks, surface convergence zones appeared along the front heads of sea breezes from East and South, and intrusion and merge of these E-S sea breezes with weak northerly ambient wind triggered deep convection and succeeding development of the MCS.

Numerical experiments by the JMA nonhydrostatic model with horizontal resolutions of 10 km and 2 km using mesoscale 4D-VAR analysis of JMA for the initial condition were conducted, but they tended to predict the intense rainfall not over Tokyo but in the west of Kanagawa prefecture. In the mesoscale ensemble forecast using perturbations from the forecast of the JMA's one-week global ensemble prediction system (EPS), some ensemble members enhanced precipitation around Tokyo, but fake precipitation areas appeared in the north of Kanto and Hokuriku district.

Modification of the model was performed where a lower limit of subgrid deviation of water vapor condensation to diagnose the subgrid cloudiness was reduced. In the simulation of the modified model, surface temperatures around Tokyo increased by about 1 C and the position of the high surface temperature area shifted inland. Ensemble prediction using a mesoscale singular vector method was onducted. One of the ensemble members unstabilized the lower atmosphere in the windward side of the Kanto district and suppressed the fake precipitation in the Hokuriku district. Observed characteristics of the local heavy rainfall on the day, such as intrusion of E-S sea breezes, propagation and merge of low level convergence at the front heads of the sea breezes, and succeeding development of deep convection, were well reproduced by the model with a horizontal resolution of 2 km. These results suggest the importance of the urban effect and radiation process to determine the position and timing of convection initiation on the day of weak synoptic forcing.

Improved representation of European precipitation in a 25-km atmospheric global circulation model

Abstract ID : 461

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Reinhard Schiemann ,r.k.schiemann@reading.ac.uk ,(Senior Research Scientist, NCAS Climate) ,United Kingdom ,Reading ,Presenting[1]

Dr. Alexander J. Baker ,alexander.baker@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Marie-Estelle Demory ,m.e.demory@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Kevin Hodges ,k.i.hodges@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Stephanie J Johnson ,stephanie.johnson@ecmwf.int ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Jane Strachan ,jane.strachan@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Pier Luigi Vidale ,p.l.vidale@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Len C. Shaffrey ,l.c.shaffrey@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Matthew Mizielinski ,matthew.mizielinski@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[9]

Dr. Malcolm Roberts ,malcolm.roberts@metoffice.gov.uk ,(Manager, Global high resolution climate modelling) ,United Kingdom ,Exeter ,Not Presenting[10]

1 - National Centre of Atmospheric Science (Climate), University of Reading 2 - National Centre of Atmospheric Science (Climate), University of Reading 3 - National Centre of Atmospheric Science (Climate), University of Reading 4 - National Centre of Atmospheric Science (Climate), University of Reading 5 - National Centre of Atmospheric Science (Climate), University of Reading 6 - National Centre of Atmospheric Science (Climate), University of Reading 7 - National Centre of Atmospheric Science (Climate), University of Reading 8 - National Centre of Atmospheric Science (Climate), University of Reading 9 - Met Office 10 - Met Office Hadley Centre

Global Climate Models (GCMs) can nowadays be run at horizontal grid spacings of about 25km over decadal to centennial periods, thanks to an increase in computational and data handling resources as well as concerted development at different modelling centres over the past years. One such effort has been the UPSCALE project, a collaboration between the National Centre of Atmospheric Science at the University of Reading and the UK Met Office, where the resolution of the HadGEM3-GA3 GCM was progressively increased from about 135km grid spacing to about 25km, with minimal other changes to the model.
Here, we evaluate the representation of European precipitation in the UPSCALE model hierarchy for present-day climate conditions. We show that there is an improvement with resolution in the climatological-mean spatial precipitation distribution, particularly during autumn and winter, and throughout a wide range of spatial scales. Furthermore, we conduct Extreme Value Analysis of the daily precipitation aggregated over large European river basins (>50000 km^2) and show that the fitted extreme value distributions also agree better with the observed precipitation in the 25-km model. We

investigate possible reasons for this improvement including (i) a more realistic representation of the North Atlantic storm track, (ii) atmospheric blocking, and (iii) the role of orography. The role of orography is investigated in terms of a sensitivity experiment where a high-resolution atmospheric model (~25km) is run with coarse orographic boundary fields (~135km). We find that the better resolved orography in the high-resolution model largely contributes to the overall improvement seen in both mean and extreme precipitation.

Complexity in estimating past and future extreme short-duration rainfall

Abstract ID : 476

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. xuebin zhang ,xuebin.zhang@canada.ca ,(None) ,Canada ,Toronto ,Presenting[1]

Dr. Alex Cannon ,alex.cannon@canada.ca ,(None) ,Canada , ,Not Presenting[1]

Mr. Guilong Li ,guilong.li@canada.ca ,(None) ,Canada , ,Not Presenting[1]

Dr. Francis Zwiers ,fwzwiers@uvic.ca ,(None) ,Canada , ,Not Presenting[4]

Mrs. Hui Wan ,hui.wan@canada.ca ,(None) ,Canada , ,Not Presenting[5]

1 - Environment and Climate Change Canada 2 - Environment and Climate Change Canada 3 - Environment and Climate Change Canada 4 - Pacific Climate Impacts Consortium 5 - None

Warming of the climate is now unequivocal, increasing the water holding capacity of the atmosphere by about 7% per Kelvin and raising the expectation of more intense extreme rainfall events. Meeting the demand for robust projections for extreme short-duration rainfall is challenging, however, because of our poor understanding of its past and future behavior. The characterization of past changes is severely limited by the availability of observational data. Climate models, including typical regional climate models, do not directly simulate all extreme rainfall producing processes, such as convection. Recently developed convection-permitting models better simulate extreme precipitation, but simulations are not yet widely available due to computational cost and have their own uncertainties. Attention has thus been focused on precipitation-temperature relationships in the hope of obtaining more robust extreme precipitation projections that exploit higher confidence temperature projections. However, the observed precipitation-temperature scaling relationships have been established almost exclusively by linking precipitation extremes with day-to-day temperature variations. These scaling relationships do not appear to provide a reliable basis for projecting future precipitation extremes. Until better methods are available, the relationship of the atmosphere's water holding capacity with temperature provides better guidance for planners in the mid-latitudes, albeit with large uncertainties.

The role of land conditions on the 2016 heatwave in Korea

Abstract ID : 572

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Emilia Kyung Jin ,k.jin@kiaps.org ,(Senior Scientist) ,South Korea ,SEOUL ,Not Presenting[1]

1 - KIAPS

To improve the predictability of extreme heatwave in Korea, the triggers and drivers of heatwave are investigated focusing on the land conditions. The recent record-breaking heatwave of 2016 in Korea is associated with the expansion of North Pacific High led by high SST anomalies in the tropical western Pacific and the persistent atmospheric high pressure system over Mongolia. The preceding and simultaneous land conditions in Europe and East Asia also act as a remote and local low boundary forcing and the land-atmospheric feedbacks amplify the heat extremes and extend the duration of heatwave.
The temporal and spatial structures of land conditions related with the initiation and maintenance of heatwave in Korea are analyzed using historical station and global dataset. The historical occurrences of heatwave are selected based on the daily maximum temperature of 60 stations over Korea and the associated surface and atmospheric patterns are statistically investigated. The heatwave in 2016 occurs as a part of the long-term changes more than decadal time-scale and the anomalous soil moisture in Mongolia and Tibetan Plateau and snow in Tibetan Plateau tend to force and enhance the heatwave. A series of numerical experiments using WRF are conducted to confirm the role of each component of land conditions.

Understanding Regional Projections of Extreme Precipitation

Abstract ID : 747

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. xuebin zhang ,xuebin.zhang@canada.ca ,(None) ,Canada ,Toronto ,Not Presenting[1]

1 - Environment and Climate Change Canada

Under global warming, coupled climate models project that there will be increased extreme precipitation over most of the globe. This projection generally results from the thermodynamic increase of atmospheric moisture (i.e., Clausius-Clapeyron scaling) cancelled in part by the reduction of the moist adiabatic lapse rate (O'Gorman and Schneider, 2009). In particular regions, however, extreme precipitation projections require understanding additional physical processes, such as changes in extreme updrafts. This paper explores these additional physical processes using output from large ensembles of the Community Earth System Model version 1 (CESM1) and the Canadian Earth System Model version 2 (CanESM2) simulating the historical and RCP8.5 climate change scenarios. Despite their different spatial resolutions and convection schemes, CESM1 and CanESM2 produce large scale patterns of extreme precipitation change that have much in common. For example, both models project decreases in the 99.9 percentile of daily mean precipitation throughout the subtropical dry zones. Scalings that assume saturated conditions (as in earlier studies) do not accurately explain extreme precipitation changes in drier regions, and we remedy this by accounting for precipitation events with saturated conditions that last much shorter than a day. Over ocean, we show that regions of extreme precipitation decrease are associated with weakened extreme updrafts which are in turn related to decreases in convective available potential energy (CAPE) frequency. Over land, however, changes in CAPE have surprisingly little effect on extreme updrafts, and increases in boundary layer height and reduction of the diurnal temperature range play key roles. These effects are strong enough to produce decreases in extreme precipitation over many land regions during boreal summer. These physical processes are general enough that we expect them to be at work in the real world and in climate models with different resolutions and convection schemes.

Composite characteristics of Nor'westers based on observations and simulations

Abstract ID : 855

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Mohan Kumar DAS ,mohan28feb@yahoo.com ,(Research Fellow) ,Bangladesh ,Dhaka ,Not Presenting[1]

1 - Institute of Water and Flood Management (IWFM), Bangladesh University of Engineering and Technology (BUET)

The Nor'westers (severe thunderstorms) that form over northeast India and adjoining Bangladesh region during the pre-monsoon season of 2008 are studied employing observations from ground based radar, Tropical Rainfall Measuring Mission (TRMM) and synoptic stations. Subsequently, an attempt is made to simulate the storms using Weather Research and Forecasting (WRF) model at 9 km horizontal resolution, and 28 vertical levels. Analyses of Radar data for 15 cases out of 108 during the study period showed that the Nor'westers typically propagate in the form of squall lines (parallel bow shaped bands) having horizontal length of about 200 km, reaching more than 400 km on some occasions. They propagate at typical speeds of about 50 km h^{-1} from northwest to southeast directions. The model underestimated the strength of the squall lines in terms of wind speed. The simulated results showed the presence of strong vertical wind shear and an advection of warm moist southerly wind from the Bay of Bengal during the formation of Nor'westers. Low level positive vorticity in combination with moist southerly wind from the Bay of Bengal and strong surface heating resulted in the formations of the Nor'westers in all the cases. Cloud tops reached as high as 18-20 km in some of the cases of the severe storms. The altitude of core of maximum precipitation was located between 3-5 km. Average cloud hydrometeor content of the Nor'westers was estimated to be about 3.5 g m^{-3}.
Keywords: Nor'westers; Thunderstorms; Radar; TRMM; WRF model

Subtropical air masses in extratropical latitudes: Their links to extreme precipitation and extreme oceanic cyclogenesis

Abstract ID : 890

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. John Gyakum ,john.gyakum@mcgill.ca ,(None) , , ,Not Presenting[1]

1 - McGill University

Virtually all regions of the middle latitudes have experienced increases in temperature and water vapor content during the past several decades. Such increases have been associated with increases in poleward surges of subtropical air masses. The goal of this study is to examine the meteorological implications of these surges into the extratropical latitudes. We focus on the physical mechanisms of poleward surges of subtropical air masses, and how they impact the frequency and intensity of extreme precipitation and ocean cyclogenesis.

We define a surge of subtropical air by identifying the 850-hPa equivalent potential temperatures (θ_e) that occur climatologically in the subtropical latitudes, and its subsequent transport into higher latitudes. The utility of using this metric is it represents the thermodynamic property of air that ascends during a precipitation event.

The role of the subtropical air mass in modulating the strength of a precipitation event is addressed with an analysis of the expression, $P = RD$, where P is the total precipitation, and R is the precipitation rate, averaged through the duration, D, of the event. Though appearing simple, this expression includes R, (assumed to be same as condensation, with an efficiency of 1), which may be expressed as the product of vertical motion and the change of saturation mixing ratio following a moist adiabat, through the troposphere. This expression for R includes the essential ingredients of lift, air mass temperature, and static stability (implicit in vertical motion). We use this expression for precipitation rate to study the extreme precipitation events in extratropical latitudes that are associated with surges of subtropical air masses, and their physical impacts on the precipitation rate.

These extremes of latent heating have important dynamical impacts on the strength of extratropical oceanic cyclogenesis, through enhanced ascent and associated surface vorticity increases. Though explosive oceanic cyclogenesis research has resulted in improved understanding and forecasting, there remain significant continuing gaps in our knowledge of explosive cyclogenesis. In particular, environmental predecessors of the earliest phase of this cyclogenesis, typically the mesoscale secondary cyclogenesis phase, are investigated in the context of subtropical air masses linkages.

Dynamical aspects of extreme event attribution

Abstract ID : 979

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Theodore G. Shepherd ,theodore.shepherd@reading.ac.uk ,(None) ,United Kingdom , ,Presenting[1]

Prof. Myles Allen ,myles.allen@ouce.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Dann Mitchell ,d.m.mitchell@bristol.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - University of Reading 2 - University of Oxford 3 - University of Bristol

The attribution of extreme weather and climate events is a research topic of growing interest. There is scientific confidence in large-scale thermodynamic aspects of climate change and their first-order effect on certain classes of extreme events, which permits strong attribution statements to be made in some cases. However, most extreme events involve a significant dynamical component, and the role of dynamics - whether changes in dynamics, or dynamically conditioned thermodynamic changes - is more uncertain and less examined. Representing the uncertainty in the dynamical aspects of extreme event attribution whilst not losing sight of the robust thermodynamic aspects requires a careful framing of the attribution question, and a well-designed experimental framework with a model that adequately reproduces the relevant processes. We report on recent work addressing this issue, with a specific focus on events associated with mid-latitude regimes.

The challenge of correctly representing changes in regional precipitation extremes and droughts in climate models

Abstract ID : 980

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Prashant Sardeshmukh ,prashant.d.sardeshmukh@noaa.gov ,(None) ,United States , ,Presenting[1]

Dr. Jih-Wang Aaron Wang ,Aaron.Wang@noaa.gov ,(None) ,United States , ,Not Presenting[2]

1 - University of Colorado/CIRES and NOAA/ESRL/PSD 2 - CIRES/University of Colorado and NOAA/ESRL/PSD

Precipitation is associated with moist tropospheric ascent. An outstanding issue in climate change research is whether regional precipitation changes associated with global warming are governed mainly by the general increase of atmospheric humidity ("thermodynamic control") or by changes in the statistics of large-scale tropospheric vertical velocity ("dynamic control"). Thermodynamic control is stronger and more robust than dynamic control in current climate models. Our investigation of observed precipitation changes over the last 70 years, however, tells a different story. At most locations around the globe, the observed changes in both the mean and extreme daily precipitation are much more consistent with similar changes in vertical velocity, i.e. with dynamic control. Most tellingly, and with important implications for drought, the observed changes in the probability of dry days are remarkably consistent with changes in the probability of days of tropospheric descent. This aspect of the precipitation statistics is consistent with dynamic control, but is totally beyond thermodynamic control. We also find that AMIP-style uncoupled atmospheric GCM simulations of the last 70 years with prescribed observed SSTs are reasonably able to capture the observed changes in precipitation and vertical velocity, and hence the dominance of dynamic control. The fact that fully coupled climate models, which predict the SSTs, do not correctly capture these changes suggests that the problem originates in their misrepresentation of the SSTs, especially tropical SSTs. Specifically, the current generation of climate models continue to underestimate the spatial variation of tropical SST trends, and hence the magnitude of changes in the mean atmospheric circulation and stormtracks, leading to an underestimation of the dynamic control of precipitation that is actually stronger than the thermodynamic control in reality. Fixing this problem is a grand challenge.

Increasing Occurrence of Midwinter Warming Events at the North Pole

Abstract ID : 1053

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. G.W.K. Moore ,gwk.moore@utoronto.ca ,(None) ,Canada , ,Not Presenting[1]

1 - University of Toronto

In late December 2015, widespread media interest revolved around forecasts that the surface air temperature at the North Pole would rise above freezing. Although there has been significant interest in the enhanced warming that is occurring at high northern latitudes, a process known as arctic amplification, remarkably little is known about these midwinter warming events at the pole including their frequency and magnitude as well as the environmental conditions responsible for their occurrence. Here we use data from the International Arctic Buoy Program along with operational weather forecasts and atmospheric reanalyses to show that such events are associated with a surface cyclone as well as a highly perturbed polar vortex. They occur once or twice each decade with the earliest identified event taking place in 1959. In addition, the warmest midwinter temperatures at the North Pole have been increasing at a rate that is twice as high as that for mean midwinter temperatures at the pole. It is argued that this enhanced trend is consistent with the loss of winter sea ice from the Nordic Seas that moves the reservoir of warm air over this region northwards making it easier for weather systems to transport this heat towards the pole.

The use of high-resolution climate models to investigate regional projections of tropical cyclone activity

Abstract ID : 1068

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Kevin Reed ,kevin.a.reed@stonybrook.edu ,(Assistant Professor) ,United States ,Forest Hills ,Presenting[1]

Mr. J. Jacob Huff ,Jake.Huff@stonybrook.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Michael Wehner ,mfwehner@lbl.gov ,(None) ,United States , ,Not Presenting[3]

Dr. Julio Bacmeister ,juliob@ucar.edu ,(None) ,United States , ,Not Presenting[4]

1 - Stony Brook University 2 - Stony Brook University 3 - Lawrence Berkeley National Laboratory 4 - National Center for Atmospheric Research

Various versions of the Community Atmosphere Model version 5 (CAM5) are used to study regional tropical cyclones (TC) activity in the North Atlantic and Pacific Oceans. The main focus of this study is to better understand climate controls on the precipitation, intensity, location and frequency of landfalling storms. For this work CAM5, a comprehensive atmospheric general circulation model, is setup with a global horizontal grid spacing of approximately 28 km and is forced with prescribed sea-surface temperatures (SSTs) and greenhouse gases. CAM5 is configured with two different dynamical cores (i.e., the central fluid flow component of the model) to explore the impact of a warming climate on TC activity. In addition, this study includes a comparison of CAM5 simulations with and without airborne dust to examine the impacts of potential decreases in airborne dust in the future on TCs in the North Atlantic. In general, we find a decrease in regional TC activity in a warming climate, but an increase in the most intense storms. This work will further explore the implications of this for landfalling storms and their associated overland extreme precipitation.

How much rainfall extremes associated with tropical cyclones can be attributable to anthropogenic influences?

Abstract ID : 1074

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. CHENG-TA CHEN ,chen@rain.geos.ntnu.edu.tw ,(None) ,Taiwan ,Taipei ,Not Presenting[1]

Mr. Shih-How Lo ,micyjon74@gmail.com ,(None) ,Taiwan , ,Not Presenting[1]

Prof. Chung-Chieh Wang ,cwang@ntnu.edu.tw ,(None) ,Taiwan , ,Not Presenting[1]

Prof. Kazuhisa Tsuboki ,tsuboki@nagoya-u.jp ,(None) ,Japan , ,Not Presenting[4]

1 - National Taiwan Normal University, Department of Earth Sciences 2 - National Taiwan Normal University, Department of Earth Sciences 3 - National Taiwan Normal University, Department of Earth Sciences 4 - Nagoya University, ISEE

The rainfall extremes and strong winds associated with tropical cyclones lead to significant damages and lost to where they make landfalling. Upward trend in term of financial lost was indicated for the past few decades from the report of major reinsurance firms. Whether the past anthropogenic warming played a significant role in such extreme event and their changes remained very controversial. On one hand, people argue it's nearly impossible to attribute an individual extreme event to global warming. On the other hand, the increase of heavy rainfall is consistent with the expected effects of climate change on tropical cyclone. To diagnose possible anthropogenic contributions to the odds of heavy rainfall associated with tropical cyclone, we adapt an existing event attribution framework of modeling a 'world that was' and comparing it to a modeled 'world that might have been' for that same time but for the absence of historical anthropogenic drivers of climate. The analysis was applied to Typhoon Morakot (2009) as an example. There was more than 2000 mm rainfall occurred over southern Taiwan when a category 1 Typhoon Morakot pass through Taiwan in early August 2009. Entire village and hundred of people were buried by massive mudslides induced by record-breaking precipitation. One limitation for applying such approach to high-impact weather system is that it will require models capable of capturing the essential processes lead to the studied extremes. Using a cloud system resolving model that can properly simulate the complicated interactions between tropical cyclone, large-scale background, topography, we first perform the ensemble 'world that was' simulations forced by the high resolution ECMWF YOTC analysis. We then re-simulate, having adjusted the analysis to 'world that might have been conditions' by removing the regional atmospheric and oceanic forcing due to human influences estimated from the CMIP5 model ensemble mean conditions between all forcing and natural forcing only historical runs. Thus our findings are highly conditional on the driving analysis and adjustments therein, but the setup allows us to elucidate possible contribution of anthropogenic forcing to changes in the likelihood of heavy rainfall associated tropical cyclone.

Ensemble Simulations of a Severe Flood over South China with a General Circulation Model IAP AGCM4.1

Abstract ID : 1076

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. He Zhang ,zhanghe@mail.iap.ac.cn ,(Associate Professor) ,China ,Beijing ,Not Presenting[1]

1 - IAP

Floods associated with the monsoon heavy rainfall cause frequently serious damages to the economy, agriculture and human life over East Asia. The climate model is an important tool to predict and understand the mechanism of heavy rainfall. In this study, we performed 20 ensemble simulations of a severe flood over South China in 1998 with a general circulation model IAP AGCM4.1, developed by the Institute of Atmospheric Physics of the Chinese Academy of Sciences. The integrations are forced by observed SST from May 1st to AUG 31st, 1998. The atmosphere is initialized from CFSR analysis data, and land is initialized from earlier AMIP simulations. The ensemble mean simulation well reproduced the extreme heavy rainfall over South China, although the simulated precipitation intensity is weaker than the observation. The simulated associated atmospheric circulation and water vapor transport are analyzed to explore the cause of the heavy rainfall. During the summer in 1998, the west Pacific subtropical high is located more southward due to the cooler sea subsurface temperature in the tropical west Pacific. As a result, an abundant moisture from the Bay of Bengal and South China Sea converges over South China, causing continuously severe rainfall over South China. Furthermore, the model performance in June is better than in July and August possibly due to the impact of initial conditions.

What are the characteristic drivers of marine heatwaves around the globe?

Abstract ID : 1092

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Neil Holbrook ,neil.holbrook@utas.edu.au ,(Associate Professor of Climatology and Climate Change) ,Australia ,Hobart ,Presenting[1]

Ms. Hillary Scannell ,hillary.scannell@noaa.gov ,(None) ,United States , ,Not Presenting[2]

Dr. Alexander Sen Gupta ,a.sengupta@unsw.edu.au ,(None) ,Australia , ,Not Presenting[3]

Dr. Jessica Benthuysen ,J.Benthuysen@aims.gov.au ,(None) ,Australia , ,Not Presenting[4]

Dr. Ming Feng ,Ming.Feng@csiro.au ,(None) ,Australia , ,Not Presenting[5]

Dr. Eric Oliver ,eric.oliver@utas.edu.au ,(None) ,Australia , ,Not Presenting[1]

Dr. Lisa Alexander ,l.alexander@unsw.edu.au ,(None) ,Australia , ,Not Presenting[3]

Dr. Michael Burrows ,Michael.Burrows@sams.ac.uk ,(None) ,United Kingdom , ,Not Presenting[8]

Dr. Markus Donat ,m.donat@unsw.edu.au ,(None) ,Australia , ,Not Presenting[3]

Dr. Alistair Hobday ,Alistair.Hobday@csiro.au ,(None) ,Australia , ,Not Presenting[10]

Dr. Pippa Moore ,pim2@aber.ac.uk ,(None) ,United Kingdom , ,Not Presenting[11]

Dr. Sarah Perkins-Kirkpatrick ,sarah.kirkpatrick@unsw.edu.au ,(None) ,Australia , ,Not Presenting[3]

Dr. Dan Smale ,dansma@mba.ac.uk ,(None) ,United Kingdom , ,Not Presenting[13]

Ms. Sandra Straub ,sandra.straub@uwa.edu.au ,(None) ,Australia , ,Not Presenting[14]

Dr. Thomas Wernberg ,thomas.wernberg@uwa.edu.au ,(None) ,Australia , ,Not Presenting[14]

1 - University of Tasmania 2 - University of Washington 3 - The University of New South Wales 4 - Australian Institute of Marine Science 5 - CSIRO Australia 6 - University of Tasmania 7 - The University of New South Wales 8 - Scottish Association for Marine Science 9 - The University of New South Wales 10 - CSIRO Oceans and Atmosphere 11 - Aberystwyth University 12 - The University of New South Wales 13 - Marine Biological Association of the United Kingdom 14 - The University of Western Australia 15 - The University of Western Australia

Adverse impacts of marine heatwaves (MHWs) include shifts in marine species ranges, local extinctions and economic losses for seafood industries. Global patterns of MHWs suggest that their magnitude, timing and distribution may be driven by known modes of climate variability. Importantly, drivers represent a combination of both local and remote processes - with the remote, larger-scale processes offering the potential for MHW predictability.
In this study, we have undertaken a global synthesis and typological assessment of identifiable MHW events and their characteristic drivers based on information reported in over 170 papers published in the peer-reviewed literature since 1950. We also applied a new quantitative MHW definitional

framework to characterise the timing, duration, maximum intensity and spatial extent of the notable MHW events, based on analysis of daily satellite sea surface temperature (SST) data since 1982. Finally, we analysed the statistically significant relationships between indices of known large-scale climate modes and all MHW events globally, identified from the satellite SST data, to understand the likely modulation of MHW events by climate modes.
The study includes several important findings. After defining and classifying what a 'driver' is in the context of causal mechanisms of MHWs, we demonstrate that both MHW characteristics and their drivers are inhomogeneous in space and time. Importantly, our expert (confidence) assessment shows that certain driver types, and thus time scales, coherently characterise some regions over others. In our presentation, we will discuss these characteristics across a selection of the 14 case study regions investigated, and classified within synoptic, seasonal to intraseasonal, interannual and decadal time scales. We will identify the MHW driver component parts - including the remote climate modes (forcing), teleconnection processes and features, and the local process that affect the heat budget - that produce the persistent extreme SST anomaly. Based on results from our statistical analysis, we will also discuss the global patterns of significant relationships between the dominant climate mode phase and increased likelihood of MHW suppression or enhancement.

Climate Models Simulation of California Heat Waves

Abstract ID : 1209

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Richard Grotjahn ,grotjahn@ucdavis.edu ,(Professor) ,United States ,Davis ,Presenting[1]

Dr. Erool Palipane ,epalipane@ucdavis.edu ,(None) ,United States , ,Not Presenting[2]

1 - University of California Davis 2 - None

Grotjahn and Faure(2008) and Grotjahn(2011,2013,2015) found that extreme heat in the California Central Valley (CCV) and much of the US West Coast is associated with LSMPs across the North Pacific and Western North America. Further, Lee and Grotjahn (2016) found that there are mainly two different LSMP structures leading up to a heat event. Grotjahn and Lee (2016) further tested these two different clusters and how they are simulated in the historical runs by 14 CMIP5 models.

We analyze LSMPs in CMIP5 RCP4.5 and CMIP5 RCP8.5 scenarios as simulated by 13 climate models. Similar to Grotjahn (2011), an index based on upper air data at the onset of each extreme heat event in the CCV region is optimized to match surface temperature extreme values. We examine distributions of this LSMP index in the model simulations to identify how the large scale dynamical pattern causing future heat waves may change in the future. Four combinations of the two RCP scenarios and two heat wave thresholds (95th percentile) are used. Two thresholds for each scenario arise based on using either: 1) the historical simulated climatology (CMIP5_fh) or 2) or the future simulated climatology (CMIP5_ff). A fifth distribution uses the recent historical climate simulations for comparison and model weighting. A weighted model-average is formed with weights based on Kolmogorov-Smirnov distance for the extreme values in the historical distribution for each model in comparison to a reanalysis. The two thresholds enable us to separate the natural variability in the pattern occurrence from higher frequency due to global warming.

Weighted model averages are presented for occurrences, durations, generalized Pareto distribution (GPD) shape and scale, and 20-year return values. We find that the LSMP pattern does not occur more (nor less) often in future simulations. A strong increase in heat waves arises when historical climate thresholds are used due to higher land temperatures, i.e. the global warming 'signal'. This signal also favors one of the two types of heat waves.

Temperature and Humidity Trends: Chasing the Global Warming ‘Hole’ around the United States

Abstract ID : 1211

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Richard Grotjahn ,grotjahn@ucdavis.edu ,(Professor) ,United States ,Davis ,Presenting[1]

Mr. Jonathan Huynh ,jonhuy@ucdavis.edu ,(None) ,United States , ,Not Presenting[1]

1 - University of California Davis 2 - University of California Davis

We examine trends over the United States (US) in several temperature-related quantities: daily average temperature (T), daily maximum T (Tx), daily minimum T (Tn), daily average temperature-humidity index (THI), daily max THI, daily maximum apparent T (Ta), and specific humidity. We include THI, Tx, and Tn are more important quantities to many agricultural operations than daily average T. For example, THI assesses stress upon animals; Tn is relevant to an animal's ability to recover from daytime heating. Similarly, Ta is a better measure of human comfort.

The literature on climate change simulations tends to focus upon daily average T, so much so that 'daily average' is often not stated in the document. We find different trends in the other variables. We consider trends over various time periods and seasons.

The notion of a global warming 'hole' over some portion of the contiguous US is discussed in the literature. However, we show how the location of this hole changes when different variables, seasons, and time periods are considered.

A New Perspective on Increased Intensities of Atmospheric Disturbances: Trends in Weather-Timescale Fluctuations

Abstract ID : 1213

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Pei-Chun Hsu ,pchsu@gate.sinica.edu.tw ,(postdoc) ,Taiwan ,Taipei ,Presenting[1]

Dr. Huang-Hsiung Hsu ,hhhsu@gate.sinica.edu.tw ,(Research Fellow Research Center for Enironmental Changes) ,Taiwan ,Taipei ,Not Presenting[2]

1 - Research Center for Environmental Changes, Academia Sinica 2 - Academia Sinica

Changes in extratropical disturbance behavior could play an important role in climate dynamics and be responsible for a part of climate-related damage. However, robust observational evidence for long-term trends in the activity is still lacking, and understanding of how it is linked with climate phenomena, such as climate extremes, is limited. In this study, we define an accumulated perturbation index (API) to quantify the variation in some scalar quantities of atmospheric disturbances. API measures the weighted areas of a certain perturbation quantity, with weight in proportion to the deviation from the climatology. This index represents an integrated activity of atmospheric disturbances at a given time relative to a long time span. API reflects more realistically the ensemble impacts of a climate perturbation and/or trend (such as global warming and ENSO) on the atmospheric disturbances, even though its impact on different regions might vary from year to year due to stochastic processes. API is calculated for 1-10-day, 10-30-day, and 30-60-day wind field fluctuations during DJF and JJA using six reanalysis data sets. The analysis reveals an overall increasing trend in API of 200-hPa meridional velocity variance and wave activity during the past six decades. In particular, 1-10-day API has clearly increased after 2000 and reached a record-breaking high in 2015/16 DJF. The findings suggest that atmospheric disturbances, especially in weather-timescale, have strengthened in widening areas during the past decade (with a profound change in the past few years), even though there might not be robust trends in wind field fluctuations at regional scales. Whether the observed trends in API are associated with certain climate patterns is under investigation. Impact of global warming is likely one of the major sources for the increasing activity.

Extended-range prediction of high-impact weather in South American monsoon: the importance of the models´ skill in simulating the MJO impacts

Abstract ID : 1325

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Alice Grimm ,grimm@fisica.ufpr.br ,(Professor) ,Brazil ,Curitiba ,Presenting[1]

Dr. Fernando Hirata ,fernando.endo.hirata@gmail.com ,(None) ,Brazil , ,Not Presenting[1]

Mrs. Gisele Martins ,gi.i_pmartins@hotmail.com ,(None) ,Brazil , ,Not Presenting[1]

Mr. Thiago Silva ,tms17@inf.ufpr.br ,(None) ,Brazil , ,Not Presenting[1]

1 - Federal University of Parana 2 - Federal University of Parana 3 - Federal University of Parana 4 - Federal University of Parana

The South Atlantic Convergence Zone (SACZ), a northwest-southeast band of enhanced convection extending from central South America over Southeast Brazil and into the subtropical Atlantic Ocean, is one of the main features of the South American summer monsoon. The SACZ affects very densely populated areas in Southeast Brazil, including Rio de Janeiro and Sao Paulo. During the austral summer this region is strongly affected by landslides and floods associated with active SACZ. Extreme precipitation events in the SACZ region receive contribution from synoptic and intraseasonal variability. To explore extended-range predictability of these events, the Madden Julian Oscillation (MJO) impacts on the frequency of extreme events in South America are determined with rain gauge data for the period 1979-2009. The MJO cycle is divided into 8 phases according to the temporal evolution of the first two modes of multivariate EOF analysis of tropical convection and zonal winds. The teleconnections associated with these impacts are analyzed with simulations and influence functions of a simple model. The results show that two of the MJO phases strongly enhance the extreme events in the SACZ region and indicate the responsible mechanisms, lending these events a higher degree of predictability on subseasonal time-scales. Therefore, it should be possible to extend the forecast range of extreme events in this region, which is crucial to prevent/mitigate socio-economic impacts. In selecting models to build a subseasonal-range forecasting scheme for extreme precipitation events, a necessary step is the assessment of their skill in reproducing the observed impacts of the MJO on South America. Two well-known models of the S2S Project, CFS-v2 and ECMWF, are analyzed. Their reforecasts for weeks 1, 2, 3, 4 are separately projected onto the first two modes of tropical convection and zonal wind variability in order to identify the MJO phases. The skill of the models in predicting these phases is good and extends to week 4, with some differences between the models. However, the skill is lower in reproducing the MJO influence on the SACZ, due to the models´ different convection anomalies in the central Pacific Ocean and associated teleconnections to South America.

The prediction of heat waves over South Africa

Abstract ID : 1456

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Christien Engelbrecht ,engelbrechtc@arc.agric.za ,(None) ,South Africa , ,Not Presenting[1]

1 - ARC

The exceptional hot 2015-16 summer over South Africa was associated with an above-normal frequency of the occurrence of heat waves. Large parts of the country experienced heat wave conditions that lasted relatively long. Over the central parts of the country, up to 10 heat waves more occurred than usual during the October 2015 to March 2016 period. The excessive hot conditions impacted negatively on various sectors in the agricultural industry and the need for weather forecasts on time scales important to agricultural production was again stressed. There is a need to know the likelihood of high-impact weather events. In this study, the predictability of heat waves on the sub-seasonal to seasonal time scale over South Africa will be presented.

APHRODITE-2: Asian Precipitation -- Highly Resolved Observational Data Integration Towards Evaluation of Extreme Events

Abstract ID : 1482

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Akiyo Yatagai ,yatagai@hirosaki-u.ac.jp ,(Associate Professor) ,Japan ,Hirosaki ,Not Presenting[1]

1 - None

The APHRODITE project aims to create accurate daily grid precipitation data over Asian land areas with a high spatial and temporal resolution based on rain-gauge observations. The APHRODITE-2 project started in June 2016 and will continue until March 2019.
One of today's greatest concerns is the future hydrometeorological conditions as a consequence of human-induced climate change. The increase in extreme events is especially a focus of international scientific and political frameworks, such as the World Climate Research Programme (WCRP) and IPCC. The APHRODITE products (Yatagai et al., 2009; Kamiguchi et al. 2010; Yasutomi et al. 2011; Yatagai et al. 2012) are used for many climatological and hydrological studies, including the downscaling of low-resolution model data, and for validating satellite observations.
The well-known APHRODITE precipitation data are hence expected to be used in the evaluation of extreme events. However, conflicting "end-of-day" times is one issue that must be resolved for further usage of APHRODITE data (e.g. comparisons with disaster records, combined use with satellite estimates, statistical analyses).
We therefore apply a time adjustment within APHRODITE-2, and evaluate the change of extreme statistics according to gridding process and the time adjustment. Furthermore, we compare meteorological conditions, such as heavy rainfall, APHRODITE precipitation and disaster events, to help understand and improve the forecasting of extreme events, thereby producing an improved APHRODITE algorithm. These efforts will inform decision making at a political level with regard to the risk associated with hydrological changes as a result of global warming. For example, the change in extreme precipitation events and river runoff.
Development of the APHRODITE algorithm is based on discussions with various users, including climate modelers and developers of satellite precipitation algorithms. We welcome feedback from users, as well as any kind of cooperation, especially with regard to the sharing of observational data.

M018 - Advances and Frontier challenges in Global Monsoon Studies

Possible changes in the boreal summer intraseasonal oscillation projected by CNRM-CM5 model under the extreme climate warming scenario

Abstract ID : 112

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Jiangyu Mao ,mjy@lasg.iap.ac.cn ,(None) ,China ,Beijing ,Presenting[1]

Dr. Jianying Li ,lijy@cug.edu.cn ,(None) ,China , ,Not Presenting[2]

1 - Institute of Atmospheric Physics, CAS 2 - China University of Geosciences

The 30-60-day boreal summer intraseasonal oscillation (BSISO) is the predominant intraseasonal variability in the Asian summer monsoon (ASM) region, representing the canonical northward and northwestward propagating convective components over South Asia (SA) and East Asia/western North Pacific (EA/WNP) sectors in conjunction with eastward propagating convective anomalies. The objective of this study is to assess possible changes of the 30-60-day BSISO in future global warming condition by comparing the twentieth century simulation with the twenty-first century projection produced by the CNRM-CM5 model under the representative concentration pathway 8.5 (RCP 8.5) scenario. In response to the increase of sea surface temperature in the tropical and subtropical Indian and Pacific Oceans, the saturation specific humidity in the planetary boundary layer (PBL) increases by about 16%, providing more moisture and moist static energy for tropical convection. Thus, the BSISO will be intensified, with large-amplitude events prevailing in a broader range of the Indo-Pacific region. The convective signal will initiate over more westward parts of the Indian Ocean and decay over the more eastward tropical Pacific. As the strengthening of northward propagations over the SA and EA/WNP sectors is intimately related to equatorial enhanced convective anomalies, the enhanced convective anomalies are accompanied by stronger ascents on the top of the PBL, together with the wetter seasonal-mean PBL background, resulting in stronger northward propagation through moisture mechanisms. Moreover, due to the increased moisture-holding capacity of the low-level atmosphere, the phase speeds of SASM and EA/WNP northward propagation will decrease.

Mechanism of decline in monsoon synoptic activity in a warming climate

Abstract ID : 248

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sandeep Sukumaran ,ss7675@nyu.edu ,(Postdoc) ,United Arab Emirates ,Abu Dhabi ,Not Presenting[1]

Dr. Ajaya Mohan Ravindran ,ajaya.mohan@nyu.edu ,(Senior Scientist) ,United Arab Emirates ,Abu Dhabi ,Not Presenting[1]

Dr. Praveen Veluthedathekuzhiyil ,pv25@nyu.edu ,(None) ,United Arab Emirates , ,Not Presenting[1]

Dr. Sabin TP ,sabin@tropmet.res.in ,(None) ,India , ,Not Presenting[4]

1 - New York University Abu Dhabi 2 - New York University Abu Dhabi 3 - New York University Abu Dhabi 4 - Indian Institute of Tropical Meteorology

The monsoon Low Pressure Systems (LPS) contribute more than half of the precipitation received over the fertile central Indian region. The future changes in the frequency and intensity of these main rain-bearing storms over India are not yet clear, partly due to the inadequate representation of LPS in the coupled models used in the Coupled Model Inter-comparison Project (CMIP5) experiments. The High Resolution Atmospheric Model (HiRAM) that realistically simulates the monsoon LPS, is used to produce current and future climate projections at high horizontal (~50km global) resolution. Four ensembles of HiRAM simulations are performed, with each ensemble driven by the sea surface temperature taken from a CMIP5 coupled model. These high resolution simulations indicate a substantial weakening (~45%) of the monsoon LPS genesis over the Bay of Bengal and an increased (~10%) frequency in the genesis of land-based weaker storms. Part of the drying over the central India by the reduced LPS genesis over the Bay of Bengal is compensated by the increased LPS genesis over land. The mechanism of changes in the LPS activity is explored. It is found that the weakening of the storm genesis over the Bay is linked to large-scale weakening of the monsoon circulation, which in turn is a response to the enhanced moist stability over the region. The enhanced atmospheric stability and weakening of monsoon circulation in a warming scenario simulated by HiRAM are in close agreement with CMIP5 projections.

Prediction and real time monitoring of indices for monsoon intraseasonal oscillations: An approach based on nonlinear laplacian spectral analysis technique

Abstract ID : 251

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sabeerali Cherumadanakadan Thelliyil ,sct4@nyu.edu ,(Postdoctoral Associate) ,United Arab Emirates ,Abu Dhabi ,Presenting[1]

Dr. Dimitrios Giannakis ,dimitris@cims.nyu.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Ajaya Mohan Ravindran ,ajaya.mohan@nyu.edu ,(Senior Scientist) ,United Arab Emirates ,Abu Dhabi ,Not Presenting[1]

Prof. Andrew J Majda ,jonjon@cims.nyu.edu ,(None) ,United States , ,Not Presenting[2]

1 - New York University Abu Dhabi 2 - New York University 3 - New York University Abu Dhabi 4 - New York University

Real time monitoring and prediction of monsoon intraseasonal oscillations (MISO) finds its application in agriculture, construction and hydro-electric power sectors and hence an important component of monsoon prediction. An improved index for real time monitoring and prediction of MISO is introduced using the recently developed Nonlinear Laplacian Spectral Analysis (NLSA) algorithm. Previous studies has demonstrated the skill of NLSA in capturing low frequency variability and intermittency of a time series. Using NLSA a hierarchy of Laplace-Beltrami (LB) eigen functions are extracted from the unfiltered daily GPCP rainfall data over the south Asian monsoon region. Two modes representing the full life cycle of complex northeastward propagating boreal summer MISO are identified from the hierarchy of Laplace-Beltrami eigen functions. These two MISO modes have a number of advantages over the conventionally used Extended Empirical Orthogonal Function (EEOF) MISO modes including higher memory and better predictability, higher fractional variance over the western Pacific, Western Ghats and adjoining Arabian Sea regions and more realistic representation of regional heat sources associated with the MISO. The skill of NLSA based MISO indices in real time prediction of MISO is demonstrated using hindcasts of CFSv2 extended range prediction runs. It is shown that these indices yield a higher prediction skill than the other conventional indices supporting the use of NLSA in real time prediction of MISO.

SST Gradient in the Tropical Indo-Pacific Domain and The Asian Summer Monsoon Onset

Abstract ID : 410

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Guoxiong Wu ,gxwu@lasg.iap.ac.cn ,(Professor) ,China ,Beijing ,Not Presenting[1]

Prof. Jiangyu Mao ,mjy@lasg.iap.ac.cn ,(None) ,China ,Beijing ,Not Presenting[2]

Dr. Yimin Liu ,lym@lasg.iap.ac.cn ,(None) ,China ,Beijing ,Not Presenting[3]

Dr. Boqi Liu ,lbq@lasg.iap.ac.cn ,(None) ,China , ,Not Presenting[4]

Dr. Rongcai Ren ,rrc@lasg.iap.ac.cn ,(Prof.) ,China ,Beijing ,Not Presenting[5]

1 - LASG, Institute of Atmospheric Physics, CAS 2 - Institute of Atmospheric Physics, CAS 3 - LASG, Institute of Atmospheric Physics, CAS 4 - CAMS, China Meteorological Administration, Beijing 5 - LASG, Institute of Atmospheric Physics

Based on a brief review of the Asian summer monsoon (ASM) onset processes and the associated mechanisms, the impacts of the sea surface temperature gradient in the tropical Indo-Pacific Ocean on the ASM onset are presented.
It is demonstrated that the vertical coupling of atmospheric circulation over the ASM area plays a fundamental role in the ASM onset processes. The genesis and evolution of the South Asian High (SAH) are controlled by the convective heating induced by land-air-sea interaction in the area, which in return influences the onset and evolution of the ASM by providing an upper pumping background. In the lower troposphere, the geneses of the SST warm pool and the unstable barotropic flow over the Bay of Bengal (BOB) create favorable conditions for the earliest ASM onset over the BOB; and the development of forced convection over the southeastern Arabian Sea results in the Indian summer monsoon onset. All the physical processes involved in the BOB and Indian summer monsoon onsets are controlled by the land-air-sea interaction in the area.
Data diagnosis demonstrates a well defined relation between the interannual variability of the ASM onset and the ENSO events: an earlier than normal ASM onset over the BOB and India occurs after a cold ENSO event, and a later than normal onset occurs after a warm even. Results further demonstrate that such an interannual variation in the ASM onset timing is closely associated with the ENSO-induced changes in vertical coupling of upper- and lower-level circulation. Through changing the longitudinal SST gradient along the tropical Indo-Pacific Ocean, the ENSO event can affect the formation of the SAH and the bartropic instability over the BOB region, resulting in the change of the BOB monsoon onset. Through changing the cross-equatorial SST gradient in the western Arabian Sea, the ENSO event can affect the inertial instability and forced convection over the southwestern coast of India, resulting in the change of the Indian summer monsoon onset.

On the shrotening of Indian Summer Monsoon Season in a Warming Scenario

Abstract ID : 462

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ajaya Mohan Ravindran ,ajaya.mohan@nyu.edu ,(Senior Scientist) ,United Arab Emirates ,Abu Dhabi ,Not Presenting[1]

Dr. Sabeerali C. T ,sabeer@nyu.edu ,(None) ,United Arab Emirates , ,Not Presenting[1]

1 - New York University Abu Dhabi 2 - New York University Abu Dhabi

Assessing the future projections of the length of rainy season (LRS) has paramount societal impact considering its potential to alter the seasonal mean rainfall over the Indian subcontinent. Here, we explored the projections of LRS using both historical and Representative Concentration Pathways 8.5 (RCP8.5) simulations of the Coupled
Model Intercomparison Project Phase5 (CMIP5). RCP8.5 simulations project shortening of the LRS of Indian summer monsoon by altering the timing of onset and withdrawal dates. Most CMIP5 RCP8.5 model simulations indicate a faster warming rate over the western tropical Indian Ocean compared to other regions of the Indian Ocean. It is found that the pronounced western Indian Ocean warming and associated increase in convection results in warmer upper troposphere over the Indian Ocean compared to the Indian subcontinent reducing the meridional gradient in upper tropospheric temperature (UTT) over the Asian summer monsoon (ASM) domain. The weakening of the meridional gradient in UTT and associated weakening of easterly vertical wind shear over the ASM domain during first and last phase of monsoon modifies the monsoon onset and withdrawal dates, ensues shortening of LRS of Indian summer monsoon in a warming scenario.

Maritime Continent seasonal climate biases in AMIP experiments of the CMIP5 multimodel ensemble

Abstract ID : 479

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Ying Ying Toh ,y.y.toh@pgr.reading.ac.uk ,(PhD student) ,United Kingdom ,Reading ,Presenting[1]

Dr. Christopher Holloway ,c.e.holloway@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Andrew Turner ,a.g.turner@reading.ac.uk ,(Lecturer) ,United Kingdom ,Reading ,Not Presenting[1]

Dr. Stephanie J Johnson ,stephanie.johnson@ecmwf.int ,(None) ,United Kingdom , ,Not Presenting[4]

1 - University of Reading 2 - University of Reading 3 - University of Reading 4 - National Centre of Atmospheric Science (Climate), University of Reading

The fidelity of 28 Coupled Model Intercomparison Project phase 5 (CMIP5) models in simulating mean climate over the Maritime Continent in the Atmospheric Model Intercomparison Project (AMIP) experiment is evaluated in this study. The performance of AMIP models varies greatly in reproducing seasonal mean climate and the seasonal cycle. The multi-model mean has better skill at reproducing the observed mean climate than the individual models. The spatial pattern of 850 hPa wind is better simulated than the precipitation in all four seasons. We found that model horizontal resolution is not a good indicator of model performance. Instead, a model's local Maritime Continent biases are somewhat related to its biases in the local Hadley circulation and global monsoon. The comparison with coupled models in CMIP5 shows that AMIP models generally performed better than coupled models in the simulation of the global monsoon and local Hadley circulation but less well at simulating the Maritime Continent annual cycle of precipitation.

To characterize model systematic biases in the AMIP runs, we performed cluster analysis on Maritime Continent annual cycle precipitation. Our analysis resulted in two distinct clusters. Cluster I models are able to capture both the winter monsoon and summer monsoon shift, but they overestimate the precipitation; especially during the JJA and SON seasons. Cluster II models simulate weaker seasonal migration than observed, and the maximum rainfall position stays closer to the equator throughout the year. The tropics-wide properties of these clusters suggest a connection between the skill of simulating global properties of the monsoon circulation and the skill of simulating the regional scale of Maritime Continent precipitation.

Furthermore, the implication of SST biases in Maritime Continent on precipitation and circulation biases and teleconnections in CMIP5 models is also investigated.

MESETA: Modelling physical and dynamical processes over the Tibetan Plateau and their regional effects over East Asia

Abstract ID : 503

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Reinhard Schiemann ,r.k.schiemann@reading.ac.uk ,(Senior Research Scientist, NCAS Climate) ,United Kingdom ,Reading ,Presenting[1]

Dr. Kevin Hodges ,k.i.hodges@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Andrew Turner ,a.g.turner@reading.ac.uk ,(Lecturer) ,United Kingdom ,Reading ,Not Presenting[3]

Ms. Julia Curio ,j.curio@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Kai Chi Wong ,k.c.wong@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - National Centre of Atmospheric Science (Climate), University of Reading 2 - National Centre of Atmospheric Science (Climate), University of Reading 3 - University of Reading 4 - National Centre of Atmospheric Science (Climate), University of Reading 5 - National Centre of Atmospheric Science (Climate), University of Reading

We present the MESETA Tibetan Plateau project, part of the Climate Science for Service Partnership China (CSSP China) research collaboration between the United Kingdom and China. MESETA has a twin focus on (i) establishing the relative role of mechanical and thermodynamic effects of Tibetan Plateau (TP) orography on the temperature and circulation of the region and its downstream impacts over East Asia; and (ii) TP atmospheric circulation, in particular the formation of Tibetan Plateau vortices (TPVs) and their role in extreme events downstream of the Plateau.
Regarding (i), sensitivity experiments have been conducted with the atmosphere-only HadGEM3 model at N96 resolution, in which the Asian orography is modified in different ways (no TP, no TP but Himalayas retained, no Iranian Plateau). We find that the Indian Summer Monsoon is more sensitive to orographic blocking from the Himalayas and from the Iranian Plateau than to elevated heating by the TP. At the same time, the East Asian Summer Monsoon is seen to be more sensitive to the presence of the TP. Additional experiments with modified TP surface albedo will demonstrate the role of TP thermal forcing.
Part (ii) is concerned with TPVs, mesoscale cyclones that occur over and downstream of the TP. A tracking algorithm has been applied to derive TPV climatologies in two reanalyses (ERA-Interim, NCEP-CFSR) and in HadGEM3 simulations at N512 resolution (~25 km). We find that, throughout the year, there is a preferred TPV genesis region to the east of a mountain ridge in the northwest TP, near 85°E, 35°N. TPVs that travel off the TP tend to form further east. During winter and spring, TPVs travel further east on average than in summer, arguably due to advection by the stronger westerly mean flow. The TPV climatologies of the model and the two reanalyses are very similar to one another. We will also present results associating the TPV tracks with precipitation in order to assess the role of TPVs in heavy precipitation events.

Evaluation of Intraseasonal Oscillation Simulations in IPCC AR5 Coupled GCMs Associated with the Asian Summer Monsoon

Abstract ID : 555

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Wenting Hu ,hwt@lasg.iap.ac.cn ,(research assistant) ,China ,Beijing ,Presenting[1]

Prof. Anmin Duan ,amduan@lasg.iap.ac.cn ,(Senior Scientist) ,China ,Beijing ,Not Presenting[2]

Dr. Bian He ,heb@lasg.iap.ac.cn ,(None) ,China ,Beijing ,Not Presenting[3]

1 - IAP 2 - None 3 - LASG/IAP

In this study, we systematically evaluate the Intraseasonal Oscillation (ISO) associated with the Asian summer monsoon region in coupled general circulation models (GCMs) participating in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5). Results show that most of the models simulate reasonable climatological circulation patterns in boreal summer, but insufficient precipitation over the Bay of Bengal (BOB) and western North Pacific summer monsoon region. Most models underestimate the variance of 12-90-day ISO mode but overestimate the percent variance of 12-90-day ISO accounting for raw precipitation anomalies. There remains a wide gap between model simulations and observations in the simulations of eastward-propagating ISO (30-80-day), while the models perform better in the northward propagation of the 30-80-day mode and the westward propagation of the 12-24-day mode. In addition, mean state circulation, atmospheric internal dynamic process, air-sea interactions, and model resolution have varying degrees of impacts on the ISO simulation. The local Hadley and Walker cell biases are investigated in this study, which might relate well with the precipitation bias in models. Within the similar background of vertical easterly shear, few models have the capacity to simulate the equivalent barotropic vorticity to the north of the convection center. Furthermore, many models have difficulty reproducing the strong air-sea interactions over the Indian Ocean and the BOB. Our results indicate that simply improving model resolution is not an effective method to obtain more reasonable propagation characteristics of the ISO, especially for eastward propagation. Therefore, further improving the capacity of the ISO simulation remains a great challenge for future development of climate system models.

Generation and variation of upper troposphere temperature maximum

Abstract ID : 560

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yimin Liu ,lym@lasg.iap.ac.cn ,(None) ,China ,Beijing ,Not Presenting[1]

1 - LASG, Institute of Atmospheric Physics, CAS

The upper-troposphere-temperature-maximum (UTTM) over South Asia is a pronounced feature in the Northern Hemisphere summer. Its formation mechanism is still unclear. This study shows that the latitude location of the upper-tropospheric warm- center (T) coincides with the subtropical anticyclone, and its longitude location is determined by the zonal distribution of vertical gradient of heating/cooling (QZ), which is different from the Gill's model. Since both convective heating and radiation cooling decrease with height in the upper troposphere, the heating/cooling generates vertical northerly/southerly shear, leading to a warm/cold center being developed between heating profile in the east/west and cooling profile in the west/east. The location of the UTTM coincides with the South Asian High (SAH) and is between a radiation cooling in the west and the Asian-monsoon convection heating source in the east. The UTTM is sensitive to this convective heating: increased heating in the source region in a general circulation model causes intensification of both the SAH and UTTM, and imposing periodic convective heating there results in oscillations in the SAH, UTTM, and vertical motion to the west with the same period. While a strong diabatic hearting above the Tibetan Plateau will results in the bi-weekly oscillation of the SAH.

Local Oceanic Precursors for the Summer Monsoon Onset over the Bay of Bengal and the Underlying Processes

Abstract ID : 1000

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Jianping Li ,ljp@bnu.edu.cn ,(Prof. Jianping Li GCESS, Beijing Normal University) ,China ,Beijing ,Presenting[1]

Ms. Nan Xing ,nxing0923@163.com ,(None) ,China , ,Not Presenting[2]

Prof. Lanning Wang ,wangln@bnu.edu.cn ,(None) ,China , ,Not Presenting[1]

Mr. Xingwen Jiang ,xingwen.jiang@yahoo.com ,(None) ,China , ,Not Presenting[4]

1 - Beijing Normal University 2 - 2. Beijing Meteorological Observatory 3 - Beijing Normal University 4 - Institute of Plateau Meteorology, China Meteorological Administration

Sea surface temperature (SST) over the Bay of Bengal (BoB) plays an important role in the onset of BoB summer monsoon (BoBSM). In the previous study we found that the meridionally warmest SST axis (WSSTA) appears in mid-April in the central BoB, and a strong meridional SST gradient occurs between BOB and south of the equator after the abrupt northward jump of WSSTA, associated with cross-equatorial flow in the eastern Indian Ocean. The onset of the southwesterlies lags behind the abrupt northward jump of WSSTA, on average, by about 2 pentads, implying that the abrupt northward jump in WSSTA from the equator to the central BoB (around north of 10°N) is a precursor for the BoBSM onset. Furthermore, we find that a warm but not the meridionally warmest center, which is defined as the secondary WSSTA (SWSSTA), occurs in early April in the central BoB, leading the BoBSM onset by five pentads. Dates of the SWSSTA occurrence are significantly positively correlated with dates of the WSSTA occurrence in the central BoB and the BoBSM onset on an interannual time scale. The SWSSTA is an earlier precursor for the BoBSM onset. The formation of the oceanic precursor and its impact on the BoBSM onset are as follows. Before the BoBSM onset, resulting from more surface heat input and shallower mixed layer affected by the low-level anticyclone and subtropical high in the central BoB, local SST shows the most rapid increase. Meanwhile, the situation is adverse to the rapid increase of SST in the equatorial BoB. For this reason, the SWSSTA occurs, and the WSSTA subsequently appears in the central BoB. The WSSTA in turn enhances local convection, eliminates the low-level anticyclone, and moves the subtropical high outward away from the BoB by inducing atmospheric instability, thus developing a heating center. Convectional heating further strengthens southwesterlies in the BoB by exciting mixed planetary-gravity waves, resulting in the BoBSM onset.

Decadal Change of the East Asian Winter Monsoon Variability and its Dynamical Prediction

Abstract ID : 1260

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Daehyun Kang ,dhkang@unist.ac.kr ,(School of Urban and Environmental Engineering) ,South Korea ,Ulsan ,Not Presenting[1]

Prof. Myong-In Lee ,milee@unist.ac.kr ,(None) ,South Korea , ,Not Presenting[2]

1 - UNIST 2 - Ulsan National Institute of Science and Technology

The East Asian Winter Monsoon (EAWM) is one of the important climate variability in boreal winter. The strong EAWM is connected with frequent cold wave over East Asia including China, Korea and Japan. This study examines that seasonal hindcast, using five state-of-the-art dynamical seasonal prediction systems: CanCM3, CanCM4, CFSv2, CM2.1, and GEOS-5. The intercomparison suggests that the models with skillful EAWM more than lead one-month represent realistic precipitation in the tropics. The EAWM shows stronger relationship with the tropical precipitation, which is represented as ENSO. The relationship between EAWM and ENSO has been intensified for 1997-2010 (r = -0.84) than that for 1983-1996 (r= -0.44). The model-dependent capability of representing ENSO-EAWM relationship is one of important predictability source of the EAWM. CFSv2 shows useful prediction skill of EAWM index until lead five month for 1997-2010, represents realistic dipole structure of ENSO precipitation between the Western North Pacific and the Central Pacific as in observation. The models with errant ENSO precipitation shows useful prediction until only lead zero month. The CMIP5 AMIP and the Historical simulations also suggest that similar ENSO influence on the EAWM. In this regard, the prediction of EAWM should be linked with a realistic representation of the ENSO precipitation and its teleconnection.

Aerosol - surface forcing - rainfall association during over Gangetic plains

Abstract ID : 1288

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Sachchida Tripathi ,snt@iitk.ac.in ,(Professor) ,India ,Kanpur ,Not Presenting[1]

1 - Indian Institute of Technology Kanpur

Aerosols radiative effect can affect the surface energy fluxes and thereby the thermodynamical conditions during monsoon onset period. Observational evidence of the association of aerosols and the Bowen Ratio (BR) during episodic periods in May-June 2016 over the city of Kanpur, in the central Gangetic plains of India, is presented. Collocated measurements of aerosols and surface energy fluxes under clear sky conditions are used. Increase in aerosols is associated with a decrease in net radiation at surface and solar dimming, thereby, suppressing sensible heat flux (SH). Simultaneously, increase in aerosols is also associated with an increase in transpiration and latent heat flux (LH), thereby resulting in a statistically significant decrease in BR. During monsoon season aerosols microphysical effect and land use heterogeneities, like urban heat islands, can exert combined influence on the space-time distribution of surface rainfall. A typical heavy rainfall event which propagated north-westward across Kanpur during 5th August 2011 is simulated using WRF model under three different scenarios. Case 1 has realistic LULC representation of Kanpur, while the grids representing Kanpur urban region in the model are replaced by cropland LULC pattern in case 2. Comparison of these two simulations illustrates that urban heat island (UHI) effect causes convergence of winds and moisture in lower troposphere, enhances the convection over urban region and induces more rainfall over urban core compared to nearby rural regions. Case 3 is similar to case 1 except that it has lower CCN concentration (CCN = CCN_case1/100) to study the relative effect of aerosol and urban land use effect on spatial rainfall distribution. Increase in CCN concentration initially suppresses warm rainfall which leads to upliftment of more water mass above the freezing level and eventually increases the mass of ice hydrometeors during the event. Thus, reduction in rainfall south of Kanpur but increases the surface rainfall over regions north of Kanpur was observed. These case studies emphasizes the importance of inclusion of aerosol effects in numerical simulations for better short-range and mid-range monsoon forecast over North India.

Onset and progression of the 2016 Indian monsoon in field campaign observations and a 4km-resolution version of the UK Met Office Unified Model

Abstract ID : 1311

Conflict Declaration : None

Content Motivation : None

Additional Information :

Dr. Arathy Menon ,arathy.menon@reading.ac.uk ,(Research Scientist) ,United Kingdom ,Reading ,Not Presenting[1]

Dr. Andrew Turner ,a.g.turner@reading.ac.uk ,(Lecturer) ,United Kingdom ,Reading ,Not Presenting[1]

Dr. Stuart Webster ,stuart.webster@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. Gill Martin ,gill.martin@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - University of Reading 2 - University of Reading 3 - Met Office 4 - Met Office

Accurately predicting the Indian monsoon remains a major challenge for weather and climate models. The inadequate representation of sub-grid scale processes is one of the major causes of biases in GCMs. Here we use detailed observations from aircraft sorties, radiosonde launches, flux towers and other measurements gathered by the joint UK-India INCOMPASS field campaign to understand the dynamics and thermodynamics associated with the progression of the Indian monsoon in 2016. We compare these in-situ data with a high-resolution (4 km) limited area configuration of the UK Met Office Unified Model. We use the high-resolution model at two configurations: a real-time forecast model which is re-initialised by the global model at every forecast step (and therefore including data assimilation of observations) and a free-running model in which the flow fields and the soil moisture are left to freely evolve. The free-running model is also tested with two land ancillaries in order to test the sensitivity to land surface processes. Our results mainly focus on the onset of the Indian monsoon and its progression from south-east to north-west. We have also analysed the effects of mid-level dry-air incursions on the progression of the rainfall.

The INCOMPASS project field and modelling campaign: Interaction of Convective Organization and Monsoon Precipitation, Atmosphere, Surface and Sea (India 2016)

Abstract ID : 1430

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Andrew Turner ,a.g.turner@reading.ac.uk ,(Lecturer) ,United Kingdom ,Reading ,Presenting[1]

Prof. Ganapati Bhat ,bhat@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[2]

1 - University of Reading 2 - Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore, India

The INCOMPASS project uses data from a field and aircraft measurement campaign during the 2016 monsoon onset to better understand and predict monsoon rainfall. The monsoon supplies the majority of water in South Asia, however modelling and forecasting the monsoon from days to the season ahead is limited by large model errors that develop quickly. Likely problems lie in physical parametrizations such as convection, the boundary layer and land surface. At the same time, lack of detailed observations prevents more thorough understanding of monsoon circulation and its interaction with the land surface; a process governed by boundary layer and convective cloud dynamics.
From May to July 2016, INCOMPASS used a modified BAe-146 jet aircraft operated by the UK Facility for Airborne Atmospheric Measurements (FAAM), for the first project of this scale in India. The India and UK team flew around 100 hours of science sorties from bases in northern and southern India. Flights from Lucknow in the northern plains took measurements to the west and southeast to allow sampling of the complete contrast from dry desert air to the humid environment over the north Bay of Bengal. These routes were repeated in the pre-monsoon and monsoon phases, measuring contrasting surface and boundary layer structures. In addition, flights from the southern base in Bengaluru measured contrasts from the Arabian Sea, across the intense rains of the Western Ghats mountains, over the rain shadow in southeast India and over the southern Bay of Bengal. Flight planning was performed with the aid of forecasts from a new UK Met Office 4km limited area model. INCOMPASS also installed a network of surface flux towers, as well as operating a cloud-base ceilometer and performing intensive radiosonde launches from a supersite in Kanpur.
Here we will outline preliminary results from the field campaign including new observations of the surface, boundary layer structure and atmospheric profiles from aircraft data. We also include initial results from nested high-resolution modelling experiments of the 2016 monsoon, at a resolution of 4km in comparison with bespoke regional forecasts run throughout the field campaign.

On the dominant intra-seasonal modes over the East Asia-western North Pacific summer monsoon region

Abstract ID : 1502

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Kyung-Ja Ha ,kjha@pusan.ac.kr ,(None) ,South Korea ,None ,Not Presenting[1]

1 - Pusan National University

Intra-seasonal monsoon prediction is the most imperative task due to high impact on 2/3 of world populations' daily life, but there remains an enduring challenge in climate science. The present study aims to provide a physical understanding of the sources for prediction of dominant intra-seasonal modes in the East Asian-western North Pacific summer monsoon (EA-WNPSM): preMeiyu&Baiu, Changma&Meiyu, WNPSM, and monsoon gyre modes classified by the self-organizing map analysis. The major modes tend to be dominated by the moisture convergence of the moisture budget equation along the rain-band. The preMeiyu-Baiu mode is strongly linked to both the anomalous low-level convergence and vertical wind shear through baroclinic instability, and the Changma&Meiyu mode has a strengthened tropic-subtropics connection along the western north Pacific subtropical high, which induces vertical destabilization and strong convective instability. The WNPSM and monsoon gyre modes are characterized by anomalous southeasterly flow of warm and moist air from western north Pacific monsoon, and low-level easterly flow, respectively. Prominent difference in response to the ENSO leads to different effects of the Indian Ocean and western Pacific thermal state, and consequently, the distinct moisture supply and instability variations for the EASM intra-seasonal modes. We discuss the major driving forces of sub-seasonal variability over EA-WNPSM regions. Lastly we attempted to determine the predictability sources for the four modes in the EA-WNPSM. The selected predictors are based on the persistent and tendency signals of the SST/2m air temperature and sea level pressure fields, which reflect the asymmetric response to the ENSO and the ocean and land surface anomalous conditions. For the preMeiyu&Baiu mode, the SST cooling tendency over the WNP, which persists into summer, is the distinguishing contributor that results in strong baroclinic instability. A major precursor for the Changma&Meiyu mode is related to the WNP subtropical high, induced by the persistent SST difference between the Indian Ocean and the western Pacific. The WNPSM mode is mostly affected by the Pacific-Japan pattern, and monsoon gyre mode is primarily associated with a persistent SST cooling over the tropical Indian Ocean by the preceding ENSO signal. This study carries important implications for prediction by establishing valuable precursors of the four modes including nonlinear characteristics.

M019 - Precipitation at all scales

Sensitivity of simulated summer monsoonal precipitation in Langtang Valley, Himalaya to cloud microphysics schemes in WRF

Abstract ID : 377

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Andrew Orr ,anmcr@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Pranab Deb ,prab@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Walter Immerzeel ,w.w.immerzeel@uu.nl ,(None) ,Netherlands , ,Not Presenting[3]

Dr. Emily Collier ,emily.collier@fau.de ,(None) ,Germany , ,Not Presenting[4]

Dr. Constantino Listowski ,constantino.listowski@latmos.ipsl.fr ,(None) ,France , ,Not Presenting[5]

Dr. Maugaux Couttet ,margaux.couttet@gmail.com ,(None) ,Switzerland , ,Not Presenting[6]

Dr. Dan Bannister ,danban70@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - British Antarctic Survey 2 - British Antarctic Survey 3 - University of Utrecht 4 - Friedrich-Alexander University (FAU) Erlangen-Nürnberg 5 - Laboratoire Atmosphères, Milieux, Observations Spatiales 6 - École Polytechnique Fédérale de Lausanne 7 - British Antarctic Survey

A better understanding of regional-scale precipitation patterns in the Himalayan region is required to increase our knowledge of the impacts of climate change on glaciers, snowpacks, and downstream water availability. This study examines the impact of four cloud microphysical schemes (Thompson, Morrison, WRF Single-Moment 5-class (WSM5), and WRF Double-Moment 6-class (WDM6)) on summer monsoon precipitation in the Langtang Valley, Himalayas, as simulated by the Weather Research and Forecasting (WRF) model at 1 km grid spacing for a ten-day period. The model results are evaluated through a comparison with precipitation and radiation measurements made at two observation sites located on the Langtang Valley floor and on the adjacent mountain slopes. Additional understanding is gained from a detailed examination of the microphysical characteristics simulated by each scheme, which are compared with measurements of cloud properties from the DARDAR (raDAR/liDAR) satellite product, and the roles of large and small-scale forcing.
The choice of microphysics scheme has a strong influence on simulated precipitation in the Langtang Valley, with large inter-model differences and significantly different day-to-day variability compared to measurements. Overall, the Morrison scheme showed the best agreement in terms of both precipitation and radiation over the ten-day period (consistent with its double-moment prediction of every ice-phase hydrometeor). Analysis of hydrometeors from each of the schemes suggests that 'cold-rain processes' are a key precipitation formation mechanism, which is also best represented by the Morrison scheme. As well as microphysical structure, both large-scale and localised forcing is also important.

Impact of resolution on the representation of precipitation variability associated with the ITCZ

Abstract ID : 409

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Marc De Benedetti ,marc.debenedetti@mail.utoronto.ca ,(Graduate Student) ,Canada ,Mississauga ,Not Presenting[1]

Prof. G.W.K. Moore ,gwk.moore@utoronto.ca ,(None) ,Canada , ,Not Presenting[1]

1 - University of Toronto 2 - University of Toronto

The intertropical convergence zone (ITCZ) is a band of precipitation that oscillates seasonally about the equator and is mainly caused by the convergence of trade winds. The ITCZ is responsible for the majority of the weather and climate in the equatorial region, as well as contributing to tropical-midlatitude interactions through the forcing of planetary waves. Therefore, being able to better determine its location, variability, and structure is important for describing atmospheric processes on a local and global scale. Being a primarily oceanic phenomenon, data on its structure and evolution is limited, and much of our knowledge regarding it has been derived from models including reanalysis datasets. The precipitation associated with the ITCZ is convective in origin, and thus it is unclear how model resolution impacts its representation. Here we use a novel technique that involves the calculation of the decorrelation length scale (DCLS) for precipitation to assess the role that model resolution plays in the representation of the ITCZ's structure. The technique was applied to the ERA-I Reanalysis (resolution ~80km), as well as a set of hindcasts, known as the Athena datasets, performed with the same model but with resolutions ranging from 16 km to 160 km. All datasets were able to represent the mean structure and seasonal evolution of the ITCZ. The DCLS analysis for the ERA-I not only resolves the mean structure but also reveals topographical effects around Hawaii as well as a noticeable effect that the upwelling cold water in the region where marine stratocumulus clouds (MSC) form along the west coast of South America have on the scale of the precipitation. The lowest resolution Athena dataset was not able to resolve these structures. The DCLS analysis for the higher resolution Athena datasets demonstrated a significant increase in fine-scale structures and was able to capture many topographical effects that are unseen in the lower resolutions, such as those associated with the MSC. The DCLS technique demonstrated a remarkable ability to provide information about the variability and structure of the precipitation, while providing insight into the role that model resolution plays in the representation of the ITCZ.

Projection of Future Winter Rainfall in Taiwan during the Late 21st Century

Abstract ID : 579

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Ho-Jiunn Lin ,hojiunn@gmail.com ,(Student) ,Taiwan ,Taipei ,Presenting[1]

Prof. Chih-wen Hung ,hungchihwen@gmail.com ,(None) ,Taiwan ,Taipei ,Not Presenting[2]

1 - Department of Geography, National Taiwan Normal University 2 - None

This paper reveals that the winter-half (November to April) rainfall in Taiwan will be fewer in the future (2075-2099) with the projection of Coupled Model Intercomparison Project Phase 5 (CMIP5) models in the worst global warming situation-representative concentration pathways 8.5W/m^2 (RCP8.5). The estimation is not simply using the precipitation output of the CMIP5 models nor any downscaling models, but using the conceptual model which represents the relationships between the winter-half Taiwan rainfall and the circulation along with water vapor convergence. In the historical observation data (1979-2003), both winter (November to January) and spring (February to April) rainfalls in Taiwan are correlated with moisture convergence near Taiwan. This study finds that there will be weaker moisture convergence in the future (2075-2099). Therefore, the Taiwan rainfall in the future (2075-2099) is possibly less than that in the historical time (1979-2003) according to the CMIP5 models projection in the RCP8.5 scenario of global warming.

Impacts of Boreal Summer Intraseasonal Oscillation on the Western North Pacific Typhoons and Rainfall in Taiwan

Abstract ID : 580

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Chih-wen Hung ,hungchihwen@gmail.com ,(None) ,Taiwan ,Taipei ,Presenting[1]

Mr. Ho-Jiunn Lin ,hojiunn@gmail.com ,(Student) ,Taiwan ,Taipei ,Not Presenting[2]

1 - None 2 - Department of Geography, National Taiwan Normal University

This study discusses the boreal summer intraseasonal oscillation (BSISO) impact on the western North Pacific (WNP) typhoons and the summer rainfall in Taiwan. The real time BSISO1 and BISISO2 indices are created using the first two and the third and fourth principal components of the multivariate empirical orthogonal function analysis, based on outgoing long-wave radiation and zonal wind at 850 hPa from Lee et al. (2013). The results show that heavy rainfall in Taiwan and the associated WNP typhoon frequency patterns are closely related to the 10 - 30 days BSISO2 phases during the typhoon season (July - October). Taiwan has larger rainfall during BSISO2 phases 3, 4, and 5 when the major BSISO2 convection moves northwestward from the Philippine Sea to the Taiwan area. During phases 3 and 4 the anomalous low-level cyclonic flow and the increased typhoon frequency directly result in larger rainfall in Taiwan. For the phase 5, enhanced low-level southwesterly flow which transports the moisture to Taiwan is responsible for more summer rainfall in Taiwan.

Northern Eurasia precipitation extremes from different datasets across space-time scales

Abstract ID : 715

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Olga Zolina ,olga.zolina@univ-grenoble-alpes.fr ,(Associate professor) ,France ,Saint Martin d'Heres ,Not Presenting[1]

1 - IGE

Ongoing and projected changes in continental water cycle are closely connected with extreme events which provide specific mechanisms of water cycle changes. This is especially true for the Northern Eurasia influenced by frequent floods and droughts some of which had hazardous impacts over the last years. We address observed variability and change in continental water cycle over the Northern Eurasia in the context of precipitation extremes using rain gauge observations from different national and international collections of in-situ precipitation measurements (E-OBS, DWD, RHMC) and modern satellite products (GPCP, TRMM, PERSIANN). Quantitative assessment includes estimation of absolute extremes and relative extremeness as well as the analysis of temporal structure of precipitation or precipitation timing. We provide pan-Eurasian estimates of all precipitation statistics, including characterization of extremes in the context of special and temporal scaling of precipitation for what selected subsets of hourly and higher resolution precipitation data for the last 2 decades were used. This allowed for the derivation of scaling parameters for precipitation extremes in the range from hours to days. In many regions climate variability of extreme precipitation over Eurasia is characterized by seasonality with different signs of linear trends being identified for the warm and sold seasons. Considering precipitation timing over last several decades both wet and dry periods have become longer in several large European regions, specifically in Central and Eastern Europe. This effect is not associated with changes in the number of wet days but, rather, with the grouping of wet days into prolonged wet and dry periods, increasing the likelihood of floods and droughts, respectively. Comparative assessments show that while climatological distributions of precipitation totals and to some extent of intensities were found to be in a qualitative agreement between station and satellite data, characteristics of precipitation extremes are poorly captured in satellite products, especially in summer over the Siberia and European Russia. Specifically, PERSIANN data also locally demonstrate significant disagreement with station data in quantifying multidecadal trends in precipitation characteristics. Results of evaluation are discussed in terms of the co-location uncertainties and the density of the rain gauge networks used for comparison.

Interannual Variations of Summer Precipitation in eastern China and related to the SST Anomalies in the East China Sea

Abstract ID : 1113

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Rongshuo Cai ,rscai@163.com ,(Scientist) ,China ,Xiamen ,Not Presenting[1]

Dr. Hongjian Tan ,tanhongjian@tio.org.cn ,(None) ,China , ,Not Presenting[1]

Prof. Ronghui Huang ,hrh@mail.iap.ac ,(None) ,China , ,Not Presenting[3]

1 - Third Institute of Oceanography, State Oceanic Administration of China 2 - Third Institute of Oceanography, State Oceanic Administration of China 3 - Insitute of Atmospheric Physics, Chinese Academy of Science

The relationship between the interannual variations of summer precipitation in eastern China and the SST anomalies in the East China Sea (ECS) is analysed using the composite and correlation analyses and the daily data of summer precipitation of China, GPCP 2.1 and HadISST datasets from 1979 to 2008. The results shows that when SST of ECS is in warm (cold) anomalies, there are less (more) rainfall in middle and lower reaches of the Yangtze River and Jianghua valley (YRJV) and the more (less) rainfall in the southern part of Northeast China. Moreover, a regional climate model (RegCM3) is used to examine the relationship. The results indicate that the warm (cold) SST anomalies in the ECS can contribute to the less (more) rainfall in the middle and lower reaches of the YRJV and most of North China and more (less) precipitation in South China, southeast part of Northeast China and the Korean Peninsula. Besides, the processes of atmospheric circulation variability over East Asia caused by the SST anomalies in the ECS are explored based on the NCEP/NCAR reanalysis and numerical simulation. The result shows that increase (decrease) of SST in the ECS has remarkable effect on zonal and meridional circulations over East Asia. When SST of ECS is above normal, a downward motion with a divergence in low level and a convergence in upper level can appear over the middle and lower reaches of the YRJV and most of North China, which contributes to the decrease of summer rainfall in these areas, in addition to an upward motion with a strong convergence in low level and a remarkable divergence in upper level can be caused over the region to the east of these seas. And a upward motion with strong convergence in low level and remarkable divergence in upper level is caused in South China, southern part of Northeast China and the Korean Peninsula, thus, the summer precipitation increase obviously in these regions. Consequently, it is suggested that the thermal state of the ECS maybe one of the important factors affecting the summer precipitation in East China.

Effect of resolution on the simulation of rainfall using the Conformal Cubic Atmopsheric Model

Abstract ID : 1301

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Mary-Jane Bopape ,mbopape@csir.co.za ,(Senior Resercher) ,South Africa ,Pretoria ,Not Presenting[1]

Dr. Francois Engelbrecht ,FEngelbrecht@csir.co.za ,(None) ,South Africa , ,Not Presenting[2]

Dr. Marcus Thatcher ,marcus.thatcher@csiro.au ,(None) ,Australia , ,Not Presenting[3]

Dr. Thando Ndarana ,thando.ndarana@up.ac.za ,(None) ,South Africa , ,Not Presenting[4]

1 - CHPC-CSIR 2 - CSIR/NRE 3 - CSIRO 4 - University of Pretoria

The grid spacing used in the numerical modelling of the atmosphere at any time scale is informed by the available computational resources and the amount of time available for the simulation to be made before decision making has to occur based on the model simulation. Direct numerical simulations that are able to capture all processes explicitly are still too far from our reach for practical purposes such as Numerical Weather Prediction (NWP), seasonal forecasting and climate change studies. Scientists therefore rely on models that use low resolution and use parameterization schemes to represent processes that models are not able to capture explicitly. Short term simulations such as those needed for NWP purposes are generally made at higher resolution than those that are made for a longer period such as for climate change studies, that require multidecadal simulations. In this study the change in the simulated rainfall structure with resolution using a model that is used across timescales, from NWP to climate change studies is investigated.

We use the Conformal Cubic Atmospheric Model (CCAM) to simulate the whole globe with horizontal grid spacings of 13, 26, 50 and 100 km. The simulations were also performed using different number of cores on the Centre for High Performance Computing (CHPC) to determine how CCAM scales. To produce a one month simulation in less than 30 minutes required the use of 864 cores for a 50km grid spacing and 13824 cores for a 13km grid spacing simulation. Preliminary results show that higher resolution simulates more details as expected, and that the partitioning of convective and nonconvective rainfal differs with resolution mostly at the equator and the subtropics in the southern hemisphere. The total amount of simulated rainfall is about the same at the equator, however, the high resolution simulates the least amount of convective rainfall. Over the subtropics, high resolution simulates more total rainfall than lower resolution, however the simulated convective precipitation is the same for different resolutions. Further analysis will include thorough studies of the convection

scheme to determine its suitability for simulations where convection is not captured at all, and when it is partially resolved.

Impacts of Convective Triggering on the Coupling of Convection and Diurnal Propagating Systems over the Southern Great Plains in CAM5

Abstract ID : 1413

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yi-Chi Wang ,yichiwang@gate.sinica.edu.tw ,(Postdoctoral Research Fellow) ,Taiwan ,Taipei city ,Not Presenting[1]

1 - Research Center for Environmental Changes

In this study, we investigated the impacts of the triggering function of the deep convection scheme on diurnal precipitating systems on the South Great Plains with the Community Atmospheric Model (CAM) version 5 (Neale et al., 2010). CAM5, like many other up-to-date climate model, has not been able to correctly capture the diurnal convection over the islands and those propagating seaward from the island edges.
To reduce this bias, we adopted the idea from the analysis in Wang et al. 2015. In that study, we found that the parameterized convective triggering in CAM5 needs to recognize the low-level inhomogeneity in the troposphere to simulate the diurnal precipitating system over the Southern Great Plains of the United States. In this study, we apply the improved parameterized triggering to the default cumulus parameterization - Zhang-Mcfarlane (ZM) scheme of CAM5 and run global-domain simulations driven by fixed sea surface temperature.
We found that the diurnal precipitating systems over the Southern Great Plains becomes the dominant diurnal mode in the simulations. We examined and validate the performance of CAM in reproducing the nocturnal convection. Large-scale circulations suggested important from the observations and mesoscale models such as the low-level jets, mountain-plains solesoid, and mid-tropospheric disturbances are validated. This study suggests the key features for cumulus parameterization to capture the diurnal nocturnal rainfall.

M020 - Role of Ocean-Atmosphere Interactions in Climate Variability, Change and Predictability

Understanding sea surface temperature forcing of precipitation variability

Abstract ID : 94

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jie He ,jhe@rsmas.miami.edu ,(Postdoctoral Research Assistant) ,United States ,Princeton ,Not Presenting[1]

1 - Princeton University

The great dependence of human society and natural ecosystems on rainfall makes precipitation variability an essential aspect of the earth's climate. In the tropics, it is well accepted that the ocean plays a crucial role in precipitation variability through variations in sea surface temperatures (SSTs). Above normal SSTs often increase the boundary-layer moist static energy and induce anomalous convection. An important yet unresolved question is: how strong is the SST forcing? Observational studies have long suggested an intense SST forcing for base SSTs around 27.5oC but little forcing for very high base SSTs. In this seminar, I will show that simultaneous SST-rainfall relationships in any coupled system, including observations, are inadequate for quantifying the SST forcing. This is largely due to the two-way interplay between the atmosphere and ocean. Results from uncoupled simulations show that the SST forcing in fact becomes larger for higher base SSTs. The relationship between the SST forcing and base SST can be parameterized with the moist static energy model. Future endeavors to quantify feedbacks between the SST and hydrological cycle will be presented with the aim of improving model simulations of tropical air-sea interaction and understanding tropical-extratropical teleconnections.

Future changes in global precipitation projected by the atmospheric global model with 60-km grid size

Abstract ID : 202

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Shoji Kusunoki ,skusunok@mri-jma.go.jp ,(Scientist) ,Japan ,Tsukuba, Ibaraki ,Not Presenting[1]

1 - Meteorological Research Institute (MRI)

We conducted global warming projections using global atmospheric model with 60-km grid size (MRI-AGCM3.2H). For the present-day climate of 21 years from 1983 through 2003, models were forced with observed historical sea surface temperature (SST). For the future climate of 21 years from 2079 through 2099, model was forced with future SST projected by conventional couple models. The emission scenario RCP8.5 is assumed. Twelve-member ensemble simulations for three different cumulus convection schemes and four different SST distributions were conducted to evaluate the uncertainty of projection. Annual average precipitation will increase over the equatorial regions and decrease over the subtropical regions. The future precipitation changes are generally sensitive to the cumulus convection scheme, but changes are influenced by the SST over the some regions of the Pacific Ocean. The precipitation efficiency defined as precipitation change per 1 degree surface air temperature warming is evaluated. The global average of precipitation efficiency for annual average precipitation was less than the maximum value expected by thermodynamical theory, indicating that dynamical atmospheric circulation is acting to reduce the conversion efficiency from water vapor to precipitation. The precipitation efficiency by heavy precipitation is larger than that by moderate and weak precipitation.

Atmospheric signature of the Agulhas Current

Abstract ID : 230

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Arielle Stela Nkwinkwa Njouodo ,a.nkwinkwa@yahoo.fr ,(PhD Student) ,South Africa ,Cape Town ,Presenting[1]

Prof. Noel Keenlyside ,noel.keenlyside@gfi.uib.no ,(None) ,Norway ,None ,Not Presenting[2]

Prof. Mathieu Rouault ,Mathieu.Rouault@uct.ac.za ,(Professor) ,South Africa ,Cape Town ,Not Presenting[3]

Dr. Shunya Koseki ,Shunya.Koseki@gfi.uib.no ,(None) ,Norway , ,Not Presenting[2]

1 - University of Cape Town 2 - Geophysical Institute, University of Bergen, Norway 3 - University of Cape town 4 - Geophysical Institute, University of Bergen, Norway

The impact of the Agulhas Current on the weather and climate of Southern Africa is not well-known. The core of the Agulhas Current, about 80-100 km wide, releases about 5 times as much water vapour to the atmosphere as does the surrounding water. This is due to a strong temperature contrast with the surrounding ocean leading to high turbulent latent heat fluxes and associated unstable condition. This leads to significant moisture convergence which enhances rainfall above the current and over the eastern part of South Africa adjacent to the Agulhas Current. In this study, satellite observation and Climate Forecast System Reanalysis (CFSR) are used from the period 1998 to 2005. The objective is to understand the influence of the Agulhas Current on precipitation in Southern Africa. The pressure adjustment mechanism is applied over the Agulhas Current region. Results unfold that the narrow band of precipitation above the Agulhas Current is collocated with surface wind convergence, sea surface temperature (SST) laplacian and sea level pressure (SLP) laplacian. The correlation between SLP laplacian and wind convergence is 0.54, 95% statistically significant. In the free troposphere, the band of precipitation above the Agulhas current is collocated with the wind divergence and the upward motion of wind velocity. The warm waters from the Agulhas current can influence coastal precipitation directly.

Pacific-Atlantic interactions heat up: Evidence from El Nino and Mid-latitude Blobs

Abstract ID : 299

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Jin-Yi YU ,jyyu@uci.edu ,(Full Professor) ,United States ,Irvine ,Not Presenting[1]

1 - University of California, Irvine

In this talk, evidence will be presented to demonstrate that interactions between the Pacific and Atlantic Oceans have increased in the past two decades resulting in a greater number of synchronized occurrences of marine heatwave and cold spell events (aka. warm and cold blobs, respectively) in North Pacific and Atlantic and also more frequent occurrences of the Central Pacific (CP) El Nino.

Most previous studies have emphasized processes within the tropical Pacific for the generation of El Niño. We will show that after a change in the phase (from negative to positive) of the Atlantic Multi-decadal Oscillation (AMO) in the early 1990s, the Atlantic Ocean has been more capable of influencing El Niño dynamics. As a result of the stronger Pacific-Atlantic interactions, El Niño has changed from being predominantly of the Eastern Pacific (EP) type to being predominantly of the Central Pacific (CP) type and has become more biennial. The sequence of the physical processes that involved in this interaction will be presented.

We will also show evidence that during this same time period unusually prolonged North Pacific heatwaves (i.e., Pacific warm blobs) have a tendency to occur together with prolonged North Atlantic cold spells (i.e., Atlantic cold blobs). These synchronized extreme events are accompanied by a Tropical Northern Hemisphere (TNH) pattern in the atmosphere, which exhibits an interesting cross-basin structure. We will discuss how the TNH can serve as an atmospheric conducting pattern to induce co-variability in the North Pacific-Atlantic sector and why it has occurred more often recently.

Links between CMIP5 model diversity in Antarctic amplification, sea ice, and projected 21st century change in the southern hemisphere eddy-driven mid-latitude westerly jet

Abstract ID : 303

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Thomas Bracegirdle ,tjbra@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - British Antarctic Survey

Climate models simulate a robust poleward shift and strengthening of the main eddy-driven belt of Southern Hemisphere (SH) mid-latitude near-surface westerly winds (the westerly jet) under future scenarios of increased greenhouse gas concentrations. However, there is a large uncertainty over the magnitude of such changes across different climate models, which has global implications in terms the rate of uptake of heat and CO2 in the Southern Ocean, Antarctic surface mass balance, and ocean circulation. Recent research into reducing multi-model uncertainty in projections of 21st century Antarctic amplification has shown promise and it is therefore important determine implications for projections of the westerly jet.

Here it is shown that in the CMIP5 climate models, 61% of the variance in projected 21st century change in annual mean westerly jet strength is related to model diversity in Antarctic amplification (based on output from RCP8.5 scenario simulations). However the link to jet shift is much weaker with only 18% of the variance in projections related to diversity in Antarctic amplification. Possible explanations for this and broader implications will be discussed. In particular, the importance of ice-ocean-atmosphere interactions is highlighted by strong links to sea ice area, which is a major feature of Antarctic amplification. It is found that approximately 45% of the CMIP5 variance in projected future change in jet strength is related to historical (present-day) climatological sea ice area. Historical sea ice area is an observable quantity, therefore the potential for observational constraints on projections of future change in the westerly jet will be discussed.

Coupled SST-windstress interactions in climate models and assessment using new observations

Abstract ID : 346

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Malcolm Roberts ,malcolm.roberts@metoffice.gov.uk ,(Manager, Global high resolution climate modelling) ,United Kingdom ,Exeter ,Presenting[1]

Mr Helene Hewitt ,helene.hewitt@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - Met Office Hadley Centre 2 - Met Office

The exchange of fluxes of heat, moisture and energy between atmosphere and ocean are key drivers for the climate system, and as such our coupled climate models need to have a realistic representation of the processes involved. It has been shown that the co-variability of, for example, sea surface temperature and windstress, can indicate whether the ocean or the atmosphere are driving climate variability in different geographical regions - if the former, then there may be improved scope for predictability too.

As part of the CMIP6 HighResMIP protocol used within the European H2020-PRIMAVERA project, multi-model coupled climate simulations are being performed with ocean resolutions ranging from 1°, through the "eddy-poor" regime around 1/4° and up to "eddy-rich" 1/12°. Using the same ocean initial conditions and forcing protocol, and with minimal differences between the model configurations, we aim to discover what horizontal resolution is adequate to represent key processes that impact on the simulated climate mean state and variability.

The assessment of the modelled co-variability of SST and windstress will be compared to that derived from observational datasets, including the new high resolution SST dataset from the ESA CCI project at around 1/20° resolution, which it is hoped will better sample the surface properties by using an improved algorithm for cloud detection. Other SST datasets, and a variety of windstress datasets, will be used to determine the "uncertainty" range from observations/reanalyses, and test whether the modelled response coincides with this in any oceanic region.

Characterizing Pacific Ocean Regime Shifts

Abstract ID : 403

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Matt Newman ,matt.newman@noaa.gov ,(Senior Research Scientist) ,United States ,Boulder ,Presenting[1]

Dr. Sanjiv Kumar ,sanjiv.kumar@noaa.gov ,(None) ,United States , ,Not Presenting[2]

1 - University of Colorado/CIRES and NOAA/ESRL/PSD 2 - Auburn University

The Pacific Decadal Oscillation (PDO), the dominant year-round pattern of monthly North Pacific sea surface temperature (SST) variability, and the related basin-wide Interdecadal Pacific Oscillation (IPO), undergoes relatively rapid changes in phase every few decades or so. Such "regime shifts", which have been related to many regional and global climate impacts including variations in the global mean temperature and the recent warming hiatus, are often thought to represent sudden nonlinear changes between relatively stable climate states. We suggest instead that these regime shifts could result from a linear superposition of different key Pacific physical processes, which operate on different timescales to drive similar PDO/IPO-like SST anomaly patterns. The combination of these processes can be represented by a low-order multivariate autoregressive model (multivariate Ornstein-Uhlenbeck process) known as a linear inverse model (LIM), empirically determined from the zero- and one-season lag covariance of observed seasonal Pacific SST anomalies. In the LIM, variations in the superposition of randomly forced processes alone can result in both Pacific regime shifts and a PDO power spectrum resembling $1/f$ noise. Key aspects of observed Pacific regime shifts since 1890, including the dominant pattern, its amplitude, and the probability distribution of regime durations (time intervals between phase changes) can all be reproduced by this simple LIM. Moreover, the LIM captures details of Pacific regime shifts significantly better than do all the CMIP5 coupled GCM simulations of the 20th century, perhaps because Pacific variability simulated by these models is often based on a different balance of processes than in nature. This is illustrated by a LIM constructed from one historical run of the NCAR CESM (one of the CMIP5 models), which is also able to reproduce the regime shift behavior found within a 40-member ensemble of the same model even as its regime behavior exhibits typically larger amplitudes and shorter durations than observations.

Eastward propagation of decadal temperature variability in the South Atlantic and Indian Oceans

Abstract ID : 412

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yushi Morioka ,morioka@jamstec.go.jp ,(Scientist) ,Japan ,Yokohama ,Not Presenting[1]

Dr. Bunmei Taguchi ,bunmei@atmos.rcast.u-tokyo.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Francois Engelbrecht ,FEngelbrecht@csir.co.za ,(None) ,South Africa , ,Not Presenting[3]

Dr. Swadhin Behera ,behera@jamstec.go.jp ,(None) ,India , ,Not Presenting[1]

1 - JAMSTEC/APL 2 - The University of Tokyo, RCAST 3 - CSIR/NRE 4 - JAMSTEC/APL

Decadal climate variability over southern Africa has a strong relation with decadal temperature variability in the southwest Indian Ocean (SWIO) through modulation of the overlying atmosphere. On decadal timescale, warm sea surface temperature (SST) anomalies in the SWIO region are associated with high sea level pressure (SLP) anomalies above, and this contributes to rainfall increase over southern Africa through enhancing moisture transport. Observation during the satellite period (1982-2015) shows that both SST and SLP anomalies originate in the South Atlantic and slowly propagate eastward to the southern Indian Ocean along the Antarctic Circumpolar Current (ACC). Although a role of the South Atlantic SST anomalies in the eastward propagation is discussed in previous modeling studies, origin and structure of eastward-propagating decadal temperature variability in the South Atlantic and Indian Oceans remain unclear. To investigate physical mechanisms behind the eastward propagation of decadal temperature anomalies, we performed 300-yr integration of a coupled general circulation model, called SINTEX-F2. The SINTEX-F2 model reasonably simulates the observed eastward propagation of decadal SST as well as SLP anomalies along the ACC. In particular, the decadal temperature anomalies in the SWIO region show strong association with underneath density anomalies. Since the density anomalies propagate at the speed of a few cm s^{-1}, slower than the speed of the ACC, and exhibit a surface-intensified barotropic structure, the eastward propagation of density anomalies is attributed to quasi-stationary oceanic Rossby waves. The density anomalies are also accompanied with the anomalous Ekman pumping, indicating an important contribution from the overlying atmospheric variability. The role of atmospheric variability is further evaluated by mixed-layer temperature balance, showing that both net surface heat flux and entrainment anomalies contribute to the warm temperature anomalies in the South Atlantic. These modeling results, therefore, suggest that the atmospheric variability in the South Atlantic plays an important role in generating eastward propagation of decadal temperature signal through the ocean mixed-layer variations.

Bidirectional connections between ENSO and stratospheric variability

Abstract ID : 517

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Chaim Garfinkel ,chaim.garfinkel@mail.huji.ac.il ,(None) ,Israel , ,Not Presenting[1]

1 - Hebrew University of Jerusalem

A long list of studies have shown that ENSO can modulate stratospheric variability and temperatures. During an El Nino event, anomalous upward propagation and dissipation of waves from a variety of sources within the troposphere leads to a warmer polar stratosphere and a cooler tropical lower stratosphere. The nature of this tropical lower stratospheric cooling is clarified in a series of simulations using the NASA Goddard Earth Observing System Chemistry-Climate Model, where we show that the impact of El Nino-Southern Oscillation in this region is nonlinear. While moderate El Nino events lead to cooling in this region, strong El Nino events appear to lead to warming, even as the response of the large scale Brewer Dobson Circulation appears to scale nearly linearly with ENSO. The tropospheric warming associated with strong El Nino events extends into the tropical tropopause layer and up to the cold point and is responsible for the nonlinearity. This enhanced warming has implications for stratospheric water vapor.

Recent work has also suggested that stratospheric ozone variability can enhance predictability of El Nino events. Specifically, polar stratospheric ozone variability appears to impact sea level pressure variability in the North Pacific sector, where it then activates the seasonal fingerprinting mechanism. The potential for ENSO predictability exceeds 20 months. Results from a coupled ocean-atmosphere model with stratospheric chemistry will be used to clarify the downward connection between polar stratospheric ozone and ENSO.

Submesoscale air-sea coupling over the California Upwelling System

Abstract ID : 598

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Lionel Renault ,lrenault@ucla.edu ,(Researcher) ,United States ,Los Angeles ,Not Presenting[1]

Prof. James C. McWilliams ,jcm@ucla.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Sebastien Masson ,smasson@atmos.ucla.edu ,(None) ,United States , ,Not Presenting[2]

1 - None 2 - UCLA 3 - UCLA

Oceanic submesoscale currents (SMCs) occur on an intermediate scale on the order of 0.1-10 km horizontally, i.e., just smaller than the mesoscale currents which are well known as the dominant reservoir of kinetic energy in the ocean. SMCs, can be a major conduit to energy dissipation and, by inducing large vertical velocities, lead to important material eddy fluxes. SMCs can have an important influence on the ecosystem by modulating the ocean productivity and the ocean ventilation.
Ocean thermal feedback to the atmosphere are known, at mesoscale, to influence the wind up to the troposphere. Recent studies show the current feedback to the atmosphere, can drastically dampens the mesoscale activity (by 42% for the US West Coast, and 27% for the Gulf Stream), by inducing surface stress anomalies and causing large sink of energy from the ocean to the atmosphere. Is also have an influence on the wind that partly counteract the surface stress response. However, air-sea interactions at submesoscale are not well known because of the size of SMCs presents an observational barrier.
In this presentation, using uncoupled and coupled ocean-atmosphere simulations, we will address to what extent the ocean-atmosphere coupling at submesoscale (both SST and current feedback) can affect the atmosphere and the oceanic submesoscale activity.

Pacific contribution to the early 20th century warming in the Arctic

Abstract ID : 647

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Lea Svendsen ,lea.svendsen@uib.no ,(Postdoctoral Fellow) ,Norway ,Bergen ,Presenting[1]

Prof. Noel Keenlyside ,noel.keenlyside@uib.no ,(None) ,Norway ,None ,Presenting[1]

Dr. Ingo Bethke ,ingo.bethke@uni.no ,(None) ,Norway , ,Not Presenting[3]

Dr. Yongqi Gao ,yongqi.gao@nersc.no ,(None) ,Norway , ,Not Presenting[4]

1 - Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research 2 - Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research 3 - Uni Research and Bjerknes Centre for Climate Research 4 - Nansen Environmental and Remote Sensing Center and Bjerknes Centre for Climate Research

Instrumental records show that there were two periods of enhanced global warming during the 20th century, the early warming from 1910-1940 and a later period from the end of the 1970s. There is evidence that both these warming periods were more pronounced in the Arctic. However, state-of-the-art coupled models do not reproduce the full extent of the early 20th century warming in the Arctic, and the understanding of what lead to this enhanced warming is not fully understood. Since decadal variability in the Pacific has been linked to 'hiatuses' and accelerated warming trends in global temperatures, we hypothesize that the Pacific could also impact temperature trends in the Artic. To investigate this, we have performed two 6-member ensembles of historical all-forcing 20th century simulations with the Norwegian Earth System Model (NorESM). The experiment consists of one fully coupled ensemble and one ensemble where daily momentum flux anomalies from the 20th century reanalysis are prescribed over the Indo-Pacific Ocean. With this method, we are able to constrain sea surface temperature variability to observations in the Pacific. El Niño events are reproduced as well at the phasing of the Pacific Decadal Oscillation, and we are able to reproduce the early 20th century warming in the Arctic. Our results show that the early 20th century warming in the Arctic could have been due to a combination of external forcing and a warming of the North Pacific. These results have implications for our understanding of the present Arctic Amplification and future climate variations in the Arctic.

The effect of the 18.6 year lunar nodal cycle on decadal temperature trends

Abstract ID : 661

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Manoj Joshi ,m.joshi@uea.ac.uk ,(Senior Lecturer) ,United Kingdom ,Norwich ,Presenting[1]

Dr. Rob Hall ,robert.hall@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Ed Hawkins ,e.hawkins@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Prof. David Stevens ,D.Stevens@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of East Anglia 2 - University of East Anglia 3 - University of Reading 4 - University of East Anglia

The lunar nodal cycle is an oscillation in tidal amplitude with an 18.6 year period, and is associated with slight changes in the orbit of the Moon around the Earth. Its effects on the circulation and state of the ocean can be parameterised in global circulation models by a small oscillatory component added to the background diffusion term that represents tides and other small-scale oscillations. To date, research using both ocean and coupled ocean-atmosphere models has shown that the lunar nodal cycle can have an effect on large scale modes of variability such as the Pacific-Decadal-Oscillation (PDO). Here we show that the lunar nodal cycle can have a small, but measurable, effect on global temperature trends in the context of warming planet; indeed, given the actual phase of the cycle, we suggest that it may have played a role in reducing temperature trends in the 1st decade of this century, and may also act to slightly accelerate temperature trends at other times. The effect of the lunar nodal cycle on sea surface temperatures (SST) is globally non-uniform for two reasons: first- tidal strength can vary geographically; second- the modulation of vertical mixing by the nodal cycle will warm or cool SSTs by an amount which depends on thermocline stability, and hence location. The nonuniformity may also help to explain observed geographical variations in warming trends.

A nonlinear approach to investigate ocean–atmosphere coupling in real datasets

Abstract ID : 665

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Stephane Vannitsem ,svn@meteo.be ,(None) ,Belgium , ,Not Presenting[1]

Dr. Jonathan Demaeyer ,jodemaey@meteo.be ,(Post-doctoral fellow) ,Belgium ,Brussels ,Presenting[1]

Prof. Michael Ghil ,ghil@atmos.ucla.edu ,(None) ,United States , ,Not Presenting[3]

1 - Royal Meteorological Institute of Belgium 2 - Royal Meteorological Institute of Belgium 3 - École Normale Supérieure, PSL Research University and University of California

In recent years, evidence of, relatively weak, coupling between the ocean and the atmosphere at midlatitudes has emerged in the context of ocean-atmosphere models of various levels of detail and in datasets. In the latter case, methods based on linear correlations or unidirectional causality, e.g. Granger causality, have been used. In the present work, we propose a nonlinear test to clarify the two-way coupling in real datasets. This test is based on the projection of the oceanic and atmospheric fields onto a dynamically defined subspace that allows one to isolate the dominant modes of variability of the coupled system (Vannitsem et al., 2015) and, furthermore, to investigate the predictability properties of the coupled system using the nonlinear forecasting approach of Sugihara and May (1990).

The proposed approach is first illustrated in the context of a simple low-order coupled ocean-atmosphere model for which the coupling between the two components is well controlled. Next, this approach is applied to reanalysis datasets from the European Centre for Medium-range Weather forecasts (Vannitsem and Ghil, 2017). Finally, we discuss the ability of this approach to yield information on the strength and the nature of the coupling.

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Responses of Regional Atmospheric Circulation and Rainfall variability over Southern Africa to Mesoscale Dynamics of the Angola-Benguela Frontal Zone

Abstract ID : 702

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Fabien Desbiolles ,fabien.desbiolles@uct.ac.za ,(None) ,South Africa , ,Not Presenting[1]

Dr. Ross Blamey ,ross.blamey@uct.ac.za ,(PDRF) ,South Africa ,Cape Town ,Not Presenting[1]

Prof. Chris Reason ,chris.reason@uct.ac.za ,(None) ,South Africa , ,Not Presenting[1]

Dr. Serena Illig ,serena.illig@gmail.com ,(None) ,South Africa , ,Not Presenting[4]

Mr. Callum Munday ,callum.munday@seh.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[5]

Dr. Lionel Renault ,lrenault@atmos.ucla.edu ,(None) ,United States ,None ,Not Presenting[6]

1 - University of Cape Town 2 - University of Cape Town 3 - University of Cape Town 4 - Department of Oceanography, MARE Institute, University of Cape Town, South Africa/Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS), Université de Toulouse, CNES, CNRS, IRD, UPS, Toulouse, France; part of the International Mixed Laboratory ICEMASA. 5 - University of Oxford 6 - University of California Los Angeles

Due to its location in the subtropics, southern Africa's climate is affected by atmospheric systems positioned in both tropics and temperate latitudes. Thus, the regional climate variability is complex and driven by several processes combining global, local, temperate and tropical systems. One of the main influences on the rainfall variability in southern Africa is the Angola low pressure system (AL), a cyclonic feature which forms during the austral summer (December-February) over the Angola / Namibia border. The AL is an important feature for tropical-extra-tropical interactions and the development of cloudbands (a key rainfall producer) over southern Africa. The main processes which affect the strength and position of the AL and its moisture supply are still poorly understood. Previous research has indicated that sea surface temperature (SST) patterns in the neighbouring Atlantic and Indian Oceans influence southern African climate. In particular, the Angola-Benguela frontal zone (ABFZ) has been identified as a key region for southern African climate variability. The ABFZ exhibits strong sub-seasonal variability, with important mesoscale SST structures.

Experiments using a regional atmospheric model (WRF) at 18km horizontal resolution have been conducted to understand and quantify the role of mesoscale variability in SSTs have on the regional low-level moisture flux into the AL system. Four numerical experiments have been performed with exactly the same physical parameterizations. The experiments only differ from each other in the SST boundary conditions applied. All the ocean forcing fields have been built from the OSTIA daily product. The first experiment uses the original SST field as the forcing for the entire domain, while the

second uses a smoothed SST field (performed with a spectral filter). In the final two experiments, the SST field within the ABFZ and that used for the rest of the domain are opposite, in that one is smoothed and the other original (and vice versa). This work shows the importance of oceanic mesoscale variability on local wind speed, air-sea fluxes and on the regional atmospheric circulation. The impact of the modified air-sea fluxes on the moisture supply to the AL system and the resulting effect on regional rainfall.

Estimating North Atlantic Ocean heat budget and its variability from VOS observations

Abstract ID : 738

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sergey Gulev ,gul@sail.msk.ru ,(None) ,Russia , ,Not Presenting[1]

Ms. Marina Alexandrova ,marina@sail.msk.ru ,(None) ,Russia , ,Not Presenting[2]

Dr. Konstantin Belyaev ,kb@sail.msk.ru ,(None) ,Russia , ,Not Presenting[2]

Prof. Mojib Latif ,mlatif@geomar.de ,(Professor) ,Germany ,Kiel ,Not Presenting[4]

1 - Russian Academy of Sciences, Shirshov Institute of Oceanology 2 - IORAS 3 - IORAS 4 - GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel

We consider here the potential of Voluntary Observing Ship (VOS) observations available form the ICOADS for estimating ocean surface heat budget at different time scales. VOS provide the longest coverage of the World Ocean by in-situ meteorological observations in time going back to the mid 19th century. However, being collected primarily along the major ship-routes, VOS observations have poor sampling density, especially for the period prior WW2. In order to minimize sampling impact on the means and variability patterns derived from VOS-based surface fluxes, we propose a concept suggesting integration of the turbulent heat fluxes in the coordinates of steering parameters (vertical surface temperature and humidity gradients on one hand and wind speed on the other) for which theoretical probability distributions are known being Weibull distribution for the wind speed and Modified Fisher-Tippet distribution for surface temperature and humidity gradients. For short-wave radiative fluxes sampling uncertainties were minimized by "rotating local observation time around the clock" and using probability density functions for the cloud cover occurrence distributions. This approach allows for the switch from flux integration over the geography domain to the integration in the parameter space and, thus, obtaining less biased and more robust large-scale estimates. Turbulent fluxes were derived using COARE-3 algorithm and for computation of radiative fluxes new algorithms accounting for cloud types were used. Analysis was performed for the North Atlantic latitudinal band from 25 N to 60 N, for which also estimates of the meridional heat transport are available from the ocean cross-sections. Over the last 35 years turbulent fluxes within the region analysed increase by about 6 W/m2 with the major growth during the 1990s and early 2000s. Decreasing incoming short wave radiation during the same time (about 1 W/m2) implies upward change of the ocean surface heat loss by about 7-8 W/m2. We discuss different sources of uncertainties of computations as well as potential of the application of the analysis concept to longer time series going back to 1920s. Further interdecadal variability of surface budget is discussed in the context of the North Atlantic multidecadal variations.

Impacts of midlatitude oceanic fronts on the mean state and variability of the extratropical atmosphere

Abstract ID : 858

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Hisashi Nakamura ,hisashi@atmos.rcast.u-tokyo.ac.jp ,(Professor) ,Japan ,Tokyo ,Not Presenting[1]

1 - University of Tokyo

Unlike in vast areas of midlatitude ocean basins, warm western boundary currents and the associated oceanic frontal zones, including the Kuroshio-Oyashio Extension, can potentially influence the overlying atmosphere. As revealed in state-of-the-art atmospheric reanalysis and AGCM experiments, effective moisture supply to individual cyclones and efficient restoration of near-surface atmospheric baroclinicity in the frontal zones allow recurrent development of cyclones, leading to the formation of storm tracks and associated eddy-driven westerlies. Both diabatic and adiabatic processes are important in forcing vertical motions around the frontal zones, acting to modify surface pressure and wind fields. Furthermore, anomalous behavior of the frontal zones and associated SST anomalies can force atmospheric anomalies. As suggested by idealized AGCM experiments, for example, the Southern Annular Mode, especially its positive phase, can be sensitive to the oceanic front latitude. In addition, decadal displacement of the Kuroshio-Oyashio Extension can also force persistent atmospheric anomalies, especially in the cold season, yielding the potential for additional predictability.

Projected sea surface temperatures over the 21st century: changes in the mean, variability and extremes

Abstract ID : 986

Conflict Declaration : None

Content Motivation : Invited talk

Additional Information : None

Mr. Michael Alexander ,Michael.Alexander@noaa.gov ,(Meteorologist) ,United States ,Boulder ,Not Presenting[1]

Mr. James Scott ,james.d.scott@noaa.gov ,(None) ,United States , ,Not Presenting[2]

1 - NOAA/Earth System Research Laboratory 2 - NOAA/ESRL and CIRES/University of Colorado

Regional oceanic changes due to increasing greenhouse gasses are shaped by atmospheric, oceanic and ice processes and interaction between these systems. Here, climate models are used to assess changes in the mean, variability and extreme sea surface temperatures (SSTs) over the global oceans with a focus on large marine ecosystems (LMEs) adjacent to North America, Europe, and the Arctic Ocean. Results were obtained from 26 models in the Community Model Intercomparison Project Phase 5 (CMIP5) archive and 30 simulations from the National Center for Atmospheric Research large ensemble (CESM-LENS). All of the simulations used the observed greenhouse gas concentrations for 1976-2005 and the RCP8.5 "business as usual" scenario for greenhouse gasses through the remainder of the 21st century. In general, differences between models are substantially larger than among the simulations in the CESM-LENS, indicating that the SST changes are more strongly affected by model formulation than internal climate variability.

The annual SST trends over 1976-2099 in the 18 LMEs examined here are all positive ranging from 0.05 to 0.5°C decade^{-1}. SST changes by the end of the 21st century are primarily due to a positive shift in the mean with only modest changes in the variability in most LMEs, resulting in a substantial increase in warm extremes and decrease in cold extremes. The shift in the mean is so large that in many regions SSTs during 2070-2099 will *always* be warmer than the *warmest year* during 1976-2005. The SST trends are generally stronger in summer than in winter, as greenhouse gas heating is integrated over a much shallower climatological mixed layer depth in summer than in winter, which amplifies the seasonal cycle of SST over the 21st century. In the Arctic, the mean SST and its variability increases substantially during summer, when it is ice free, but not during winter when a thin layer of ice reforms and SSTs remain near the freezing point. The SST variabiity also change in parts of the North Atlantic and the atmospheric and oceanic processes that may be responsible for these change will be discussed.

Air-Sea Interaction Regimes and their Synoptic and Climatological Interpretation

Abstract ID : 1087

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Thomas Spengler ,thomas.spengler@uib.no ,(None) ,Norway ,None ,Not Presenting[1]

1 - University of Bergen

Interactions between the atmosphere and ocean play a significant role in the climate system through their exchange of energy and momentum. While the total exchange is most crucial for climatological investigations focusing on the balance between these two climate components, it is still somewhat unclear what kind of processes contribute most to these totals. Furthermore, mean fluxes are often interpreted by mean wind and mean oceanic and atmospheric states, though the actual flux accumulation is most often associated with short-lived synoptic or even mesoscale weather events.
In this study, we investigate the fluxes based on ERA-Interim data, where we aggregate the fluxes in different regimes separated by varying time means. For example, the 6-hourly fluxes are aggregated into the total flux, where the information about the actual wind direction and intensity as well as the weather regime are recorded. The same analysis is done for daily, weekly, monthly, and seasonal mean fluxes. It is shown that the physical interpretation of the accumulated fluxes changes depending on the chosen time regime. The differences lead to different interpretations with respect to the cause of the fluxes, which will be discussed and scrutinized based on their physical meaning.

The roles heat flux in equatorial—extratropical South Atlantic air-sea interactions

Abstract ID : 1163

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Hyacinth Nnamchi ,hyacinth.nnamchi@unn.edu.ng ,(Lecturer) ,Nigeria ,Nsukka ,Not Presenting[1]

Prof. Noel Keenlyside ,noel.keenlyside@gfi.uib.no ,(None) ,Norway ,None ,Not Presenting[2]

Prof. Fred Kucharski ,kucharsk@ictp.it ,(None) ,Italy ,None ,Not Presenting[3]

Mr. Jianping Li ,ljp@bnu.edu.cn ,(Prof. Jianping Li GCESS, Beijing Normal University) ,China ,Beijing ,Not Presenting[4]

Prof. Ping Chang ,ping@tamu.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Riccardo Farneti ,rfarneti@ictp.it ,(None) ,Italy , ,Not Presenting[3]

Prof. In-Sik Kang ,insik.kang1@gmail.com ,(None) ,South Korea , ,Not Presenting[7]

1 - 2 - Geophysical Institute, University of Bergen, Norway 3 - The Abdus Salam International Centre for Theoretical Physics 4 - Beijing Normal University 5 - Texas A&M University 6 - The Abdus Salam International Centre for Theoretical Physics 7 - Seoul National University

Dominant patterns of equatorial and South Atlantic Ocean (SAO) interannual sea surface temperature (SST) anomalies have previously been described, viz: the equatorial Atlantic Niño, the SAO dipole (SAOD) and the South Atlantic subtropical dipole (SASD). However, it remains unclear how these patterns are connected. We will present observational and numerical modelling results to show that the Atlantic Niño, SASD and SAOD may largely represent one mode of ocean-atmosphere interactions reminiscent of the SAOD structure peaking during the austral winter. We will further discuss heat budget calculations and atmospheric anomalies suggesting that the interannual SST anomalies are primarily driven by heat flux anomalies related to perturbations in the strength of St. Helena subtropical anticyclone. In this framework, the southern extratropics plays important roles in equatorial Atlantic interannual variability.

Interactions between Oceanic variability and Storm tracks in the midlatitudes

Abstract ID : 1218

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Lixin Wu ,lxwu@ouc.edu.cn ,(None) ,China , ,Presenting[1]

Dr. Bolan Gan ,gbl0203@ouc.edu.cn ,(Scientist) ,China ,Qingdao ,Not Presenting[2]

1 - Ocean University of China/Qingdao National Laboratory for Marine Science and Technology 2 - Ocean University of China/ Qingdao National Laboratory for Marine Science and Technology

Storm tracks, characterized by intense activities of synoptic-scale transient eddies prevalent in the midlatitudes aloft, play a critical role in the climate system. Previous studies have revealed the importance of oceanic fronts associated with strong sea surface temperature (SST) gradients on the climatological structure of storm tracks. However, the coupling relationship between ocean and storm-track variations remains unclear. On the basis of reanalysis datasets and statistical assessment, we identified two-way interactions between changes in storm-track activity and SST in the midlatitude North Pacific, North Atlantic, and Southern Hemisphere Oceans, respectively. Results show a strong (sub)seasonal dependence of the coupling, which is characterized by the most prominent one in the boreal early winter (December) for the North Pacific, the boreal early spring (March) for the North Atlantic, and the austral mid-summer (January) for the Southern Hemisphere, respectively. In all cases, influences of SST anomalies on storm tracks can be detected three months ago. At a longer lead time, the wintertime-mean storm-track anomalies over the North Pacific and North Atlantic are found to be associated with decadal SST anomalies in the Kuroshio-Oyashio Extension and Gulf Stream Extension in the preceding three years and one year, respectively. Meanwhile, a positive feedback between the wintertime-mean SST and storm-track anomalies may enhance the decadal climate variability in the North Pacific and North Atlantic.

Intrinsic interannual variability in the western boundary currents

Abstract ID : 1243

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Masami Nonaka ,nona@jamstec.go.jp ,(None) ,Japan ,Yokohama ,Presenting[1]

Dr. Hideharu Sasaki ,sasaki@jamstec.go.jp ,(None) ,Japan , ,Not Presenting[1]

Dr. Niklas Schneider ,nschneid@hawaii.edu ,(Professor) ,United States ,Honolulu ,Not Presenting[3]

1 - JAMSTEC 2 - JAMSTEC 3 - University of Hawaii

Evidences for possible ocean-to-atmosphere influences through oceanic frontal zones associated with the western boundary currents have been accumulated. This suggests importance of understanding dynamics of interannual to decadal variability in the western boundary currents to deepen our knowledge about climate variability in midlatitudes. In the western boundary regions, it has been known that oceanic internal dynamics can induce interannual intrinsic variability under atmospheric forcing without interannual variability. In the present study, to investigate intrinsic interannual variability in the western boundary currents under realistic interannually varying forcing, we have conducted eddy-resolving quasi-global OGCM ensemble experiments for 25 years. Five ensemble members with slightly different initial conditions show substantial spread in their interannual variability under the identical atmospheric reanalysis fields. Even on interannual time scale, intrinsic variability (and thus uncertainty) is similar to or larger than the wind-driven variability in the western boundary current regions. Also, it is found that in the Kuroshio Extension region, part of interannual variability in eddy activity can be wind-driven and propagates westward associated with current speed anomalies.

Weakening of the tropical atmospheric circulation response to local sea surface temperature anomalies under global warming

Abstract ID : 1276

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ping Huang ,huangping@mail.iap.ac.cn ,(None) ,China ,Beijing ,Not Presenting[1]

1 - IAP, CAS

In the tropics, the atmospheric circulation response to sea surface temperature (SST) anomalies is a crucial part of the tropical coupled air-sea interaction-the primary process of tropical climate. How it will change under global warming is of great importance to tropical climate change. Here, we show that the atmospheric vertical circulation response to local SST anomalies will likely be weakened under global warming using 28 selected Coupled Model Intercomparison Project Phase 5 models. The weakening of the circulation response to SST anomalies is closely tied to the increased atmospheric stability under global warming, which increases at the same rate as the circulation response decreases-around 8% for 1 K tropical-mean SST warming. The spatial pattern of background warming can modify-mainly in the equatorial central-eastern Pacific-the spatial distribution of the changes in the circulation response. The atmospheric response to SST anomalies may increase where the local background warming is pronouncedly greater than the tropical mean. The general weakening of the atmospheric circulation response to SST anomalies leads to a decreased circulation response to the structured variability of tropical SST anomalies, such as the El Niño-Southern Oscillation and the Indian Ocean dipole. The decreased circulation response will offset some of the enhancement of the tropical rainfall response to these SST modes as a result of global warming-induced moisture increase, and also implies a decreased amplitude of the tropical air-sea interaction modes.

Dynamics of the wind stress response to ocean mesoscale surface temperatures

Abstract ID : 1305

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Niklas Schneider ,nschneid@hawaii.edu ,(Professor) ,United States ,Honolulu ,Not Presenting[1]

Dr. Bunmei Taguchi ,bunmei@atmos.rcast.u-tokyo.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Masami Nonaka ,nona@jamstec.go.jp ,(None) ,Japan ,Yokohama ,Not Presenting[3]

Dr. Akira Kuwano-Yoshida ,akiray@jamstec.go.jp ,(None) ,Japan , ,Not Presenting[3]

Dr. Hisashi Nakamura ,hisashi@atmos.rcast.u-tokyo.ac.jp ,(Professor) ,Japan ,Tokyo ,Not Presenting[5]

1 - University of Hawaii 2 - The University of Tokyo, RCAST 3 - JAMSTEC 4 - JAMSTEC 5 - University of Tokyo

The response of the surface wind--stress to sea surface temperatures associated with the ocean mesoscale is typically characterized by regressions, or coupling coefficients, between wind stress divergence and curl, and gradients of sea surface temperature aligned and across the large scale surface winds, respectively. Here, the underlying dynamics of the response are deconstructed using output from an 19 year integration of an atmospheric general circulation model forced by observed, high resolution sea surface temperatures. Linearization of the wind stress around the large-scale winds reveals that 80% and 100% of coupling coefficients for the sea surface temperature induced wind stress divergence and curl, respectively, are due to stability dependence of the wind stress. SST induced changes in surface wind speed account for 20% of the wind stress divergence coupling coefficients. Changes of wind direction do not affect wind-stress coupling coefficients.
Surface wind responses are poorly described by coupling coefficients. Instead, spectral transfer functions describe the in-phase and phase-shifted surface wind response to ocean mesocale sea surface temperatures as a function of spatial scale, and background wind direction and speed. A linear theory explains these spectral transfer functions by distinct physical regimes of the wind responses in the directions aligned and across background winds, and by scale-dependent magnitude of sea surface temperature induced vertical mixing and hydrostatic pressure gradients.

Ocean atmosphere interactions on different scales as simulated with AWI-CM

Abstract ID : 1393

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Dmitry Sein ,Dmitry.Sein@awi.de ,(None) ,Germany , ,Presenting[1]

Dr. Dmitry Sidorenko ,dmitry.sidorenko@awi.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Tido Semmler ,tido.semmler@awi.de ,(None) ,Germany , ,Not Presenting[3]

Dr. Thomas Rackow ,thomas.rackow@awi.de ,(None) ,Germany , ,Not Presenting[3]

Dr. Sergey Danilov ,Sergey.Danilov@awi.de ,(None) ,Germany , ,Not Presenting[2]

Prof. Thomas Jung ,thomas.jung@awi.de ,(None) ,Germany , ,Not Presenting[2]

1 - Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research 2 - Alfred Wegener Institute for Polar and Marine Research 3 - AWI 4 - AWI 5 - Alfred Wegener Institute for Polar and Marine Research 6 - Alfred Wegener Institute for Polar and Marine Research

The ocean component of AWI-CM (FESOM) uses unstructured meshes, which allows the use of variable resolutions without traditional nesting. Due to the flexibility of unstructured meshes, one needs to carefully design meshes so that the variable resolution can most efficiently improve the simulated results with the least possible computational cost. We use the satellite-observed sea surface height variability to determine the regions where high resolution should be assigned. The ocean atmosphere interactions on different scales are analyzed by running two different FESOM ocean setups (LR and HR) coupled with the to different ECHAM6 atmospheric setups T127 and T63. LR (low resolution) employs a coarse mesh with nominal resolution of about 100 km in the global ocean, about 25 km north of 50N, about 35 km in the equatorial band, and moderate refinement along the coasts. HR (high resolution) uses a locally eddy-resolving mesh. Its design relies on the AVISO satellite altimetry product. The coarsest resolution on this mesh is set to ~60 km, and the finest resolution is ~10 km. The refinement was determined by a low-pass filtered SSH variance (SSHV) pattern derived from the AVISO data. Fine resolution is obtained in regions with high SSHV. The HR mesh contains about 1.3 million surface grid nodes. This mesh size ensures reasonably fast simulations with available computational resources. The AWI-CM simulations with the two global ocean and atmosphere setups (4 simulations totally, i.e. LR/T63, LR/T127, HR/T63, HR/T127) were carried out according to the HighResMIP protocol for the 1950-2100 (RCP8.5 scenario). The results clearly demonstrate the added value of HR/T127 simulations for both the ocean and atmospheric climate in comparison with LR/T63. Biases are strongly reduced almost over the entire globe. The most remarkable reduction in 2m temperature can be seen in the equatorial Pacific, in the Kuroshio current region, and over Southeast Asia. We analyze the ocean atmosphere interactions in the

regions of significant differences between LR/T63 and HR/T127 in the sense of importance of ocean and atmospheric models resolution in reduction of the AWI-CM biases as well as its in the climate change signal.

The impact of Northern Hemisphere western boundary current on the atmospheric large-scale circulation

Abstract ID : 1404

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Nour-Eddine Omrani ,Noureddine.Omrani@uib.no ,(None) ,Norway , ,Not Presenting[1]

Mr. Fumiak Ogawa ,Fumiaki.Ogawa@uib.no ,(None) ,Norway , ,Not Presenting[2]

Dr. Hisashi Nakamura ,hisashi@atmos.rcast.u-tokyo.ac.jp ,(Professor) ,Japan ,Tokyo ,Presenting[3]

Prof. Noel Keenlyside ,noel.keenlyside@uib.no ,(None) ,Norway ,None ,Not Presenting[4]

Mr. Sandro Lubis ,slubis@uchicago.edu ,(None) ,United States , ,Not Presenting[5]

Prof. Katja Matthes ,kmatthes@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[6]

1 - University of Bergen 2 - Geophysical Institute Bjerknes Centre for Climate Research 3 - University of Tokyo 4 - Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research 5 - University of Chicago 6 - GEOMAR Helmholtz Centre for Ocean Research Kiel

In this work we used semi?idealized model-experiments to investigate the role of the Gulfstream and kuroshio current in maintaining the Northern Hemisphere (NH) large-scale atmospheric circulation and its variability including the stratospheric circulation.
It is shown that the combined effect of the Pacific and Atlantic SST-fronts act to maintain the strong tropospheric eddy-driven jet and weaken the polar night jet with response-patterns projecting on the Northern Annular Mode (NAM). These atmospheric responses play an important role for different aspects of the atmospheric circulation. (1) It maintains the annular structure and the strength of the NAM as internal mode of variability (2) It enhances the extratropical poleward atmospheric heat transport both through synoptic eddies, mean state and quasi?stationary eddies, which dampens the Equator-to-pole temperature contrast and milden the extratropical climate in both stratosphere and troposphere. (3) It strengthen the Brewer-Dobson circulation and stratospheric warming, which reduces the potential formation of stratospheric clouds considerably and thus the potential formation of the ozone hole in Northern Hemisphere.

M022 - Sub-seasonal to Seasonal Prediction--except extremes

MJO Prediction and Teleconnections in sub-seasonal forecasts

Abstract ID : 274

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Frederic Vitart ,Frederic.Vitart@ecmwf.int ,(Principal Scientist) ,United Kingdom ,Reading ,Not Presenting[1]

1 - ECMWF

The Madden Julian Oscillation (MJO) is the dominant intra-seasonal mode of organized convective activity in the Tropics,
with also a considerable impact in the middle and high latitudes. The skill of sub-seasonal forecasting systems to predict
the MJO has improved significantly over the past decade thanks mostly to changes in the convective parameterization, although most models still have difficulties propagating the MJO across the Maritime continent. The MJO predictive skill and teleconnections in the high latitudes have been diagnosed in 10 operational sub-seasonal prediction models from the WWRP/WCRP Sub-seasonal to Seasonal Prediction (S2S) database. Results suggest that the S2S models display skill to predict the MJO between 2 and 4 weeks, although the majority of S2S models tend to produce a too weak and slow propagating MJO in the extended forecast range. All the S2S models produce MJO extratropical teleconnections which are too weak over the Euro-Atlantic sector, which suggests that they do not fully exploit the predictability associated to the MJO in the Northern Extratropics, particularly over Europe. The impact of model resolution and ocean-atmosphere coupling on
the MJO prediction skill and teleconnections will be discussed.

Iracema F.A. Cavalcanti : The author asked poster presentation

Predictability of East-Atlantic regimes at sub-seasonal range using S2S forecast data

Abstract ID : 334

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Laura Ferranti ,laura.ferranti@ecmwf.int ,(Principal Scientist) ,United Kingdom ,Reading ,Not Presenting[1]

Dr. Linus Magnusson ,L.Magnusson@ecmwf.int ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Frederic Vitart ,Frederic.Vitart@ecmwf.int ,(Principal Scientist) ,United Kingdom ,Reading ,Not Presenting[1]

1 - ECMWF 2 - ECMWF 3 - ECMWF

The ability of S2S forecast systems in predicting the dominant circulation patterns over the Atlantic sector is evaluated. It has been noted since early studies that strong and persistent large scale high pressure systems, such as blocking, affect the surface weather in terms of temperature and precipitation. Their occurrences are often associated with dry-spells, and with heat-waves in summer and cold-spells in winter. For example, it was the anti-cyclonic circulation persisting during August 2003 that brought the hot dry tropical continental air mass over Western Europe. While the winter of 2009/2010 was characterized by record persistence of the negative phase of the North Atlantic Oscillation (NAO) which caused several severe cold spells over Northern and Western Europe. The large spatial scale and the low-frequency nature of such flow patterns are the key attributes for successful predictions at the sub-seasonal time-scale. In fact, circulation patterns like the NAO are often associated with global teleconnections through propagation of Rossby wave trains. Here we explore the ability of the S2S systems to predict the winter circulation patterns that are generally associated with cold spells.

Iracema F.A. Cavalcanti : This presentation confirmed to be otal.

A multi-model ensemble of S2S precipitation forecasts

Abstract ID : 404

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Nicolas Vigaud ,vigaud@iri.columbia.edu ,(ARS) ,United States ,New York ,Presenting[1]

Dr. Andrew Robertson ,awr@iri.columbia.edu ,(None) ,United States , ,Not Presenting[1]

Prof. Michael K. Tippett ,tippett@iri.columbia.edu ,(None) ,United States , ,Not Presenting[1]

1 - IRI 2 - IRI 3 - IRI

Non-linear logistic regression is well suited to probability forecasting and has been successfully applied in the past to ensemble weather and climate predictions, providing access to the full probabilities distribution without any Gaussian assumption. However, little work has been done at sub-monthly lead times where relatively small re-forecast ensembles and lengths represent new challenges for which post-processing avenues have yet to be investigated. A promising approach consists in extending the definition of non-linear logistic regression by including the quantile of the forecast distribution as one of the predictors. So-called Extended Logistic Regression (ELR), which enables mutually consistent individual threshold probabilities, is here applied to ECMWF, CFSv2 and CMA re-forecasts from the S2S database in order to produce rainfall probabilities of weekly and bi-weekly averages. The ELR model is trained on seasonally-varying tercile categories computed for lead times of 1 to 4 weeks. It is then tested in a cross-validated manner, i.e. allowing real-time predictability applications, to produce rainfall tercile probabilities from individual hindcasts that are finally combined by equal pooling. Results will be first discussed over a broader North American region, where individual and MME weekly forecasts are characterized by good probabilistic reliability but low sharpness, exhibiting systematically more skill in winter than summer. Bi-weekly week 3+4 forecasts lead to more skill, as well as when applying spatial smoothing to ELR inputs. Skill relationships to both ENSO and MJO will then be examined to illustrate potential opportunities for skillful predictions.

Frederic Vitart : None

The influence of Quasi-Biennial Oscillation on Madden-Julian Oscillation and its prediction skill in the Subseasonal to Seasonal (S2S) models

Abstract ID : 828

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Yuna Lim ,jennifer125@snu.ac.kr ,(None) ,South Korea ,Seoul ,Not Presenting[1]

Mr. Andrew G. Marshall ,andrew.marshall@bom.gov.au ,(None) ,Australia , ,Not Presenting[2]

Dr. Harry H. Hendon ,H.Hendon@bom.gov.au ,(None) ,Australia ,None ,Not Presenting[2]

Prof. Kyong-Hwan Seo ,khseo@pusan.ac.kr ,(None) ,South Korea , ,Not Presenting[4]

Dr. Seok-Woo Son ,seokwooson@snu.ac.kr ,(Associate Professor) ,South Korea ,Seoul ,Presenting[1]

1 - Seoul National University 2 - Australian Bureau of Meteorology 3 - Australian Bureau of Meteorology 4 - Pusan National University 5 - Seoul National University

The recent study has shown that Madden-Julian Oscillation (MJO) is significantly modulated by the stratospheric Quasi-Biennial Oscillation (QBO). In general, boreal-winter MJO convections over the Indian Ocean and Maritime Continents become stronger during the easterly phase of QBO (EQBO) than the westerly phase (WQBO). In this study, such finding is applied to the latest operational models, which participated in the WCRP/WWRP Subseasonal-to-Seasonal (S2S) prediction project, to examine the stratospheric influence on the MJO prediction skill. On average, S2S models show the MJO prediction skills of 2-5 weeks with a pronounced inter-model spread. More importantly, all models robustly show a higher MJO prediction skill during EQBO than WQBO winters. In terms of bivariate anomaly correlation coefficient of 0.6, the improvement of MJO prediction skill is up to 7 days. This result is consistent with anomalously strong and long persistence of MJO during EQBO winter. But, it is also caused by better organization of MJO during EQBO winter, especially when MJO convections are located around the Indian Ocean and Maritime Continent (MJO phases 2-5). These results indicate that MJO prediction skill is quite sensitive the stratospheric mean state, highlighting the importance of stratospheric data assimilation in the operational S2S models.

Frederic Vitart : None

Mechanisms for a teleconnection pattern in response to the MJO

Abstract ID : 844

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Kyong-Hwan Seo ,khseo@pusan.ac.kr ,(None) ,South Korea , ,Not Presenting[1]

1 - Pusan National University

Kinematic mechanisms of the Pacific/North American (PNA)-like teleconnection pattern induced by the Madden-Julian oscillation (MJO) is examined using an atmospheric general circulation model (GCM) and a barotropic Rossby wave theory. Observation shows that a negative PNA-like teleconnection pattern emerges in response to MJO phase 2 forcing with enhanced (suppressed) convection located over the Indian (western Pacific) Ocean. The GCM simulations show that both forcing anomalies contribute to creating the PNA-like pattern. Indian Ocean forcing induces two major Rossby wave source (RWS) regions: a negative region around southern Asia and a positive region over the western North Pacific (WNP). The negative RWS to the north of the enhanced convection in the Indian Ocean arises from southerly MJO-induced divergent wind crossing the Asian jet. Unexpectedly, another significant RWS region develops over the WNP due to refracted northerly divergent wind. A ray tracing method demonstrates three different ways of wave propagation emanating from the RWS to the PNA region: 1) direct arc-like propagation from the negative RWS to the PNA region occurs in the longest waves; 2) shorter waves are displaced first downstream by the jet waveguide effect and then emanate at the jet exit to the PNA region; and 3) waves with zonal wavenumbers 1 and 2 exhibit canonical wave propagation from the positive RWS at the jet exit to the PNA region.

Frederic Vitart : None

Representation of large scale and regional features in model hindcasts to improve precipitation predictions at subseasonal timescale in South America.

Abstract ID : 1144

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Iracema F.A. Cavalcanti ,iracema.cavalcanti@gmail.com ,(Ph.D., Researcher) ,Brazil ,São José dos Campos ,Not Presenting[1]

1 - INPE

The main meteorological system that occurs during the austral summer associated with the South America Monsoon System (SAMS) is the South Atlantic Convergence Zone (SACZ). Precipitation anomalies in the SACZ region have been associated with teleconnection patterns and with atmospheric regional features. Global models have been able to represent teleconnection patterns and regional features in studies of climate variability. However, there is low seasonal precipitation predictability in the SACZ, as its development occurs in a transition region (SE) between the tropical Northeast and extratropical south, which have higher predictability. The objective of this study is to analyze results of global models hindcasts at sub seasonal time scale to verify the representation of the main SAMS features, and the associated teleconnections and regional features. Large scale and regional features are combined to establish indices that can be used in sub seasonal prediction. The hindcasts are obtained from the Canadian Center models (CanCM3 and CanCM4) and consist of 12 months prediction initialized at each month. The prediction is focused on January, which is the mature stage month of SAMS, and the predictions are analyzed with 1 and 2 months lead-time. The results show that the hindcasts of 1 and 2 month lead-time represent the main SAMS and global features of January and also the precipitation variability in some periods. Correlations of precipitation over SE with atmospheric variables and SST and other statistical tools give clues to elaborate the indices. The indices can be used to improve the subseasonal predictions of precipitation useful in agriculture and hydroelectricity power sector.

A01 - Geomagnetic secular variation and rapid core dynamics (DIV I – DIV V)

Identifying MHD waves in numerical models of the geodynamo

Abstract ID : 211

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Robert Teed ,rt449@cam.ac.uk ,(Research Associate) ,United Kingdom ,Cambridge ,Not Presenting[1]

Prof. Chris Jones ,C.A.Jones@maths.leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Kumiko Hori ,amtkh@leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Prof. Steve Tobias ,S.M.Tobias@leeds.ac.uk ,(None) ,U.S. Virgin Islands , ,Not Presenting[2]

1 - University of Cambridge 2 - University of Leeds 3 - University of Leeds 4 - University of Leeds

Several types of magnetohydrodynamic waves are theorised to operate in Earth's outer core. Detection of such waves is limited by the inability to probe the fluid core directly although the secular variation and periodic changes in the length-of-day provide evidence of their possible existence. Numerical simulations of core dynamics enable us to directly search for waves and determine their properties. With this information it is possible to consider whether such waves can be the origin of features observed in the secular variation. We focus on two types of wave identified in our numerical experiments: torsional waves and slow magnetic Rossby waves. Periodic, Earth-like torsional waves are found to originate at the tangent cylinder (TC, the theoretical cylinder aligned with the rotation axis that circumscribes the inner core). We discuss their properties and excitation by small modes of convection and jets at the TC. Our work also shows that magnetic Rossby waves riding on a mean zonal flow may account for some geomagnetic westward drifts observed at mid-latitudes. We discuss how the detection of these waves can also provide an estimate of the strength of the toroidal component of the magnetic field within the planetary fluid core which, unlike the poloidal part, cannot be measured directly with observations.

nicolas gillet : None

A global analysis of the quasi-biennial oscillation in the geomagnetic field

Abstract ID : 221

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Jiaming Ou ,oujm@mail.iggcas.ac.cn ,(postdoctor) ,China ,Beijing ,Presenting[1]

Mr. Aimin Du ,amdu@mail.iggcas.ac.cn ,(None) ,China , ,Not Presenting[1]

Dr. Chris Finlay ,cfinlay@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[3]

1 - Institute of Geology and Geophysics, Chinese Academy of Sciences 2 - Institute of Geology and Geophysics, Chinese Academy of Sciences 3 - DTU Space, Technical University of Denmark

Quasi-biennial oscillations (QBO), with periods in the range 1-3 years, have been persistently observed in the geomagnetic field. They provide unique information on the mechanisms by which magnetospheric and ionospheric current systems are modulated on interannual time scales, and are also of crucial importance in studies of rapid core field variations. We document the global characteristics of the geomagnetic QBO, using ground-based data collected by geomagnetic observatories between 1985 and 2010, and re-examine the origin of the signals.
Fast Fourier Transform analysis reveals salient QBO signals at periods of 1.3, 1.7, 2.2, 2.9 and 5.0 years, with the most prominent peak at 2.2 years. The signature of geomagnetic QBO is generally stronger in the X and Z components and with larger amplitudes on geomagnetically disturbed days. The amplitude of the QBO in the X component decreases from the equator to the subauroral regions, showing a maximum at the auroral zones. The QBO in the Z component enhances from low latitudes towards the polar regions. At high latitudes (poleward of 50°) the geomagnetic QBO exhibits stronger amplitudes during LT 00:00-06:00, depending strongly on the geomagnetic activity level.
The characteristics of the multiple peaks in the QBO range are found similar in latitudinal and local time distributions, suggesting that these oscillations are derived from a common source. The features, including the strong amplitudes seen on disturbed days and during post-midnight sectors, and the results from spherical harmonic analysis, verify that the majority of geomagnetic QBO is of external origin.

nicolas gillet : None

Automated absolute magnetic measurements for monitoring of the main field changes (invited)

Abstract ID : 354

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Jean Rasson ,jr@oma.be ,(Head) ,Belgium ,Viroinval ,Not Presenting[1]

Mr. Stephan Bracke ,stbracke@meteo.be ,(None) ,Belgium , ,Not Presenting[1]

Mr. Alex Gonsette ,alexandre.gonsette@meteo.be ,(None) ,Belgium , ,Not Presenting[1]

1 - RMI 2 - RMI 3 - RMI

After many years of research, design and protototyping, fully automatic magnetic observatories are now a reality.
We present a description of the new automatic instrumentation involved and the constraints associated with their deployment, operation and data transfer.
Advantages and drawbacks are carefully examined.
Recent deployments are described and their performance assessed.

Tammy Maart : None

Sequential assimilation of the Earth's core magnetic field and secular variation

Abstract ID : 576

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Julien Baerenzung ,baerenzung@gmx.de ,(Postdoc) ,Germany ,Berlin ,Not Presenting[1]

1 - None

The geomagnetic field evolution is controlled by the motions of the electrically conducting fluid in the Earth's outer core. Because of the low electrical conductivity of the mantle, the core magnetic field and secular variation observed at the Earth's surface can be directly connected to the flow at the Earth's core mantle boundary (CMB)
through the radial induction equation. Inverting this equation allows therefore for recovering the velocity field at the CMB. In our study, this operation is included in an Ensemble Kalman filter approach. With this method, the state variables, here the radial component of the magnetic field and the velocity field at the CMB represented through a large ensemble of possible states, are first forecasted in space and time, to be then updated whenever data become available. Whereas to predict the evolution of the magnetic field, the radial induction equation with hyperdiffusion is numerically solved, the spatio temporal behavior of the velocity field is constrained by a first order auto regressive process.
In this model, a particular care has been taken to account for the scale dependency of both spatial and temporal statistical properties of the velocity field. To correct the trajectories of the state variables, both the magnetic field and the secular variation of a model deriving from geomagnetic observations are used. The properties of the flow at the CMB as well as the reliability of certain features it is exhibiting are systematically examined between the epochs 1900 and 2010. The ability of the method to provide short term prediction of the magnetic field evolution will also be presented.

nicolas gillet : None Tammy Maart : None

Detection of secular acceleration pulses from observatory data

Abstract ID : 884

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Anatoly Soloviev ,a.soloviev@gcras.ru ,(Deputy Director for Science) ,Russia ,Moscow ,Not Presenting[1]

Dr. Arnaud Chulliat ,arnaud.chulliat@colorado.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Shamil Bogoutdinov ,shm@gcras.ru ,(None) ,Russia , ,Not Presenting[1]

1 - Geophysical Center of the Russian Academy of Sciences 2 - Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder 3 - Geophysical Center of the Russian Academy of Sciences

Geomagnetic secular variation (SV) models for the epochs before the space era are based on magnetic observatory data, which represent relatively rough and noisy time series due to magnetic storms, anthropogenic spikes and gaps. These models are often strongly regularized in time, so that fast variations in the SV are smoothed out. However, recent studies show that at least some of the geomagnetic jerks observed at the Earth's surface emanate from increasing and decreasing phases of secular acceleration (SA) pulses at the core surface. The latter ones are direct manifestation of the dynamic processes taking place in the liquid core. They were first detected from satellite data, which are both of higher quality and more homogeneous in terms of geographical coverage than ground data. Herein we attempt to carry out similar studies based on observatory data available for a longer period. The proposed method of SV modeling and recognition of SA pulses relies on a new technique of processing time series based on fuzzy mathematics. Comparison with the SV modeling results derived from satellite data shows their high conformity with the proposed method. Stability and reliability of the SA pulse recognition are demonstrated by the examples of well-studied SA pulses in 2006, 2009 and 2012. Moreover, several new SA pulses around 1996, 1999, 2002 and 2014 are discovered as a result of the new approach application to multi-observatory data analysis. The latter provides a basis for applying the method to older historical data and investigate SA pulses and geomagnetic jerks further back in time.

nicolas gillet : None Tammy Maart : None

Assimilation of geomagnetic data, a window to a better understanding of core dynamics

Abstract ID : 957

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sabrina Sanchez ,sanchezs@mps.mpg.de ,(Max Planck Institute for Solar System Research) ,Germany ,Gottingen ,Not Presenting[1]

Dr. Johannes Wicht ,wicht@mps.mpg.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Alexandre Fournier ,fournier@ipgp.fr ,(None) ,France ,Paris ,Not Presenting[3]

Dr. julien aubert ,aubert@ipgp.fr ,(None) ,France , ,Not Presenting[4]

1 - Max Planck Institute for Solar System Research 2 - Max Planck Institute for Solar System Research 3 - Institut de Physique du Globe de Paris 4 - IPGP

The core magnetic field is generated by a natural dynamo mechanism, which bears a wide range of temporal variations due to a combination of advective and diffusive processes and wave-like signals. For the last two decades, such variability has been globally recorded through high precision satellite and observatory geomagnetic data. Using such large-scale surface data to constrain the global state of the core, and therefore the geodynamo, remains, however, a challenging ill-posed inverse problem. One attractive way to tackle this problem is by applying data assimilation techniques to merge geomagnetic data with numerical dynamo simulation outputs. In the geomagnetic data assimilation framework, the dynamical model is used to provide prior knowledge of the observable and hidden parts of the dynamo system in terms of its expected value and corresponding uncertainty. This information is then connected to the surface observations and their associated uncertainty by means of the Kalman filter, generating a most-likely posterior estimate of the dynamo state referred to as the analysis of the system's state. When performed sequentially, the analysis is forecasted in time by the dynamo model, until the moment when it meets new observations, in which a subsequent analysis is produced. Through the constant input of observations carried by the forecast-and-analysis cycles, the estimated state can be brought closer and closer to the unknown true state, allowing for past reconstructions and future forecasting of the geodynamo system. In this talk, I will present the main characteristics of geomagnetic data assimilation, targeting the short-term variability of the system and ensemble assimilation, outlining its potentiality and challenges. The salient points to be discussed englobe the choice between raw data and geomagnetic field models, the optimal architecture of the assimilation system, the role of sparsity and uncertainty of the observations for a convergent filtering, and the different spatio-temporal correlations of dynamo models, crucial to understanding the static and dynamic information propagation in the system. Lastly, I will discuss the possibility and benefits of

jointly assimilating satellite, observatory, historical and archeomagnetic databases to the improvement of our understanding of the core dynamics.

A02 - Earth's core dynamics and planetary dynamos (DIV I)

Are laminar and turbulent hydromagnetic dynamos dependent on the Prandtl number?

Abstract ID : 313

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jan Simkanin ,jano@ig.cas.cz ,(Senior scientist) ,Czech Republic ,Prague ,Not Presenting[1]

Dr. Juraj Kyselica ,kyselica@ig.cas.cz ,(None) ,Czech Republic , ,Not Presenting[2]

1 - None 2 - Institute of Geophysics of the CAS

We study laminar and turbulent dynamos in spherical shells filled by the electrically conducting incompressible fluid in the Boussinesq approximation using the PARODY dynamo code. Our Rayleigh number exceeds the critical Rayleigh number by a factor of 2.2 for laminar dynamos and by a factor 216 for turbulent dynamos. In both laminar and turbulent cases, we investigate when generated magnetic and velocity fields are dependent on the Prandtl number. We gradually choose the Prandtl number, which equals one, and then greater and smaller than one. At low Rayleigh numbers, our dynamos are dependent on the Prandtl number, what was expected. On the other hand, at the high Rayleigh numbers, such a dependence becomes weak.

Phil Livermore : None Tammy Maart : None

Analysis of initial Juno magnetometer data: Use of an elastic net to probe small-scale structure in Jupiter's magnetic field

Abstract ID : 328

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jeremy Bloxham ,jeremy_bloxham@harvard.edu ,(Professor) ,United States ,Cambridge ,Not Presenting[1]

Dr. John Connerney ,jack.connerney@nasa.gov ,(None) ,United States , ,Not Presenting[2]

Dr. Jose Merayo ,jmgm@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[3]

Ms. Kimberly Moore ,kimmoore84@gmail.com ,(None) ,United States , ,Not Presenting[1]

Dr. John Jorgensen ,jlj@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[3]

1 - Harvard University 2 - NASA GSFC 3 - Technical University of Denmark 4 - Harvard University 5 - Technical University of Denmark

The Juno spacecraft in a near polar orbit around Jupiter comes to within 1.06 Rj of the planet's center, much closer than any previous mission. With a nominal radius of the dynamo region of 0.85 Rj, Juno comes much closer to the dynamo region than is possible at any other planet in the Solar System. Each orbit of Juno has very high resolution along track, but with off-track resolution limited to a band around the track: multiple orbits are essential to build up a complete picture. We present a method that provides a high-resolution window into Jupiter's magnetic field along each spacecraft track.
Our method consists of three steps: first, we remove VIP4 from the Juno observations to create a residual dataset; second, we use an elastic net [Zou and Hastie, 2004] to fit a set of magnetic pixels on a spherical surface at a given radius to this residual dataset; and finally, we add the resulting magnetic pixels back onto VIP4, creating an enhanced VIP. The set of magnetic pixels consists of approximately 10,000 nearly uniform and mostly hexagonal elements on a spherical surface. Crucially in this method, the elastic net, which is a combination of L1 and L2 regularizations, ensures that magnetic pixels, or groups of correlated magnetic pixels, will only be nonzero if required by the data. The structure we obtain suggests the possible presence of both equatorial spots, as might result from flux expulsion, and low polar flux, as might result from the effect of a tangent cylinder.

Phil Livermore : None

Constraining the date of the martian dynamo shutdown by means of craters' magnetization signatures

Abstract ID : 473

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Matthias Grott ,matthias.grott@dlr.de ,(Member of Research Staff) ,Germany ,Berlin ,Not Presenting[1]

Dr. Foteini Vervelidou ,foteini@gfz-potsdam.de ,(Postdoctoral researcher) ,Germany ,Potsdam ,Presenting[2]

Dr. Vincent Lesur ,lesur@ipgp.fr ,(Head of magnetic observatories) ,France ,Paris ,Not Presenting[3]

Dr. Robert Lillis ,rlillis@ssl.berkeley.edu ,(None) ,United States , ,Not Presenting[4]

Mr. Achim Morschhauser ,mors@gfz-potsdam.de ,(Staff Scientist) ,Germany ,Niemegk ,Not Presenting[5]

1 - DLR 2 - GeoForschungsZentrum Potsdam 3 - Institut de Physique du Globe de Paris 4 - UC Berkeley Space Sciences Laboratory 5 - GFZ Potsdam

Mars is characterized by a strong crustal magnetic field, particularly over its southern hemisphere, which is believed to be the remnant of an ancient core dynamo. The dynamo is believed to have ceased operating approximately 4 Ga ago, although the exact time is still under debate. The scope of this study is to introduce constraints on the possible timing of its cessation by studying the magnetization signatures over 32 craters which have reliable crater retention ages and are large enough for the impact to have reset the crustal magnetization within. The input of the study is the latest available lithospheric magnetic field model of Mars, which is based on the Mars Global Surveyor dataset. The inherent non-uniqueness characterizing the estimation of the magnetization distribution from magnetic field data is dealt with by estimating the visible part of the magnetization, i.e., the part of the magnetization that gave rise to the observed magnetic field, by means of a new conversion formula. Furthermore, we demonstrate that a (non) zero visible magnetization is a valid proxy for the entire magnetization being (non) zero, under the assumption of a magnetization distribution that has not been altered since its acquisition by a core dynamo. Our results show that this assumption yields a consistent picture of the dynamo time line. In particular, according to our results, the dynamo was functional approximately up to 4.1 Ga ago, which is in agreement with previous studies based on remote sensing data and laboratory measurements of meteorite samples. In addition, our results suggest that the dynamo might have gone through two distinct phases, one initial weak phase up to 4.21 Ga ago and a subsequent fully functional phase before shutting down at around 4.1 Gyr.

Phil Livermore : None Tammy Maart : None

Probing the core surface flow with satellite data

Abstract ID : 533

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited

Prof. Kathy Whaler ,kathy.whaler@ed.ac.uk ,(None) ,United Kingdom ,Edinburgh ,Presenting[1]

Mr. Magnus Hammer ,magdh@space.dtu.dk ,(None) ,Denmark ,Holte ,Not Presenting[2]

Dr. Chris Finlay ,cfinlay@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[2]

Prof. Nils Olsen ,nio@space.dtu.dk ,(None) ,Denmark ,None ,Not Presenting[4]

1 - University of Edinburgh 2 - DTU Space, Technical University of Denmark 3 - DTU Space, Technical University of Denmark 4 - DTU

Time series of the geomagnetic secular variation (SV) at permanent observatories are a key tool for exploring the advective flow at the core surface. However, the number and distribution of observatories restricts the resolution of the resulting flows. Satellite data offer much better spatial coverage, but do not provide time series of the SV at a single point. We use the 'virtual observatory' technique of Mandea and Olsen (2006) (with some enhancements, such as using along- and across-track differences of Swarm data) to produce monthly SV time series at an array of points. These data are then inverted for two extremes of core surface flow: 'snapshots' from successive triples of monthly values, which show large month-to-month variability, and by inverting all the data simultaneously for a series of monthly flow models, but penalising temporal changes between them. We also produce flows in which the only temporal variability permitted is that consistent with torsional oscillations. We will present results from the Swarm and CHAMP satellite missions, using 8 years of the re-processed CHAMP data, and Swarm data from mid-2014 to February 2016. CHAMP-era flows will be compared with those obtained by the same methods using ground observatory data from 1997 to 2013 (Whaler et al., 2016). We will also compare the resolution matrices and averaging functions for ground and virtual observatory flows to quantify the improvement that the satellite data provide. We will examine the flows for features, such as planetary gyres and jets, which have been inferred by other methods and likely relate to the dynamic regime of the core. Our flows are predominantly toroidal (but not consistent with purely toroidal flow, such as might be associated with a stably stratified layer at the core surface), tangentially geostrophic and equatorially symmetric. They undergo periods of spatially localised relatively rapid acceleration, even when temporal variability is minimised. We will use the data sampling, or Green's, functions for the flow to infer the extent to which flow changes can be related to features of the observatory time series, such as periods of rapid SV.

Effects of lateral CMB heat flow variations on a thermally stratified outer core

Abstract ID : 728

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Grace Cox ,Grace.Cox@liverpool.ac.uk ,(Postdoctoral research associate) ,United Kingdom ,Sheffield ,Not Presenting[1]

Dr. Chris Davies ,C.Davies@leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Phil Livermore ,p.w.livermore@leeds.ac.uk ,(Associate Professor) ,United Kingdom ,Leeds ,Not Presenting[2]

1 - University of Liverpool 2 - University of Leeds 3 - University of Leeds

Seismological observations, geomagnetic data and mineral physics calculations have all been used to infer the presence of a stably stratified layer at the top of Earth's fluid outer core. The outer core responds to the core-mantle-boundary (CMB) as a rigid surface with a fixed heat flux imposed by the lower mantle because the timescales of core motion are much shorter than those of the overlying mantle. Seismic tomography shows two large regions of the lowermost mantle with anomalously low S-wave velocity, the Large Low Shear Velocity Provinces (LLSVPs), which are usually thought to be hotter than their surroundings, though perhaps chemically distinct, and so extract less heat from the core. Previous studies of convection in rotating spherical fluid shells have shown that lateral heat flow variations on the outer boundary will drive thermal winds and that boundary-driven flows are capable of penetrating deep into the fluid. These previous works have considered only weakly (or not at all) stratified fluids, so a key question is whether boundary forcing can penetrate into a strongly stratified layers and mix the layer into the bulk of the fluid. We use numerical simulations of boundary driven flow in a rapidly rotating, thermally stratified spherical annulus with a Y22 spherical harmonic heat flux pattern imposed on outer boundary. We explore a broad range of thermal stratification strength (St), boundary anomalies strength (B) and Ekman number (E) and investigate the scale of penetration of flow into the fluid and whether strong thermal anomalies can induce radial flows such that the stratified layer is destroyed. For steady solutions, a clear transition is found between low St, which has virtually no influence on flow, and high St, which reduces velocities and confines flow to thin shear layers at the top of the core. We develop scaling laws for the dynamics, which we extrapolate to Earth's core parameters.

Saturn’s magnetic field and dynamo in the Cassini era

Abstract ID : 799

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Michele Dougherty ,m.dougherty@imperial.ac.uk ,(None) , , ,Presenting[1]

Dr. Hao Cao ,haocao@caltech.edu ,(None) ,United States , ,Not Presenting[2]

1 - Imperial College London 2 - California Institute of Technology

The magnetometer (MAG) onboard the Cassini spacecraft has been monitoring Saturn's magnetic field since 2004. In April 2017, Cassini began the "Grand Finale" phase with periapses only a few kilometers above the cloud deck of Saturn. The Cassini magnetometer measurements prior to the Grand Finale phase have confirmed the unusual character of Saturn's internal magnetic field known from previous spacecraft flybys and have revealed additional properties that suggest a rather unique planetary dynamo. Here we review our knowledge of Saturn's internal magnetic field prior to the Cassini "Grand Finale", focusing on the extreme axisymmetry, the extremely slow secular variation, relatively low magnetic field strength, and the "zig-zag" magnetic power spectrum. The proposed connection between the characteristics of Saturn's intrinsic magnetic field and the interior structure (e.g. Helium rainout and stable stratification) and dynamics (e.g. deep zonal flows) of Saturn will also be discussed. In addition, some preliminary MAG findings from the first few orbits of the "Grand Finale" phase of Cassini will be described and how these findings further inform our understanding of the interior of Saturn.

A time-averaged regional model of the Hermean magnetic field

Abstract ID : 929

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Erwan Thebault ,erwan.thebault@univ-nantes.fr ,(?) ,France ,Nantes ,Not Presenting[1]

Mr. Benoit Langlais ,benoit.langlais@univ-nantes.fr ,(None) ,France , ,Not Presenting[1]

Dr. Joana S. Oliveira ,joansofi@gmail.com ,(None) ,France , ,Not Presenting[3]

Mr. Hagay Amit ,hagay.amit@univ-nantes.fr ,(None) ,France , ,Not Presenting[1]

Dr. Ingo Wardinski ,ingo.wardinski@univ-nantes.fr ,(None) ,France , ,Not Presenting[1]

1 - LPG Nantes 2 - LPG Nantes 3 - IPGP 4 - LPG Nantes 5 - LPG Nantes

We present the first regional magnetic field model of Mercury developed with mathematical continuous functions. The model is derived to the spatial resolution of about 830 km without a priori information about the geometry of the internal and external fields or regularization. It relies on an extensive dataset of the MESSENGER's measurements selected over its entire orbital lifetime between 2011 and 2015. A first order separation between the internal and the external fields over the Northern hemisphere is achieved under the assumption that the magnetic field measurements are acquired in a source free region within the magnetospheric cavity. When downward continued to the core-mantle boundary, the model confirms the general structures already observed in previous studies such as the dominance of zonal field, the location of the North magnetic pole, and the global absence of significant small scale structures. The transformation of the regional model into a global spherical harmonic one provides an estimate for the axial quadrupole to axial dipole ratio of about 0.27. This is much lower than previous estimates of about 0.40. We note that it is possible to obtain a similar ratio provided that more weight is put on the location of the magnetic equator and less elsewhere. A larger ratio of about 0.39 could be obtained by adding a specific constraint on the location of the magnetic dip equator.

The inner core's 3-D rotation under the mantle-inner core gravitational coupling: A revisit

Abstract ID : 1077

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Benjamin Fong Chao ,bfchao@earth.sinica.edu.tw ,(Distinguished Research Fellow) ,Taiwan ,Taipei ,Not Presenting[1]

1 - Institute of Earth Sciences, Academia Sinica

The Earth's mantle-inner core gravitational (MICG) interaction due to non-spherical density anomalies was proposed by Buffett (1996). We here develop the spherical-harmonic multipole formulation for the 3-D MICG dynamics, a scheme that proves to be rather concise in mathematics and efficient in conceptualizing the physics. We examine both the 1-D axial component and the 2-D equatorial component considering also the hydrostatic pressure influences of the fluid outer core. For the axial component we (re)deduce the simple-harmonic axial torsional libration of the inner core, which would result in an accompanying oscillation in the Earth's length-of-day (LOD). Equating the latter to the observed 6-year ΔLOD oscillation would then lead to meaningful constraints on estimation of the equatorial ellipticities of the mantle and the inner core. For the equatorial component, which understandably involves much greater subtleties in physics, the Euler-Liouville equation leads to the rotational mode that is the inner-core wobble (ICW). The well-established knowledge about the oblateness of the Earth system then provides tight estimate for the ICW period. We show that the period (considering the finite elasticity and viscosity of the inner core) can be comparable to the ~28-year period of the Markowitz wobble that is observed in the Earth's polar motion, whereby interesting geophysical implications can presumably be inferred. Furthermore, from the observed amplitudes of the 6-year ΔLOD oscillation and the Markowitz wobble, the required strength of the overall electromagnetic torques can be estimated for the axial and the equatorial components respectively.

Phil Livermore : None Tammy Maart : None

Initial iron-60 abundance in the solar nebula constrained by delayed onset of a planetesimal dynamo

Abstract ID : 1179

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Huapei Wang ,huapei@cug.edu.cn ,(Postdoc / Professor) ,China ,Wuhan ,Not Presenting[1]

Dr. Benjamin P. Weiss ,bpweiss@mit.edu ,(None) ,United States , ,Not Presenting[2]

Dr. John W. Crowley ,jwgcrowley@gmail.com ,(None) ,Canada , ,Not Presenting[3]

1 - Massachusetts Institute of Technology / China University of Geosciences (Wuhan) 2 - Massachusetts Institute of Technology 3 - Natural Resources Canada

The paleomagnetism of meteorites provides evidence for advecting metallic core dynamos and large-scale differentiation on their parent planetesimals. Their small sizes relative to planets enable new opportunities to understand the physics of dynamo generation. Wang et al. [2017] studied the paleomagnetism of three volcanic angrites (D'Orbigny, 4563.37±0.12 Ma; Sahara 99555, 4563.54±0.14 Ma; Asuka 881371, 4562.4±1.6 Ma) and one plutonic angrite (Angra dos Reis, 4556.51±0.11 Ma). Their results show that the older volcanic angrites recorded no detectable paleomagnetic field, while the younger plutonic angrite recorded a paleomagnetic field of ~17 µT interpreted as evidence of a core dynamo on the angrite parent body (APB). This indicates that the initiation of the APB dynamo was delayed until sometime between ~4 and ~11 My after the formation of calcium aluminum-rich inclusions (CAIs) at 4567.30 ± 0.16 Ma. This late timing is consistent with recent planetesimal thermal evolution models invoking shallow magma oceans [Neumann et al. 2014], which predict that planetesimal dynamos would not initiate until the core began to crystallize. It is also consistent with thermal evolution models invoking large-scale magma oceans that considered thermal blanketing of the core by ^{26}Al decay in the mantle [Roberts et al. 2013, Sterenborg and Crowley 2013], which would delay thermal convection dynamos until several My after accretion (occurred <0.25 My after CAIs for the APB [Schiller et al. 2015]) and differentiation. Because the presence of even a small amount of ^{60}Fe in the core could effectively remove the thermal blanketing effect of mantle ^{26}Al, we can use the delay in timing of the dynamo to constrain the abundance of ^{60}Fe on the APB. Our planetesimal thermal evolution models show that if the initial solar nebula ^{60}Fe/^{56}Fe ratio was greater than $\sim 5\times10^{-9}$, the APB core dynamo would have to start earlier than ~4 My after CAIs, in contradiction to the paleomagnetic constraints. Thus, we argue that $\sim 5\times10^{-9}$ is an upper limit of the initial ^{60}Fe/^{56}Fe ratio in the solar nebula. This upper limit is consistent with independent isotopic measurements of the Sahara 99555 angrite, which found ^{60}Fe/^{56}Fe ratio of $(6.96 \pm 1.60)\times10^{-9}$ [Tang and Dauphas, 2015].

Phil Livermore : None Tammy Maart : None

Characteristics of Mercury's magnetic fields and their temporal variations

Abstract ID : 1281

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ingo Wardinski ,ingo.wardinski@univ-nantes.fr ,(None) ,France , ,Presenting[1]

Dr. Erwan Thebault ,erwan.thebault@univ-nantes.fr ,(?) ,France ,Nantes ,Not Presenting[1]

Mr. Benoit Langlais ,benoit.langlais@univ-nantes.fr ,(None) ,France , ,Not Presenting[1]

Mr. Ronan Modolo ,ronan.modolo@latmos.ipsl.fr ,(None) ,France , ,Not Presenting[4]

1 - LPG Nantes 2 - LPG Nantes 3 - LPG Nantes 4 - Latmos Paris

In this study we compare magnetic field residuals derived in Mercury's body fixed (MBF) and Mercury sun oriented (MSO) coordinate systems. These residuals are computed from differences between MESSENGER's magnetometer measurements and a magnetic field model that describes large scale external and internal sources of Mercury's magnetic field. Residuals can be separated further into external and internal residual fields. The external residual field shows spatial patterns that are fixed with respect to the sun position, and therefore cannot be modeled as a potential field in MBF coordinate system. These un-modelled signals appear to be strongest at Mercury's day side approximately 20 - 30 degrees north of the equator. The cause of these magnetic signatures remains not fully understood, but the altitude range of these magnetic signatures may suggests dynamical processes in Mercury's exosphere to generate these signals.

Considering residuals in different coordinate systems also aids to disentangle different timescales of the residuals variability and their interferences. Beside spatial structures related to an exospheric dynamo, we identify typical temporal variations of residuals, that are related to: (a) the solar rotation, (b) Mercury's rotation, and (c) Mercury's orbital period around the sun. Results of our analyses suggest a temporal correlation between external and internal field varition. Moreover, a time lag between external and internal residual field variation seems to exist. This time lag may bear inferences on processes that are generating Mercury's magnetic fields. However, further theoretical developments and analysis are required to refine our

understanding of external and internal field generation and to substantiate these first results.

A03 - Towards an understanding of the time variations of the geodynamo (DIV I)

The time-averaged palaeomagnetic field during 3-7 Ma at high northern latitudes

Abstract ID : 349

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Radchagrit Supakulopas ,r.supakulopas14@imperial.ac.uk ,(PhD student) ,United Kingdom ,London ,Not Presenting[1]

Dr. Morten Riishuus ,riishuus@hi.is ,(None) ,Iceland , ,Not Presenting[2]

Dr. Adrian Muxworthy ,adrian.muxworthy@imperial.ac.uk ,(Convenor) ,United Kingdom ,London ,Presenting[3]

Prof. Conall Mac Niocaill ,conallm@earth.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. Arne Dø ,ards@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[5]

1 - Imperial College London 2 - University of Iceland 3 - Imperial College 4 - University of Oxford 5 - DTU

The geocentric axial dipole (GAD) hypothesis states that when we average the geomagnetic field over sufficient time intervals, the time-averaged field (TAF) behaves like a dipole aligned along the Earth's spin axis and positioned at the Earth's centre. This hypothesis is crucial in palaeomagnetic research such as palaeosecular variation, palaeoclimate and plate tectonic reconstruction. However, the time interval to average the field to achieve a GAD is still debated. For example, there is some evidence for the persistence of long-term hemispheric asymmetry on time scales of 10^5-10^6 yr, particularly at high-latitudes. As most palaeomagnetic research is conducted under the GAD hypothesis, the hypothesis needs to be rigorously tested. In this research we aim to investigate the symmetry of the palaeomagnetic field and to test the GAD hypothesis during 3-7 Ma using full-vector palaeomagnetic data - including palaeodirection and palaeointensity - from dated lava piles in northern Iceland. The demagnetisation measurements including alternating field (AF) and thermal were made to determine palaeomagnetic directions. We found mean declination and inclination of 355.0° and 72.0° with 95% confidential limit of 2.2°. The modelling of the field was performed by adding 4% of quadrupole and 11% of octupole to the model; the model returns the inclination of 72.1° at 65°N. Our dataset passed the reversal test with Class A which is indicative of high accuracy. The directional data were

converted to virtual geomagnetic pole (VGP) which is located at 81.3°N and 180.2°E. The Curie temperature determination was performed using strong field thermomagnetic analysis prior to palaeointensity experiment. Evidence from strong field thermomagnetic curves indicates the presence of Ti-rich titanomagnetite, Fe-rich titanomagnetite and titanomaghemite in samples across the lava flows. Palaeointensity experiment was conducted in a helium atmosphere in order to prevent oxidation on the samples. We found the mean intensity of 22.0±2.7μT, which is lower than the intensity of the GAD field (55.9 μT) at 65°N, and the virtual dipole moment (VDM) of 32 ZAm^2. The investigation of palaeomagnetic data from Icelandic basalts reveals that the non-dipole field persists during 3-7 Ma at high-northern latitudes.

Transdimensional Inference of Archeomagnetic Intensity Change

Abstract ID : 368

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Phil Livermore ,p.w.livermore@leeds.ac.uk ,(Associate Professor) ,United Kingdom ,Leeds ,Not Presenting[1]

Dr. Thomas Bodin ,Thomas.bodin@ens-lyon.fr ,(None) ,France , ,Not Presenting[2]

Prof. Alex Fournier ,af0974@gmail.com ,(None) ,France , ,Not Presenting[3]

Dr. Yves Gallet ,gallet@ipgp.fr ,(None) ,France , ,Not Presenting[3]

1 - University of Leeds 2 - University Claude Bernard Lyon 1 3 - Institut de Physique du Globe de Paris 4 - Institut de Physique du Globe de Paris

One of the main goals of archeomagnetism is to document the secular changes of Earth's magnetic field by laboratory analysis of the magnetization carried by archeological artefacts. Typical techniques for creating a model of temporal change include assuming a prescribed temporal discretisation which, when coupled with sparse data coverage, requires strong damping in order to ensure smoothness. Because such damping is often chosen arbitrarily, and applied to the entire time series, interpretation and detection of rapid changes and frequency content may be difficult. Key to proper modelling (and physical understanding) is a method that places a minimum level of regularisation on any fit to the data.

Here we apply the transdimensional Bayesian technique to sparse archeointensity datasets, in which the temporal complexity of the model is not set a priori, but is self-selected by the data. The method produces the posterior distribution of intensity as a function of time, which is a useful tool for archeomagnetic dating. By extending the model to include the sample ages within a hierarchical Bayesian framework, we are also able to calculate the posterior distribution of the age of any individual contributing sample. We demonstrate the power of this technique within archeomagnetism by showing the results of its application to a variety of datasets.

Is the geomagnetic field evolution during the Laschamp excursion similar to the present field evolution?

Abstract ID : 480

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Carlo Laj ,carlo.laj@ens.fr ,(Emeritus professor) ,France ,Paris ,Not Presenting[1]

Dr. Catherine Kissel ,Catherine.Kissel@lsce.ipsl.fr ,(research scientist) ,France ,Gif-sur-Yvette ,Not Presenting[2]

1 - Ecole normale Supérieure 2 - LSCE

We discuss on a very precise record of the Laschamp excursion, obtained by stacking relative paleointensity records (20-75 ka) from high deposition rate sedimentary sequences largely distributed worldwide. This stack (GLOPIS-75) calibrated to absolute values using volcanic data, has been precisely placed on the most recent GICC05 age model (Andersen et al., 2006) based on annual layer counting. This age model yields an evaluation of the duration and rate of change with unprecedented temporal resolution. The decay rate of the field intensity during the Laschamp excursion attains values of the order of 5-6 times that expected for simple decay by diffusion. Moreover, a Bayesian inversion of the most precise directional records of the excursion (Leonhardt et al., 2009) shows that a main feature are inverse magnetic flux patches at the CMB which emerge at the equator and move poleward. Therefore significant similarities exist between the field evolution during the Laschamp excursion and the evolution of the present field, which has been steadily decreasing at a similar very high rate for the last 400 years and is probably going to decrease at a similar rate at least for the next century (Aubert, 2015). In addition, as initially noted by Gubbins (1987) the decrease of intensity is directly related to the intensification and southward migration of a patch of reverse flux occurring below the southern tip of Africa (the South Atlantic Anomaly), and the fall may lead to a polarity change. Assuming that the dynamo processes of the present field are very similar to those documented for the Laschamp excursion, a reversal of an excursion we may tentatively suggest that a reversal or an excursion may be expected but not before 500-1000 years.

Gillian Turner : Invited talk - to be presented by Laj (30 minutes) Please check the last sentence of abstract "a reversal or excursion" is repeated Tammy Maart : None

Archeomagnetic intensity spikes – how unusual are they?

Abstract ID : 490

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Monika Korte ,monika@gfz-potsdam.de ,(Researcher) ,Germany ,Potsdam ,Not Presenting[1]

Prof. Catherine Constable ,cconstable@ucsd.edu ,(None) ,United States ,La Jolla, 92093-0225 ,Not Presenting[2]

1 - GFZ German Research Center for Geosciences 2 - University of California-San Diego

Variations of the geomagnetic field prior to direct observations are inferred from archeo- and paleomagnetic experiments. Apparent unusual variations not seen in the present day and historical field are of particular interest to constrain the full range core dynamics. Recently, archeomagnetic "intensity spikes", characterised by very high field values that appear to be associated with rapid secular variation rates, have been widely discussed. They were first noted in data from the Levant at around 900~BCE. A recent re-assessment of previous and new Levantine data, involving a rigorous quality assessment, interprets the observations as an extreme local geomagnetic high with at least two intensity spikes between the 11th and 8th centuries BCE (Shaar et al., 2016, Earth and Planetary Science Letters). However, studies invoking intense magnetic flux spikes at the core-mantle boundary, or core flow models under the frozen flux approximation, cannot reconcile a strongly localized surface spike with presently accepted understanding of the geodynamo process in Earth's core. Moreover, recently reported high intensity values from other parts of the world, e.g., China and Texas, at similar times raise the question of whether such features might be common occurrences, or whether they might even be part of a global magnetic field feature. We use spherical harmonic modelling to test two hypotheses: firstly, whether the Levantine and other potential spikes might be related to higher dipole field intensity than shown by existing global field models around 1000~BCE, and secondly, whether the observations from different parts of the world are compatible with a westward drifting intense flux patch. Preliminary results indicate that a connection of the spikes to high dipole moment seems conceivable if one assumes rather high dipole variation rates, but the observed spikes in China and the Levant do not seem to be caused by westward drift of an intense magnetic flux patch.

Gillian Turner : Is this to be presented by Monika Korte? (The presenting author has not been nominated) Tammy Maart : None

Combined Investigations of Geomagnetic Field Evolution and Cosmogenic Isotope Production Rates on Multi-Millennial Time Scales

Abstract ID : 504

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sanja Panovska ,sanja.panovska@gfz-potsdam.de ,(Postdoc researcher) ,Germany ,Potsdam ,Presenting[1]

Ms. Monika Korte ,monika.korte@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

1 - Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences 2 - Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences

Paleomagnetic data from lake and marine sediments, and lava flows data are typical records for reconstructing the geomagnetic field variations on millennial or longer timescales. Another independent source of information for the Earth's magnetic field changes are cosmogenic isotope records. Their production rate is affected by the variations of intensity and orientation of the geomagnetic field and by the solar activity, but the solar effect is generally smaller on long timescales. Higher frequencies solar modulation can be filtered out in order to minimize the solar influence. As an alternative, the solar component can be extracted by analyzing the cosmogenic isotope signal with eigenanalysis techniques for separating the patterns of geomagnetic field and non-geomagnetically sourced contributions. Then, cosmogenic isotope records can represent relative paleointensity variations. We compiled more than 40 globally distributed records of ^{10}Be from sediments, loess and ice cores. Their comparison to a 100 kyr global, time-dependent, geomagnetic field model allows us to analyze their geomagnetic shielding signal in more detail, globally and regionally. As some of the sediment locations provide both types of signals, these are first used to check for any delays in recordings of the two signals. We investigate the global/regional character of the geomagnetic signal in the ^{10}Be cosmogenic isotopes and analyze advance/delay of global dipole moment lows, their locations and intensities especially during periods of geomagnetic field excursions, with the aim of utilizing cosmogenic isotope records for global geomagnetic field reconstruction.

Gillian Turner : None Tammy Maart : None

Documenting the field changes during the last geomagnetic reversal

Abstract ID : 505

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Jean-Pierre Valet ,valet@ipgp.fr ,(None) ,France ,Paris ,Not Presenting[1]

Mrs. Tatiana Savranskaia ,savranskaia@ipgp.fr ,(None) ,France , ,Not Presenting[1]

Dr. Franck Bassinot ,Franck.Bassinot@lsce.ipsl.fr ,(None) ,France , ,Not Presenting[3]

Prof. Laure Meynadier ,meynadier@ipgp.fr ,(None) ,France , ,Not Presenting[1]

Dr. Quentin Simon ,simon@cerege.fr ,(None) ,France , ,Not Presenting[5]

Prof. Didier Bourles ,bourles@cerege.fr ,(None) ,France , ,Not Presenting[5]

Prof. Nicolas Thouveny ,thouveny@cerege.fr ,(None) ,France , ,Not Presenting[5]

1 - IPGP 2 - IPGP 3 - LSCE 4 - IPGP 5 - Cerege 6 - Cerege 7 - Cerege

A large dataset involving records from sedimentary and volcanic rocks has been published concerning the last geomagnetic reversal. Various Issues are still debated like the reversal age determination, the transition duration, the pattern of field intensity, the presence of precursors and rebounds and the field geometry during the successive episodes. Controversial features are frequently generated by different interpretations related to the temporal resolution of the signals.
We measured and stepwise demagnetized the remanent magnetization of single samples from 4 different transition zones from sediments of the Indian, Pacific and Atlantic oceans with deposition rates between 2.5 and 4.5 cm/kyr in order to investigate what reliability can be given to transitional directions derived from these relatively low resolution records. Similarly to most reversal records from sediments, we obtained low quality transitional directions. We show that scatter of directions during demagnetization is generated by inappropriate timing of remanent magnetization acquisition with respect to the rate of transitional field changes. We infer that suitable records can only be obtained from records with deposition rates of at least 10 cm/kyr. In one specific case, we found clear evidence for post-depositional processes that allow us to document further the processes and the timing of magnetization acquisition in this situation. We also investigated what confidence can be given to transitional directions derived from U-channel measurements in presence of low and fast sedimentation.
Despite poor resolution of the transitional directions, it is possible to scrutinize the changes in geomagnetic intensity using standard techniques of relative paleointensity as long as the field is predominantly dipolar. The period of low field intensity with poor magnetic alignment is less suitable for detailed paleointensity determinations but remains a faithful indicator of the amplitude of field

intensity decrease. In parallel, we performed high resolution measurements of beryllium ten across the same four sedimentary records of the last reversal. We also relied on detailed delta 18O isotope records to determine the reversal position within each sequence and evaluate possible offsets between the different records.
If we refer to the volcanic database after discussing what confidence can be given to the different records, we can extract pertinent information concerning directional changes during the transition, reversal duration, precursors and rebounds as well as the age of the event. Additional detailed records are still needed to define the first-order transitional field geometry, but the existing results and a few high resolution records from sedimentary sequences converge to confirm the dominance of rapidly time-varying non-dipolar components.

Gillian Turner : Is Valet the presenting author? Tammy Maart : None

On the Possibility of Lightning-Induced Remagnetization of Detrital Minerals During Continental Erosion

Abstract ID : 772

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Joseph L. Kirschvink ,kirschvink@caltech.edu ,(None) ,United States , ,Not Presenting[1]

1 - California Institute of Technology/ Tokyo Institute of Technology

Past efforts to constrain the existence of a geomagnetic field during Hadean time from detrital mineral grains have ignored the possibility that they might have been re-magnetized in a complex fashion by lightning strikes. Lightning bolts can have peak currents of up to 100,000 A, producing circularly-oriented magnetic fields that decrease in intensity around the current path following an inverse distance law: $B(r) = \mu o I/(2\pi r)$, where μo is the permeability of free space, I the current, and r the distance from the current path. A bolt of this strength, for example, will produce fields in excess of 1 Tesla at a few cm, and nearly 100mT at a distance of .5 meters. Hence, lightning has the potential to remagnetize minerals like magnetite and hematite that have microscopic coercivities in this range.

Lightning strike density is extremely low at high latitudes, and peaks at between 20 and 70 strikes per km^2 per year in the equatorial continental zones. In the typical mid-latitude granitic basement area of Vredefort, South Africa, Carporzen et al. (2012) calculate that there is an average of one lightning strike per 10 m^2 every ~750 years. Hence, a 1 m^2 patch of this granite would be struck every ~ 75 thousand years. Typical erosion rates of granites in highly-vegetated areas are between 0.1 and 1 µm per year (e.g., Zakharova et al. 2009), but abiotic weathering during Hadean and early Archean time is estimated to be 10 - 100 times slower than this (Zambell et al., 2012). Taking the mid range values for these estimates implies erosion rates of ~ 1 cm/Myr for Hadean / early Archean time, and upwards of hundreds of strikes capable of imparting IRM components per grain. Multiple strikes during the erosional process with random spatial orientations would impart IRMs of varying direction and magnitude to the eroding grains, making their net magnetization resemble that produced by typical TRM or CRM components. Hence, recovering a primary TRM from detrital zircons like those in 3.2 billion year old sediments from the Jack Hills of Australia - which may have gone through several sedimentary rock cycles - would be an extraordinarily unlikely event.

Gillian Turner : I assume Kirschvink is presenting this paper? Tammy Maart : None

Coarse predictions of dipole reversals by low-dimensional modeling and data assimilation

Abstract ID : 773

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Alexandre Fournier ,fournier@ipgp.fr ,(None) ,France ,Paris ,Not Presenting[1]

Mr. Matthias Morzfeld ,mmo@math.arizona.edu ,(None) ,Germany , ,Not Presenting[2]

Dr. Gauthier Hulot ,gh@ipgp.fr ,(Deputy Director in charge of research and space activities) ,France ,Paris ,Presenting[1]

1 - Institut de Physique du Globe de Paris 2 - University of Arizona 3 - Institut de Physique du Globe de Paris

Low-dimensional models for Earth's magnetic dipole may be a powerful tool for studying large-scale dipole dynamics over geological time scales, where direct numerical simulation remains challenging. We investigate the utility of several low-dimensional models by calibrating them against the signed relative paleointensity over the past 2 million years. Model calibrations are done by "data assimilation" which allows us to incorporate nonlinearity and uncertainty into the computations. We find that the data assimilation is successful, in the sense that a relative error is below 8% for all models and data sets we consider. The successful assimilation of paleomagnetic data into low-dimensional models suggests that, on millennium time scales, the occurrence of dipole reversals mainly depends on the large-scale behavior of the dipole field, and is rather independent of the detailed morphology of the field. This, in turn, suggests that large-scale dynamics of the dipole may be predictable for much longer periods than the detailed morphology of the field, which is predictable for about one century. We explore these ideas and introduce a concept of "coarse predictions", along with a sound numerical framework for computing them, and a series of tests that can be applied to assess their quality. Our predictions make use of low-dimensional models and assimilation of paleomagnetic data and, therefore, rely on the assumption that currently available paleomagnetic data are sufficiently accurate, in particular with respect to the timing of reversals, to allow for coarse predictions of reversals. Under this assumption, we conclude that coarse predictions of dipole reversals are within reach. Specifically, using low-dimensional models and data assimilation enables us to reliably predict a time-window of 4 kyr during which a reversal will occur,
without being precise about the timing of the reversal. Indeed, our results lead us to forecast that no reversal of the Earth's magnetic field is to be expected within the next few millennia. Moreover, we confirm that the precise timing of reversals is difficult to predict, and that reversal predictions based on intensity thresholds are unreliable, which highlights the value of our model based coarse predictions.

Gillian Turner : None Tammy Maart : None

Precambrian paleointensity – perspectives and challenges

Abstract ID : 947

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Elisa Piispa ,ejpiispa@mtu.edu ,(Geophysicist) ,New Zealand ,Wellington ,Not Presenting[1]

1 - None

Data on the strength of the Precambrian magnetic field are important for understanding the behavior of Earth's geodynamo in the deep past. Furthermore, Precambrian paleointensity has been used to explore a multitude of important interconnected Earth's evolution processes including the Earth's thermal evolution, age of the inner core, core thermal conductivity, mantle convection, plate tectonics, magnetospheric shielding, atmospheric chemistry, and even the emergence of life. However, obtaining reliable Precambrian paleointensity data still remains one of the most challenging tasks of paleomagnetic research due to high failure rates resulting from natural and laboratory alteration, sparsity of source material, non-optimal carriers of magnetization and other factors. Consequently, although the Precambrian spans more than 85 % of the entire geological record, the Precambrian paleointensities only comprise about 9 % of the available data and are characterized by an uneven geographical and temporal distribution. Here, a review of the Precambrian paleointensity records is provided together with the related perspectives and challenges. In addition, the implications of the Precambrian paleointensity for understanding temporal behavior of the geodynamo in the past is discussed. A special emphasis will be given to a discussion of what questions we can or cannot realistically address based on the available paleointensities: What are the knowns and unknowns related to the existing Precambrian paleointensity record?

Gillian Turner : Invited talk - 30 minutes Tammy Maart : None

On Models of Growth and Decay of Earth’s Dipole Moment

Abstract ID : 1478

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Catherine Constable ,cconstable@ucsd.edu ,(None) ,United States ,La Jolla, 92093-0225 ,Not Presenting[1]

1 - University of California-San Diego

The geomagnetic field exhibits large changes on a range of temporal and spatial scales. Earth's dipole strength has declined since the first absolute intensity measurements were made in the nineteenth century. This decrease is associated with a deepening intensity low in the southern Atlantic region and generally more active secular variation in the Atlantic hemisphere than the Pacific one. Time varying global spherical harmonic field models derived from paleo and archeomagnetic data reveal an overall asymmetry in field structure for the past 10 ky with stronger average fields in the northern hemisphere and more active secular variation in the southern hemisphere. There is a long-term increase in the dipole from about 6000 BC until 300 AD, and one interval exhibiting particularly strong growth corresponds to the rapid appearance of regional spikes in field strength in the Levantine region. Since 300 AD the axial dipole strength has generally declined from its peak of over 100 ZAm^2 to the present day value near 80 ZAm^2. The regional extent and impact of the Levantine field spikes on global average field strength during the Holocene has yet to be fully elucidated, and it remains an open question whether similar features occur at other places and times.

In this work I explore two questions. The first is the relationship between spike-like behavior, dipole growth, and other field properties. The second is to understand the changes that lead to intervals of decreasing dipole moment as is happening today and occurred in more dramatic form during the Laschamp excursion centered about 41 ka. Time-varying spherical harmonic and stochastic paleofield models are used as a basis for exploration of two periods of change in geomagnetic dipole moment: (i) the dipole moment decay and subsequent recovery in a period of 20 ky surrounding the Laschamp excursion, and (ii) growth in dipole moment from about 6000 BC to 300 AD and transition to decay seen in the present field.

A04 - Open session on paleo- and rock magnetism (DIV I)

Rock magnetism applied to decipher the firing conditions in mysterious Neolithic burnt settlements in SE Europe – the case study of Mursalevo site (Bulgaria)

Abstract ID : 692

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Neli Jordanova ,neli_jordanova@hotmail.com ,(scientist) ,Bulgaria ,Sofia ,Presenting[1]

Prof. Diana Jordanova ,diana_jordanova77@abv.bg ,(None) ,Bulgaria , ,Not Presenting[1]

Dr. Marya Kostadinova-Avramova ,miki4740@abv.bg ,(None) ,Bulgaria , ,Not Presenting[1]

Dr. Deyan Lesigyarski ,dekemvri14@abv.bg ,(None) ,Bulgaria , ,Not Presenting[1]

1 - NIGGG-BAS 2 - NIGGG-BAS 3 - NIGGG-BAS 4 - NIGGG-BAS

Archaeological excavations in the Struma (Strimon) river valley (SW Bulgaria) done recently (2014-2015) discovered one of the largest known Neolithic settlements at the Balkans dated to the Early (first half of the 6th millennium BC) and the Late Neolithic (end of the 6th and the beginning of the 5th millennium BC) period, characterized by massive strong burning of almost all houses. Such "burnt house horizon" has been also found in other Neolithic sites in SE Europe and this phenomenon is widely discussed in prehistorical archaeology. Because of the evidences for very strong fire, causing destruction of the houses, the hypothesis for deliberate burning with ritual purposes has been put forward. Opposed to this, different other hypotheses supporting non-deliberate fire are debated. Detailed sampling of burnt clay remains from 20 burnt houses from Mursalevo site for rock-magnetic investigations have been carried out. The main purpose of the study was to evaluate the firing temperatures reached during house burning and to provide evidence supporting one of the hypotheses for the most probable cause of houses destruction. Magnetic mineralogy deduced from high-temperature behavior of magnetic susceptibility, IRM acquisition curves analysis and hysteresis measurements show the presence of magnetite, hematite and possibly wustite. Firing temperatures determined according to the method based on step-wise re-firing followed by magnetic susceptibility measurements at room temperature, vary in a wide range between 720 and 1140 degrees Celsius. Temperatures in excess of 1000 deg.C are related to vitrified clay, characterized by Scanning Electron Microscopy observations as well. Maps of field magnetic susceptibility, laboratory measured mass-specific magnetic susceptibility and ancient firing temperatures evaluated are constructed and discussed in archaeological context.

On the cause of the non-Gaussian distribution of residuals in geomagnetism

Abstract ID : 806

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Gauthier Hulot ,gh@ipgp.fr ,(Deputy Director in charge of research and space activities) ,France ,Paris ,Presenting[1]

Prof. Andrei Khokhlov ,fbmotion@gmail.com ,(None) ,Russia , ,Not Presenting[2]

1 - Institut de Physique du Globe de Paris 2 - IEPT, Russian Academy of Sciences and Institute of Physics of the Earth, Russian Academy of Sciences

To describe errors in the data, Gaussian distributions naturally come to mind. In many practical instances, indeed, Gaussian distributions are appropriate. In the broad field of geomagnetism, however, it has repeatedly been noted that residuals between data and models often display much sharper distributions, sometimes better described by a Laplace distribution. In the present study, we make the case that such non-Gaussian behaviors are very likely the result of what is known as mixture of distributions in the statistical literature. Mixtures arise as soon as the data do not follow a common distribution or are not properly normalized, the resulting global distribution being a mix of the various distributions followed by subsets of the data, or even individual datum. We provide examples of the way such mixtures can lead to distributions that are much sharper than Gaussian distributions and discuss the reasons why such mixtures are likely the cause of the non-Gaussian distributions observed in geomagnetism. We also show that when properly selecting sub-datasets based on geophysical criteria, statistical mixture can sometimes be avoided and much more Gaussian behaviors recovered. We conclude with some general recommendations and point out that although statistical mixture always tends to sharpen the resulting distribution, it does not necessarily lead to a Laplacian distribution. This needs to be taken into account when dealing with such non-Gaussian distributions.

Principal component analysis of palaeomagnetic directions: converting a Maximum Angular Deviation (MAD) into an ?95 angle

Abstract ID : 807

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Andrei Khokhlov ,fbmotion@gmail.com ,(None) ,Russia , ,Not Presenting[1]

Dr. Gauthier Hulot ,gh@ipgp.fr ,(Deputy Director in charge of research and space activities) ,France ,Paris ,Presenting[2]

1 - IEPT, Russian Academy of Sciences and Institute of Physics of the Earth, Russian Academy of Sciences 2 - Institut de Physique du Globe de Paris

Directions recovered from palaeomagnetic samples are usually archived with some quantitative information about their precision, most often in the form of a so-called α95 angle. Such angles are classically co-estimated with the recovered palaeomagnetic direction from a collection of samples providing individual estimates of this direction. In some instances, however, palaeomagnetic directions have to be inferred from a single sample in which case no α95 angle can be recovered in this way. Fortunately, the progressive demagnetization techniques and principal component analysis universally used to recover directional information from single samples provide alternative measures of the error affecting the recovered direction, known as Maximum Angular Deviation (MAD) angles. These have so far only been considered as rough quality indicators. Here, however, we show that directions recovered in this way can be assumed to satisfy a Fisher distribution, and that the corresponding MAD angles can be rescaled into α95 estimates by multiplying it by an appropriate factor, which only depends on the number of demagnetization steps used in the principal component analysis and on whether one relies on a standard or a so-called 'anchored' principal component analysis. These coefficients have been tabulated and practical recommendations for taking advantage of them outlined in the final section of the text. They provide simple means for users to produce much needed error bars on declination and inclination time series recovered from sedimentary long sequences

VARIFORC v.4: a new tool for dealing with the complexity of advanced FORC analyses without specialized knowledge

Abstract ID : 920

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ramon Egli ,ramon.egli@zamg.ac.at ,(None) ,Austria ,None ,Not Presenting[1]

1 - Central Institute for Meteorology and Geodynamics, Vienna

In recent years, first-order reversal curves (FORC) have become a standard tool for detailed rock-magnetic analyses and numerical unmixing of magnetic components. For certain applications, the use of specific FORC measurement protocols and analysis tools is critical. Paradigmatic examples are given by weak sediment samples containing non-interacting single-domain particles, and all materials whose hysteresis loop is characterized by strongly contrasting slopes (e.g. rectangular or wasp-waisted). To overcome such intrinsic difficulties and avoid the misinterpretation of measurement and/or processing artifacts, while providing sufficient noise rejection, high-resolution measurement protocols and varia-ble-smoothing processing have been developed [1-3]. These tools, however, came at cost of a universal approach accessible also to non-specialists. The first version of VARIFORC focused on the introduction of exhaustive user-controlled parameters that handle all abovementioned processing problems. These parameters can be easily recalled when batch-processing similar measurements, however, the correct choice of processing options during initial runs requires some experience. A new automated assistant has been added in the latest version of VARIFORC [4], which guides unexperienced user step by step without any previous knowledge, and the need to refer to a user manual. Working examples demonstrate the effectiveness of this approach and how critical pitfalls are automatically overcome. VARIFORC v.4 is therefore an interesting option for students and experienced users.

[1] Egli et al., Geochem. Geophys. Geosys. 11 (2010).
[2] Heslop and Roberts, Geochem. Geophys. Geosys. 13 (2012).
[3] Egli, Global Planet. Change 110 (2013).
[4] Available at www.conrad-observatory.at/zamg/index.php/downloads-en/ before conference starts.

Revisiting the connection between the past geomagnetic field and the radionuclide production rate

Abstract ID : 995

Conflict Declaration : None

Content Motivation : None

Additional Information : This work has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 659901.

Mr. F. Javier Pavón-Carrasco ,fjpavon@ucm.es ,(Marie Sk?odowska-Curie Postdoctoral Fellow) ,Spain ,Madrid ,Presenting[1]

Dr. Miriam Gómez-Paccard ,mgomezpaccard@igeo.ucm-csic.es ,(None) ,Spain , ,Not Presenting[2]

Dr. Saioa A. Campuzano ,sacampuzano@ucm.es ,(None) ,Spain , ,Not Presenting[1]

Dr. J. Fidel González-Rouco ,fidelgr@ucm.es ,(None) ,Spain , ,Not Presenting[1]

Dr. M. Luisa Osete ,mlosete@ucm.es ,(None) ,Spain , ,Not Presenting[1]

1 - Complutense University of Madrid 2 - Instituto de Geociencias IGEO (UCM-CSIC) 3 - Complutense University of Madrid 4 - Complutense University of Madrid 5 - Complutense University of Madrid

The production rates of cosmogenic isotopes, such as ^{14}C and ^{10}Be, are directly modulated by the strength of the Solar and Earth magnetic fields. Changes in the isotope production rate during the Holocene are estimated mainly from isotopic sampling in tree and ice cores, while the past evolution of the geomagnetic field can be recovered from well-dated rock samples containing magnetic minerals than can be used to obtain the so-called paleomagnetic data. However, no indirect measurements provide the past solar activity. Estimates of solar forcing play an important role in understanding paleoclimatic temperature reconstructions and as boundary conditions in simulations with climate models due to its influence to modify the energy balance of the Earth. Nowadays, different studies consider that both magnetic fields affect the production rate at two different timescales: the long-term modulation is associated to changes in the geomagnetic field and the shorter variations to the past solar activity. However, the most recent palaeomagnetic reconstructions developed during the last years provide a new picture with higher temporal resolution of the past variations of the strength of the Earth's magnetic field. In this work, we revisit the connection between the past evolution of the Earth's magnetic field and the production rates of ^{14}C and ^{10}Be for the Holocene by means of the more complete paleomagnetic database and the most recent geomagnetic reconstructions.

Harald Böhnel : in case of time limits, this could go to posters as indicated by author

Environmental magnetism study for the determination of paleoclimates and paleoenvironmental conditions in Serdan Oriental Basin.

Abstract ID : 1285

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Kurt Heinrich Wogau ,kurtwogau@gmail.com ,(None) ,Mexico ,Queretaro ,Not Presenting[1]

Dr. Harald Böhnel ,hboehnel@geociencias.unam.mx ,(None) ,Mexico ,Queretaro ,Not Presenting[2]

Dr. Tripti Bhattacharya ,tripti@email.arizona.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Roger Byrne ,arbyrne@berkeley.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Kenneth L Verosub ,klverosub@ucdavis.edu ,(None) ,Mexico , ,Not Presenting[5]

1 - UNAM 2 - Centro de Geociencias, Universidad Nacional Autónoma de México 3 - University of Arizona 4 - University of California, Berkeley 5 - University of California, Davis campus

Aljojuca lake is located in the Serdan Oriental basin in the state of Puebla, in the eastern part of the Transmexican Volcanic Belt. Three lake sediment cores were recovered for studying the magnetic mineralogy, in order to study the the paleo climate and paleo environmental conditions of the area. Core images and magnetic concentration dependent parameters were used to correlate the core sections and then build a compound core. The length of this core is 1171.2 cm and the maximum age is 5460 years according to fifteen C-14 ages. The core was subdivided into four zones with similar behavior of the magnetic concentration-dependent parameters. The results shows that the main magnetic minerals in Aljojuca lake are magnetite and titanomagnetite, with the rare presence of hematite and iron sulfurs like greigite. The principal magnetic grain size observed in the sediments is pseudo single-domain, determined from King and Day plots. Comparing the results of magnetic mineralogy with different chemistry and oxygen isotopes, we interpreted the paleo climatic-environmental conditions. Zones I (6-4 kyr) is dominated by hight input of sediments, showed in the magnetic susceptibility and Al_2O_3 parameter, interpreted as a wetter conditions. Zone II (4-2.5 kyr) the input of sediments is reduced, there is significan change in grain size of magnetic particles and the presence of hematite, suggesting the change to wetter to dry conditions. Zone III (2.5-1 kyr) we relate the presence of gregite, due the high concentration of organic matter, producing reducing conditions during the low level of the lake, related with dry climates. This episode coincides with the fall of prehispanic city of Cantona around 950 CE. Zone IV (1 kyr - present) is characterized by hight input of sediments related with the increase of anthropogenic activity, first by the spanish conquest and the for the modern agriculture activities.

Tomasz Werner : None

The MagIC (Magnetics Information Consortium) Database: Current Status and Future Prospects

Abstract ID : 1477

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Catherine Constable ,cconstable@ucsd.edu ,(None) ,United States ,La Jolla, 92093-0225 ,Presenting[1]

Prof. Anthony Koppers ,akoppers@coas.oregonstate.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Rupert Minnett ,rminnett@cogense.com ,(None) ,United States , ,Not Presenting[3]

Prof. Lisa Tauxe ,ltauxe@ucsd.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Nicholas Jarboe ,njarboe@ucsd.edu ,(None) ,United States , ,Not Presenting[4]

Ms. Lori Jonestrask ,mintblue87@gmail.com ,(None) ,United States , ,Not Presenting[4]

1 - University of California-San Diego 2 - Oregon State University 3 - Cogense Inc 4 - Scripps Institution of Oceanography, UCSD 5 - Scripps Institution of Oceanography, UCSD 6 - Scripps Institution of Oceanography, UCSD

The goals of the Magnetics Information Consortium (MagIC) are to improve research capacity in the Earth sciences, by maintaining an open community digital data archive for rock and paleomagnetic data with web portals that allow users free access to archive, search, visualize, and download these data. MagIC supports the international rock and paleomagnetic communities and strives to bring data out of researchers' private archives and personal computers, making them accessible to everybody and useable for new creative and collaborative activities. A major task undertaken under MagIC is the integration of data spread across disparate IAGA databases enabling uniform access to a broad range of sample-based records.
MagIC infrastructure includes: **(i)** a standard data and metadata model (currently version 3.0) for archiving data that allows interoperable searches with other Earth science databases, **(ii)** the capability for researchers to archive data in a freely accessible online database accommodating the broadest possible range of rock and paleomagnetic data and associated information, **(iii)** search and visualization tools, **(iv)** the capability for downloading data to use in future research, and finally **(v)** novel ways for scientists to collaborate online with colleagues, co-authors and students, using the website, tools and database in a protected/private manner, before their data are made public.

Current capabilities will be described emphasizing recent improvements in version 3.0 that facilitate easy upload of data, visualization, and search capabilities.

A05 - 50 years since Zijderveld: Tectonic reconstructions from palaeomagnetism and magnetic fabric (DIV I)

Low- and high field AMS of the Early Triassic rocks from Spitsbergen

Abstract ID : 592

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Katarzyna Dudzisz ,katarzyna.dudzisz@gmail.com ,(Ph.D. candidate) ,Poland ,Warsaw ,Presenting[1]

Prof. Ann Marie Hirt ,ann.hirt@erdw.ethz.ch ,(None) ,Switzerland , ,Not Presenting[2]

Prof. Rafal Szaniawski ,rafsz@igf.edu.pl ,(None) ,Poland ,None ,Not Presenting[3]

Dr. Krzysztof Michalski ,krzysztof.michalski@igf.edu.pl ,(None) ,Poland , ,Not Presenting[1]

1 - Institute of Geophysics, Polish Academy of Sciences 2 - Institute of Geophysics ETH Zurich 3 - Institute of Geophysics Polish Academy of Sciences 4 - Institute of Geophysics, Polish Academy of Sciences

A rock magneticstudy was undertaken on EarlyTriassicsediments from the West Spitsbergen Fold and Thrust Belt (Hornsund, Bellsund) and from the foreland of this orogen (Sassendalen) in order to studyhowthermal and deformationaleventsaffectedtheirmagneticmineralogy. The ferromagneticmineralogy was determinedusinghysteresis, backfield IRM, thermaldemagnetization of a composite IRM, FORC, and thermomagneticanalysis. In addition, low-field AMS was measured to assess the degree of deformation and high-field torque magnetometry was applied to isolate the ferro- and paramagneticsubfabrics. The ferromagneticmineralogyisverydiversealong the WSFTB and rather uniform atSassendalenwheremagnetite with variablecontent of Ti predominate. FORC diagramsindicatepresence of SP grains of magnetite and mixture of PSD grains of magnetite and greigite. The magneticsusceptibilityisvariablewithin the investigatedarea, reaching the highest and most homogenousvaluesatsitestaken from Sassendalen (100-300*10-6 SI). AMS studies show that a normalmagneticfabricispresent in most sites. However, invertedfabricsweredetectedattwo of the southermostsites from Hornsund and a furthertwo from Sassendalen. Results of torquemeasurements and hysteresisstudiesimplythatmagneticsusceptibility in the majority of rocksaredominated by paramagneticminerals (>95%), and onlyattwosites, containinghaematite, have a moresignificantferromagnetic (s.l.) contribution. Torquemeasurementsindicatethatbothreverse and normalfabricsarecarried by the paramagneticphases. Siderite was found to be responsible for invertedfabric in Hornsundsites, whileatSassendalen, other iron-bearingcarbonatesmay be

responsible. At the Hornsund and Bellsundareas, directions of magneticlineationfollow the general NNW-SSE trend of the WSFTB, whereaslineationatoutcrops in Sassendalenareperpendicular to the WSFTB, and represent most likely direction of palaeotransport. These results reflect the necessity of understanding the minerals that carry the magnetic fabric in order to interpret the deformational history.

Paleomagnetic evidence for a collision of Patagonia with Gondwana in the Permo-Triassic?

Abstract ID : 794

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Tomás Luppo ,tomasluppo@gmail.com ,(None) ,Argentina , ,Not Presenting[1]

Dr. Augusto Rapalini ,rapalini@gl.fcen.uba.ar ,(Associate Professor) ,Argentina ,Buenos Aires ,Presenting[2]

Dr. Carmen Martinez Dopico ,carmenmd@ingeis.uba.ar ,(None) ,Argentina , ,Not Presenting[1]

Dr. Mónica López de Luchi ,deluchi@ingeis.uba.ar ,(None) ,Argentina , ,Not Presenting[1]

Dr. Christopher Mark Fanning ,mark.fanning@anu.edu.au ,(None) ,Australia , ,Not Presenting[5]

1 - CONICET 2 - Universidad de Buenos Aires 3 - CONICET 4 - CONICET 5 - Australian National University, Canberra

The "origin" of Patagonia has been an unsolved debate for the last three decades. The Permo-Triassic Ventana Fold Belt in central-eastern Argentina, and its continuation in the South African Cape Fold Belt, far-away from the southwestern Gondwana active margin has been the most conspicuous evidence in favour of a Late Paleozoic accretion of an allochtonous or para-authochtonous Patagonia terrane. Correlation of Early Paleozoic basement rocks between northern Patagonia and the Pampean Ranges in central Argentina, on the other hand, has been interpreted as evidence for an "authochtonous" Patagonia. Scarce paleomagnetic data on Paleozoic rocks from Patagonia have suggested limited if any relative displacement with respect to Gondwana since Devonian times. However, not only this database is scarce but shows very loose age constraints for the paleomagnetic poles, turning ambiguous any comparison with a reference apparent polar wander path (APWP) for Gondwana. We present new paleomagnetic data on accurately dated volcanic rocks from the North Patagonian Massif. A paleomagnetic pole from the Collinao Dacite (253±2 Ma) based on seven sites, and validated by an inverse contact test, plus a single VGP from a Rhyolite Dome (264±2Ma) and two from subvertical basic dykes (255-246 Ma?) fall in an anomalous position with respect to the reference APWP of Gondwana. A second paleomagnetic pole, computed from 12 subvertical acidic dykes (244±2Ma) in the same region, agrees with 250-240 Ma Gondwana reference poles. To reconcile both observations a tectonic model in which Patagonia collided with the southern Gondwana margin by the latest Permian-early Triassic, closing a small V-shaped oceanic basin is presented. Recently found evidence of Permo-Triassic highly deformed granitoids in northeastern Patagonia and timing of deformation in the Hesperides Basin offshore central Argentina is consistent with such model. Preliminary paleomagnetic results from a nearly continuous succession of volcanic rocks that encompass the Permian-Triassic boundary in the same region would support this interpretation.

Anomalous variation of magnetic anisotropy with low-field in some volcanic dykes and its magneto-mineralogical origin

Abstract ID : 1094

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Frantisek Hrouda ,hrouda@agico.cz ,(None) ,Czech Republic , ,Presenting[1]

Dr. Martin Chadima ,chadima@agico.cz ,(Research Scientist) ,Czech Republic ,Brno ,Not Presenting[2]

Dr. Josef Jezek ,josef.jezek@natur.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[3]

1 - Charles University 2 - AGICO, Inc. & Institute of Geology of the CAS, v. v. i. 3 - Faculty of Sciences, Charles University, Prague, Czech Republic

The fields used in common AMS meters are relatively weak, only slightly exceeding the Rayleigh Law range. Theory of the low-field anisotropy of magnetic susceptibility (AMS) assumes a linear relationship between induced magnetization and magnetizing field, resulting in field-independent susceptibility. This is valid for diamagnetic and paramagnetic minerals by definition and also for pure magnetite, while in titanomagnetite, pyrrhotite and hematite the susceptibility may be clearly field-dependent even in low fields used in common AMS meters. However, the linear AMS theory is routinely applied also for the rocks whose AMS is carried by the latter minerals. This is because the linear theory is simple and elegant and it is believed that the errors introduced through linear fit to non-linear data are not too large for common geological application. And indeed, it was demonstrated many times that, in rocks whose AMS is carried by a sole magnetic mineral showing low-field-dependent susceptibility, the field variation of the principal directions and the shape of the AMS ellipsoid are very weak. Consequently, if we are primarily interested in the orientations of magnetic lineation, magnetic foliation and magnetic fabric symmetry (and this is the case in most geological applications), one can use the simple and illustrative linear theory without danger of significant loss of accuracy.

Exceptionally, the principal directions may vary even with low-field. Examples of this variation are provided by some (titano-)magnetite bearing rocks sampled in volcanic dykes of the Bohemian Massif. As shown by temperature variation of susceptibility, the magnetic susceptibility of these rocks is carried by two (or more) magnetic phases, both showing significant, but different, variations of susceptibility with low-field. If these phases possess differently oriented magnetic fabrics, the whole-rock AMS (i.e. principal directions, magnitude and symmetry) varies with field according to gradual activations of these phases with increasing field. Gradual changes in composite AMS fabric can be interpreted using field variations of in-phase and out-of-phase AMS together with anisotropy of anhysteretic remanence.

Tammy Maart : None

Anisoft – Complex Treatment of Magnetic Anisotropy Data

Abstract ID : 1165

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Martin Chadima ,chadima@agico.cz ,(Research Scientist) ,Czech Republic ,Brno ,Presenting[1]

1 - AGICO, Inc. & Institute of Geology of the CAS, v. v. i.

Since its first release, Anisoft software has gained a broad popularity mainly due to its straight-forward and user-friendly interface enabling to visualize magnetic anisotropy tensors. After almost a decade, a major update of Anisoft is presented transforming a rather simple data browser into a platform offering a complex treatment of anisotropy data. The updated Anisoft introduces new enlarged binary data format which may store both in-phase and out-of-phase (if measured) tensors of anisotropy of magnetic susceptibility (AMS) or tensors of anisotropy of magnetic remanence (AMR) together with respective confidence ellipses of principal anisotropy directions and values of F-tests for anisotropy. In addition to the tensor data, a whole array of orientation angles and orientation parameters is stored for each record enabling to perform any post-acquisition corrections in orientation of specimens or mesoscopic foliation or lineation. The input data may be directly acquired by AGICO Kappabridges, imported from various external data formats or manually created (e.g., if one has data in a non-electronic form). Calculated principal anisotropy directions are conventionally displayed in stereoplots together with histograms of a wide array of quantitative anisotropy parameters and x-y diagrams showing mutual relationship of any combination of these parameters (e.g., P vs. T, Km vs. P plots...etc.). Anisotropy data can be split into various clusters by selecting them either manually (in a list of specimens, stereoplot or any x-y plot) or by filtering them according to their values. When processing a group of specimens, individual principal directions (maximum, intermediate, or minimum) can be contoured, or a mean tensor and respective confidence ellipses of its principal directions can be calculated using either the Hext-Jelinek (Jelinek 1978) statistics or the Bootstrap method (Constable & Tauxe 1990). Selected anisotropy data can be exported into simple text files ready to be imported to various types of external data processing software. Each graphical output can be exported into vector or raster graphical formats or, via clipboard, pasted directly into a presentation or publication manuscript.

Identification of Mass Transport Deposits on the Submarine Bank of Portimão (Gulf of Cadiz, SW Iberia)

Abstract ID : 1449

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Pedro Silva ,pmfsilva@fc.ul.pt ,(Researcher) ,Portugal ,Lisbon ,Presenting[1]

Dr. Cristina Roque ,cristina.roque@ipma.pt ,(None) ,Portugal , ,Not Presenting[2]

Dr. Teresa Drago ,tdrago@ipma.pt ,(None) ,Portugal , ,Not Presenting[3]

Dr. Ana Lopes ,anaijlopes@gmail.com ,(None) ,Portugal , ,Not Presenting[3]

Dr. Belen Alonso ,belen@icm.csic.es ,(None) ,Spain , ,Not Presenting[5]

Dr. Juan Vázquéz ,juantomas.gemar@gmail.com ,(None) ,Spain , ,Not Presenting[6]

Dr. David Casas ,d.casas@igme.es ,(None) ,Spain , ,Not Presenting[7]

Dr. Nieves Lopéz ,nieves.gemar@gmail.com ,(None) ,Spain , ,Not Presenting[8]

Dr. Gemma Ercilla ,gemma@icm.csic.es ,(None) ,Spain , ,Not Presenting[9]

1 - IDL and ISEL 2 - EMEPC- Estrutura de Missão para a Extensão da Plataforma Continental, Paço de Arcos, Portugal 3 - IPMA-Instituto Português do Mar e da Atmosfera, Tavira, Portugal 4 - IPMA-Instituto Português do Mar e da Atmosfera, Tavira, Portugal 5 - CSIC- Instituto Ciencias del Mar, Barcelona, Spain, 6 - IEO- Instituto Espanol de Oceanografía, Málaga, Spain 7 - IGMEInstituto Geológico y Minero de España, Madrid 8 - IEO- Instituto Espanol de Oceanografía, Málaga, Spain, 9 - Instituto de Ciencias del Mar

Submarine mass transport deposits (MTDs) plays an important geo-hazards role along continental margins. Their identification and characterization is then crucial to understand their sources, dynamics, frequency and spatial distribution. In this work a piston core located at the slope (2876 m water depth) of the southern flank of Portimao Bank (Portugal, Gulf of Cadiz, SW Iberia) underwent detailed magnetic (fabric and rock magnetism) and sedimentological (grain-size, carbonates, organic matter) analyses complemented by AMS 14C dating. Such multidisciplinary study identified about one meter of sediments that is unconformable with the ages obtained above and below this layer. Its magnetic fabric, as determined by anisotropy of magnetic susceptibility, indicates sharply changes from oblate to neutral shape, decrease of the anisotropy and preferred orientation of the magnetic susceptibility ellipsoid. Such layer is also individualized by sedimentary parameters, especially in its upper part by a lighter colour and decrease of the mean grain size than the rest of the core. Based on

these results it is possible to conclude that the sedimentary column analyzed here shows evidence of an on-going development of a slide, which is well individualized and characterized by magnetic fabric studies.

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Keywords: Submarine mass transport deposits, magnetic fabrics, Portimão bank, Gulf of Cadiz.

A06 - Environmental and magnetic signal in sediments, soils, and dust (DIV I)

First magnetic monitoring of the London's particulate matter

Abstract ID : 347

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Adrian Muxworthy ,adrian.muxworthy@imperial.ac.uk ,(Convenor) ,United Kingdom ,London ,Not Presenting[1]

Miss. Claire Lam ,claire.lam10@imperial.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. David Green ,david.c.green@kcl.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - Imperial College 2 - Imperial College London 3 - Kings College London

We report the first magnetic study of London's atmospheric particulate matter. We measured time-series of filters from three localities from the London Air Quality Network to monitor pollution and to regarding pollution reduction. Most of the measurements were magnetic hysteresis, but we also report low-temperature magnetic analyses. Statistical analysis including a principal component analysis (PCA) was applied to relate magnetic parameters to pollution and meteorological parameters. The magnetic mineralogy for all three stations were similar; the main contributor was deemed to be partially-oxidised magnetite that were < 100nm in diameter. However, there were large variations between the sites in terms of abundance; this abundance correlates with the average number of vehicles in the vicinity of sampling localities. There was also observed to be a strong correlation with meteorological data. We suggest that the pollution to be locally derived from vehicles and consist of exhaust and break-on dust.

Past variations of the deep circulation in the South China Sea reconstructed using magnetic properties of sediments.

Abstract ID : 631

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Catherine Kissel ,Catherine.Kissel@lsce.ipsl.fr ,(research scientist) ,France ,Gif-sur-Yvette ,Presenting[1]

Dr. Carlo Laj ,carlo.laj@ens.fr ,(Emeritus professor) ,France ,Paris ,Not Presenting[2]

Dr. Zhimin Jian ,jian@tongji.edu.cn ,(None) ,China , ,Not Presenting[3]

Miss. Camille Wandres ,Camille.Wandres@lsce.ipsl.fr ,(None) ,France , ,Not Presenting[1]

1 - LSCE 2 - Ecole normale Supérieure 3 - Marine Geology, Tongji University 4 - LSCE

Present-day Pacific deep waters enter into the South China Sea (SCS) through the Luzon strait at about 2400 meters depth and invade the SCS through a basin-scale cyclonic circulation. After upwelling in the southwestern part of the SCS, they return into the Pacific, again through the Luzon strait, as an intermediate depth water mass. Past variations of the intensity, depth and path of this deep water mass are still poorly known at the scale of the entire SCS. They can be traced by analyzing the magnetic fraction of the sediment delivered by the surrounding continental regions and re-distributed within the SCS by the oceanic water masses. Indeed, previous studies have shown that the magnetic composition of the river sediments drained into the SCS is significantly variable from north to south. On the basis of this knowledge, we examine the magnetic properties of a number of cores distributed along the Asian continental margin in a roughly N-S transect and in depth between 1400 and 3200 m. They all cover at least the last climatic cycle with sedimentation rates of the order of 10-20 cm/ka. Low field susceptibility, anhysteretic (ARM) and isothermal (IRM) remanent magnetizations, S-ratio, HIRM have been measured with a resolution of 4 cm giving access to the magnetic coercivity and concentration. Thermal demagnetization of three axes IRM allow to identify the magnetic minerals associated to each coercivity family determined by hysteresis parameters, FORC diagrams and log Gaussian decomposition of IRM acquisition curves. Clear changes are observed at the glacial/interglacial scale at each site and the contrast between North and South is of minor amplitude during interglacials than glacials. These results which suggest a more active deep water mass during interglacials than during glacials, will be compared and discussed with other data and reconstructions.

Wildfires as a factor in build-up of the environmental magnetic record of forest soils

Abstract ID : 686

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Diana Jordanova ,diana_jordanova77@abv.bg ,(None) ,Bulgaria , ,Not Presenting[1]

Prof. Neli Jordanova ,neli_jordanova@hotmail.com ,(scientist) ,Bulgaria ,Sofia ,Presenting[1]

1 - NIGGG-BAS 2 - NIGGG-BAS

The variations of magnetic properties along depth of different soil types are widely used as proxies for the reconstruction of the environmental conditions during pedogenesis. These are systematically explored in relation to climate attributes - temperature and precipitation. Along with the natural in situ formation of pedogenic iron oxides, wildfires also may cause significant soil magnetic enhancement of the uppermost soil layers. These phenomena are explored for three locations in mountainous areas in Bulgaria, covered by coniferous forests. From each location two soil profiles have been sampled - burnt and natural. Burnt sites are characterized in terms of time of fire occurrence, fire severity and burn severity. Detailed magnetic studies reveal that wildfires cause significant magnetic enhancement of the soil uppermost 3 to 5cm, affected by fire, which is significantly different from the observed magnetic enhancement of the adjacent non-burnt natural soil profiles. The major characteristics, related to wildfire effect are the Anhysteretic remanence (ARM) and partially frequency dependent magnetic susceptibility. Laboratory step wise heating at 300, 350 and 400 deg.C of samples from the natural soil profiles and the following room-temperature measurements of magnetic susceptibility, ARM and Isothermal remanence (IRM2T) were used to infer the most probable maximum temperature of the uppermost mineral soil attained during wildfire. SEM and TEM observations reveal the presence of typical combustion derived spherules, resulting from combustion aerosols.

Can syn-depositional remanent magnetizations faithfully record the Earth magnetic field? First insights from a new model

Abstract ID : 918

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited

Dr. Ramon Egli ,ramon.egli@zamg.ac.at ,(None) ,Austria ,None ,Not Presenting[1]

1 - Central Institute for Meteorology and Geodynamics, Vienna

Since the first experiments on depositional remanent magnetization (DRM) acquisition experiments by Johnson et al. in 1948, the mechanics of magnetic grain alignment during the complex sequence of syn- and post-depositional processes (PDRM) is not fully understood - so that important limitations persist in the capability of disentangling paleomagnetic and environmental signals. (P)DRM acquisition models can be divided into two main categories: those based on a dynamic equilibrium with the magnetic field in presence of decaying randomization processes (e.g. bioturbation-induced [1]), and those where particle rotation is halted before full alignment is reached (e.g. particles settling in a resting environment [2]). The former category bears the same well-behaved paleomagnetic characteristics of thermore-manent magnetizations, while the latter yields magnetizations whose intensity is sensitive to the timing of the process, as seen from the evolution of DRM model results from Nagata's isolated magnetic particles to flocculation, where DRM intensity depends on the thickness of the water column and the (environmentally-driven) concentration of suspended particles [2]. A severe limitation of current DRM models is the assumption that settling occurs in a resting fluid, where hydrodynamic torques depend only on the characteristics of suspended particles and their reciprocal interactions. Natural basins, on the other hand, provide a strongly anisotropic hydrodynamic environment - the turbulent boundary layer - which has the largest influence on particle orientation. Numerical models of so-called wall flows show that the resulting DRM is affected by strong inclination shallowing, while the magnetization intensity is modulated by the mean flow speed. Such effects are particularly pronounced in the limit case of turbi-dites, explaining natural observations [3], and remain significant even in the quietest deep-sea settling environments. This implies that syn-depositional DRM always provide biased and environmentally modulated records of the Earth-magnetic. Reliable sedimentary paleomagnetic signals therefore appear to rely on further particle reorientation inside the uppermost few cm of sediment.

[1] Zhao et al., Nat. Comm. 7 (2016).
[2] Mitra and Tauxe, Earth Planet. Sci. Lett. 286 (2009).
[1] Shcherbakov and Sycheva, Geochem. Geophys. Geosys. 11 (2010).
[2] Tanty et al., Geochem. Geophys. Geosys. 17 (2016).

Source-to-sink magnetic properties of NE Saharan dust: paleoenvironmental implications

Abstract ID : 1028

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Juan Larrasoaña ,jc.larra@igme.es ,(Staff Scientist) ,Spain ,Zaragoza ,Not Presenting[1]

Prof. Andrew Roberts ,andrew.roberts@anu.edu.au ,(None) ,Australia , ,Not Presenting[2]

Prof. Qingsong Liu ,qsliu@sustc.edu.cn ,(None) ,China , ,Not Presenting[3]

Prof. Frank Oldfield ,oldfield.f@gmail.com ,(None) ,United Kingdom , ,Not Presenting[4]

Prof. Eelco Rohling ,eelco.rohling@anu.edu.au ,(None) ,Australia , ,Not Presenting[5]

Dr. David Heslop ,david.heslop@anu.edu.au ,(Academic) ,Australia ,Canberra ,Not Presenting[2]

1 - IGME 2 - Australian National University 3 - SUSTC 4 - University of Liverpool 5 - ANU 6 - Australian National University

Here we present a review of the magnetic properties of NE Saharan dust that was conducted, following a source-to-sink approach, to unravel the paleoclimatic significance of environmental magnetic records from Eastern Mediterranean marine sediments. Our synthesis indicates that pedogenic hematite, formed during past wetter Green Sahara periods (GSPs), is the most common magnetic mineral in Eastern Mediterranean marine sediments as a result of its eolian transportation, along with smaller amounts of lithogenic hematite, from the NE Sahara. Coupled with the limited impact of reductive sedimentary diagenesis on hematite abundances in sediments, this indicates that hematite concentrations provide reliable quantitative estimates of NE Saharan dust supply. Variations in NE Saharan dust supply record an on-off mechanism in which a key control on eolian input is provided by the monsoon-driven spread and retreat of savannah vegetation through the Sahara. Magnetite/maghemite is also a common magnetic mineral, also formed pedogenically during GSPs, in NE Saharan dust. Limited production of magnetite/maghemite in the source area during GSPs, along with the later imprint of diagenetic processes, indicates that magnetite/maghemite abundances cannot be used to estimate dust inputs from the NE Sahara. Goethite cannot be used either to estimate variations in NE Saharan dust supply, because its occurrence in Eastern Mediterranean marine sediments also appears to be linked to fluvial inputs. Our review reinforces the view that a source-to-sink approach should be routinely conducted in environmental magnetic studies to understand the complex combination of processes involved in the production, transportation, sedimentation and diagenetic evolution of magnetic minerals in sedimentary environments.

The application of magnetics measurements in South African 'cut and fill' landscapes: implications for reconstructing internal and external drivers.

Abstract ID : 1133

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Chris Oldknow ,chris.oldknow62@gmail.com ,(Honorary Research Fellow) ,United Kingdom ,Liverpool ,Not Presenting[1]

1 - University of Liverpool

Detailed magnetic measurements on complex late Quaternary alluvial and colluvial sequences in semi-arid environments are relatively rare. The present case study illustrates the value of magnetic measurements in: (i) reconstructing and distinguishing between transient sediment stores, long term sinks and major transport pathways; and (ii) characterising pedogenic and diagenetic changes in valley fills lying at a major climatic junction in the Great Karoo, South Africa. The magnetic data are embedded within a detailed morphostratigraphic and geochemical context supported by micromorphological data from a major palaeosol. The results of this study offer a unique opportunity to evaluate the usefulness of magnetic properties with respect to unravelling the relative roles of internal (autogenetic, complex response, connectivity) and external (climate) processes governing landscape evolution in a region of the Karoo that has been undergone episodic 'cut and fill' in the past 20,000 years.

Magnetic signal from the Archean/Paleoproterozoic Transition from the Pilbara Craton, Western Australia

Abstract ID : 1463

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Julie Carlut ,jcarlut@yahoo.fr ,(Dr) ,France ,PARIS ,Not Presenting[1]

Dr. Aude Isambert ,isambert@ipgp.fr ,(None) ,France , ,Not Presenting[2]

Ms. Hélène Bouquerel ,bouquerel@ipgp.fr ,(None) ,France , ,Not Presenting[2]

Dr. Pascal Phillipot ,phillipot@ipgp.fr ,(None) ,France , ,Not Presenting[2]

Dr. Francois Guyot ,guyot@ipgp.fr ,(None) ,France , ,Not Presenting[5]

1 - None 2 - IPGP 3 - IPGP 4 - IPGP 5 - MHN

The formation of iron oxides in Archean and Paleoproterozoic Iron Banded Iron Formations is still a matter of debate. We report a detailed rock magnetic and paleomagnetic study coupled with scanning and transmission electron microscopy and electron microprobe analyses on samples which encompasses the Archean-Proterozoic transition (from the Boolgeeda into the Kungarra Formation in the Pilbara Craton, Western Australia). Treatment of the remanence acquisition curves by cumulative log-Gaussian functions allowed to quantify the relative magnetic contribution of magnetite and hematite throughout the section. Magnetite is identified as the main magnetic carrier in all iron-rich layers including hematite-bearing jasper beds. A sharp decrease in magnetization at the Archean-Proterozoic transition attest for the almost complete disappearance of magnetite/hematite in the section at the onset of the Paleoproterozoic. Chemically impure silician magnetite is reported within specific interval within the late Archean. The detection of nano carbon phase in the same interval attest for a close association of organic carbon with Si-rich magnetite. The paleomagnetic directions obtained are consistent with paleopoles for the region at 2.4-2.5 Ga.

A07 - Earth and beyond: The theory and applications of rock magnetism (DIV I)

Paleomagnetic field reconstruction from mixtures of titanomagnetites

Abstract ID : 333

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Thomas Berndt ,t.berndt13@imperial.ac.uk ,(None) ,United Kingdom ,London ,Presenting[1]

Dr. Ricardo Ramalho ,ric.ramalho@bristol.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Adrian Muxworthy ,adrian.muxworthy@imperial.ac.uk ,(Convenor) ,United Kingdom ,London ,Presenting[3]

Mr. Miguel Valdez-Grijalva ,m.valdez-grijalva13@imperial.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

1 - None 2 - University of Bristol 3 - Imperial College 4 - Imperial College London

Stepwise thermal demagnetization and alternating field (AF) demagnetization are commonly used in paleomagnetic studies to isolate remanent magnetic components of different origins. The magnetically hardest, i.e. highest unblocking temperature/peak field component, is often interpreted as the primary magnetization and magnetically softer components as subsequent remagnetizations due to geological events posterior to the formation of the rock, such as reheating or formation of new magnetic minerals. The correct interpretation of the sequence of the geological events such as tectonic rotations from paleomagnetic data often relies on correctly attributing the observed magnetic directions to the remanence carriers and acquisition mechanisms. Using a numerical model to simulate remanence acquisition and stepwise thermal and AF demagnetization experiments, we show that the presence of mixtures of different magneticminerals, such as magnetite and titanomagnetites of varying titanium-content can have very significant effects on Zijderveld plots. In thermal demagnetization experiments a spurious third component at intermediate temperatures or a continuous curvature may arise from an overlap of the primary remanence with a subsequent thermal or viscous remagnetization carried by small-grained iron-rich magnetite and large-grained titanium-rich titanomagnetite. AF demagnetization plots of magnetic mixtures are even more complex: primary and secondary remanences carried by different minerals may appear as either three or four components in Zijderveld plots. During alternating field demagnetization the highest coercivity component is not necessarily equivalent to the primary remanence and does not necessarily correspond to the highest temperature component in an analogous thermal demagnetization

experiment, i.e., the primary remanence direction cannot be recovered. The effects are shown to be due to the different responsiveness of magnetite and titanomagnetites towards viscous or thermoviscous remanence acquisition: remanent magnetizations with long acquisition times are more effectively recorded by titanium-poor minerals, while short acquisition times are equally well recorded by titanium-rich minerals. In demagnetization experiments on laboratory timescales, the relative contribution of two minerals to Zijderveld plots differs to the relative contribution of remanence acquisition over geological timescales, leading to overlapping components in Zijderveld plots. The model was also used to simulate paleointensity (ancient magnetic field intensity) experiments and it was found that the grain distribution affects the slope of Arai plots, but is negligible compared to the effect of the cooling rate of NRM acquisition. The simulations suggest that for slowly cooled rocks a cooling rate correction of up to 1.5 to 1.6 may be required depending on the mineralogy.

The Hunting of the ‘Psark' - 40 Years On

Abstract ID : 366

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Wyn Williams ,wyn.williams@ed.ac.uk ,(Professor) ,United Kingdom ,Edinburgh ,Not Presenting[1]

Dr. Les Nagy ,l.nagy@ed.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Adrian Muxworthy ,adrian.muxworthy@imperial.ac.uk ,(Convenor) ,United Kingdom ,London ,Presenting[3]

Mr. Pádraig Ó Conbhuí ,s1165102@sms.ed.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. Karl Fabian ,karl.fabian@ngu.no ,(None) ,Norway , ,Not Presenting[5]

Dr. Trevor Almeida ,Trevor.Almeida@glasgow.ac.uk ,(None) ,United Kingdom , ,Not Presenting[6]

1 - University of Edinburgh 2 - University of Edinburgh 3 - Imperial College 4 - University of Edinbyurgh 5 - NGU 6 - University of Glasgow

In 1977 David Dunlop published his influential paper "The Hunting of the 'Psark'", in which he speculated on the nature of the magnetic structure in pseudo-single-domain (PSD) grains and their contribution to paleomagnetic recordings. Almost 40 years on, and although there has been significant progress in our understanding of magnetic properties of small particles, we are only just beginning to understand the detailed magnetic structure of PSD grains and their ability to hold stable thermomagnetic recordings. In this presentation we will explore the evolution of magnetic domain structure in magnetite from the smallest uniformly magnetised grains below 30nm in size through the PSD grain size range and demonstrate how PSD structures evolve into well defined multi domain (MD) grains in sizes above a few microns. The simulation of magnetic structures will be made using a new parallelised micro-magnetic model, capable of modelling magnetite particles up to ~3µm, and with element sizes well below the exchange length. The results show that PSD grains are dominated by vortex structures where the net magnetisation resides in the vortex core. These vortex cores have SD-like properties similar to that imagined by Dunlop's 'Psark's', and their stability is governed by the barriers to 'coherent' vortex core rotation. Evolution to MD states is seen to occur by distortion of the vortex core to generate wings along the hard ?100? direction that eventually form into well defined domain walls separating ?111? domains. We will illustrate this domain state evolution in cuboctahedral grains where the formation closure domains at the surface can also be identified.

On the anisotropy of magnetization measurements of deformed hematite samples

Abstract ID : 791

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Eduard Petrovsky ,edp@ig.cas.cz ,(senior researcher) ,Czech Republic ,Prague 4 ,Presenting[1]

Dr. Matej Machek ,mates@ig.cas.cz ,(None) ,Czech Republic , ,Not Presenting[2]

Dr. Vladimir Kusbach ,kusbach@ig.cas.cz ,(None) ,Czech Republic , ,Not Presenting[2]

Dr. Zuzana Roxerova ,roxerova@ig.cas.cz ,(None) ,Czech Republic , ,Not Presenting[2]

Dr. Ramon Egli ,ramon.egli@zamg.ac.at ,(None) ,Austria ,None ,Not Presenting[5]

Prof. Heinrich Siemes ,siemes@rwth-aachen.de ,(None) ,Germany , ,Not Presenting[6]

1 - Institute of Geophysics 2 - Institute of Geophysics CAS, Prague 3 - Institute of Geophysics CAS, Prague 4 - Institute of Geophysics CAS, Prague 5 - Central Institute for Meteorology and Geodynamics, Vienna 6 - The Institute of Reservoir Petrology RWTH, Aachen

In rock magnetism, induced magnetization measurements (hysteresis loops and FORC diagrams) as well as remanent magnetization measurements are often used to identify the carriers of magnetic signal and assess their grain-size distibution. Unlike magnetic susceptibility, which is in the case of solid rock samples in general assumed to be anisotropic, the above mentioned measurements are often performed in one direction only. Anisotropy of remanent magnetization has been studied and reported in several papers. However, this is not the case of directional dependence of hysteresis loops. The aim of this presentation is to provide evidence that hysteresis loops may be significantly anisotropic. Thus, the interpretation of standard hysteresis loop (and FORC) measurements, along with the remanent magnetization acquisition curves, may be significantly biased and erroneous, if anisotropy is ignored. We studied hematite ore samples (98% Fe_2O_3) from the Superior-type banded iron formations (BIFs) from the Sishen Mine, South Africa, deformed in torsion at 400 MPa confining pressure and constant temperature of 950°C, with constant strain rate of 4.2-4.4 × $10^{-5}s^{-1}$. The finite shear strain ranged between 0.5 and 4.5. The samples were cut in small specimens following the strain gradient. The samples showed high magnetic susceptibility (in the order of 10^{-3}) and thermomagnetic curve characteristic for hematite. Angular-dependent hysteresis loops were measured using EV9 VSM vibrating sample magnetometer (max. applied field of 2 T, rotation around each of three axes with a step of 30°). Set of partial loops for FORC diagrams as well as the remanent magnetization acquisition curves were measured in selected cases along three perpendicular directions. Our results clearly show that deformation induced significant anisotropy of both remanent and induced magnetization, degree of anisotropy being higher for more deformed

specimens. This anisotrpy may be attributed to rearrengement of hematite grains, resulting in preferred orientation of basal planes of hematite. If hysteresis loops were measured in one direction only, their interpretation would result in significantly biased and erroneous interpretation. Therefore, one should always check for the effect of anisotropy, even if the anisotropy of magnetic susceptibility is negligible.

Frequency-Dependent Magnetic Susceptibility: How Trustworthy It Is in Proving Superparamagnetic Particles?

Abstract ID : 793

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Eduard Petrovsky ,edp@ig.cas.cz ,(senior researcher) ,Czech Republic ,Prague 4 ,Presenting[1]

Dr. Hana Grison ,grison@ig.cas.cz ,(researcher) ,Czech Republic ,Prague ,Not Presenting[2]

Dr. Aleš Kapi?ka ,kapicka@ig.cas.cz ,(None) ,Czech Republic , ,Not Presenting[3]

1 - Institute of Geophysics 2 - Institute of Geophysics Czech Academy of Sciences 3 - Institute of Geophysics CAS CR

Frequency-dependent magnetic susceptibility became the primary indicator of significance, of ultrafine superparamagnetic (SP) magnetite (maghemite) particles. The use of this parameter has been historically determined by the availability of Bartington dual-frequency meter, measuring at 470 Hz and 4700 Hz and amplitude of 80 A/m. Later on, more sensitive and accurate AGICO kappabridge MFK1 became available, using three frequencies (976, 3904 and 15616 Hz) and various amplitudes in the range between 2 and 700 A/m. This approach is based on the assumption that the frequency dependence under these measurement conditions is solely due to viscous relaxation of rotation of magnetic moments. In general, the initial susceptibility has two origins; one is the reversible magnetization rotation, and the other is reversible domain-wall motion. Hence, both mechanisms may be frequency-dependent under the measurement conditions using either Bartington or AGICO instrument. It was shown that in case of amorphous alloys measured along the easy axis at field of 0.3 A/m, the relaxation at low frequency is regarded as the domain-wall component and dominates until frequency of about 360 kHz. It is possible that also in other magnetic materials reversible domain wall motion (e.g., vibration and breathing) may play significant role. In our contribution, we will show an example of andic soil developed on basalt, which was supposed to be controlled by lithology, but exhibited significant frequency-dependent magnetic susceptibility (6% obtained from the MFK1, volume susceptibility of 16´10^{-3}), while no other studied parameter indicated significant pedogenesis. Thus the question is to what extent we may trust this parameter as reliable indicator of presence of SP particles. In order to find alternative, we used amplitude dependence of susceptibility, assuming simple model of magnetization acquisition, saturated al low fields in the case of SP particles, combined with non-linear magnetization curve related to multi-domain (MD) particles. By comparing with behavior of reference SP and MD materials, we found that amplitude dependence of magnetic susceptibility of samples of andic soils reflects clear features of SP particles for amplitudes below about 100 A/m, while at higher amplitudes the pattern reflects MD features only. Thus we suggest using amplitude dependence as additional indicator of SP particles.

Utilize rock magnetism to better determine paleointensities for Thellier-series experiments

Abstract ID : 943

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Huapei Wang ,huapei@cug.edu.cn ,(Postdoc / Professor) ,China ,Wuhan ,Presenting[1]

Dr. Dennis V. Kent ,dvk@rutgers.edu ,(None) ,United States , ,Not Presenting[2]

1 - Massachusetts Institute of Technology / China University of Geosciences (Wuhan) 2 - Rutgers University & Lamont-Doherty Earth Observatory

Partial thermal remanent magnetization (pTRM) check is often taken for granted as thermal alteration indicator for Thellier-series paleointensity experiments. In this study, we use rock magnetic properties to monitor thermal alteration of Galapagos lavas from site GAX that were previously used for multidomain (MD) corrected paleointensities [Wang and Kent, 2013, G-cubed]. The main magnetization carriers are fine magnetite grains ranging from single domain (SD)-like to MD-like behaviors. High-field thermomagnetic experiments show mostly reversible heating and cooling curves, which suggest little thermochemical alteration due to magnetic mineralogical changes. We compared two ~30 mg fresh subsamples, one of an SD-like lava that had passed a 500ºC pTRM check but was rejected by the MD corrected paleointensity linearity criteria, and an MD-like lava that had failed pTRM check but yielded a qualified MD-corrected paleointensity estimate. We heated the fresh lava samples stepwise in 50°C intervals up to 600ºC and after each step, we measured their hysteresis parameters, first-order reversal curves (FORC) and high-resolution FORC. Our results show that the rock magnetic properties of the MD-like sample were very stable at all heating steps whereas for the SD-like sample, FORC diagrams show that it changes from the original non-interacting pseudo-SD to interacting SD around 500ºC, which indicates thermal domain status alterations. However, these results are opposite to what would have been inferred from pTRM checks. This discrepancy is because most of the magnetic grains in sample thermally alter at the first time when reaching a new high temperature. Giving sample a pTRM at a lower temperature will only magnetize the magnetic grains that have blocking temperature lower than that. Grains with blocking temperatures in between the current high temperature and the previous low temperature will not carry useful magnetization signals to identify thermal alteration. On the other hand, for the MD-like sample, its MD effects contribute to the pTRM checks, causing false alarms even if it did not alter. We conclude that pTRM checks should not be relied upon to indicate thermal alteration for Thellier paleointensity experiments. Instead, appropriate rock magnetic properties are more faithful monitors for thermal alteration.

How do sediments get magnetized?

Abstract ID : 945

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. David Heslop ,david.heslop@anu.edu.au ,(Academic) ,Australia ,Canberra ,Not Presenting[1]

Prof. Andrew Roberts ,andrew.roberts@anu.edu.au ,(None) ,Australia , ,Not Presenting[1]

Dr. Liao Chang ,liao.chang@pku.edu.cn ,(None) ,China , ,Not Presenting[3]

1 - Australian National University 2 - Australian National University 3 - Peking University

Despite the fact that paleomagnetic studies of sediments and sedimentary rocks have been undertaken for over 65 years, major questions remain concerning the mechanisms by which sediments acquire a remanent magnetization. The detrital remanent magnetization (DRM) concept is based on the premise that sedimentary paleomagnetic signals are acquired when tiny nanomagnets, derived from the erosion of igneous rocks, align with the ambient magnetic field and record the field direction at the time of deposition. The textbook treatment of isolated magnetic particles aligning passively with the ambient geomagnetic field during deposition is questionable at many levels. Hydrodynamic forces associated with fluid movements in anything but perfectly still water will exceed geomagnetic aligning torques, and even modest salinities will cause clays and magnetic particles to aggregate into flocs so that magnetic particles are not isolated. If isolated magnetic particles contributed to a DRM as envisioned in older textbooks, sedimentary magnetizations would be much more efficient than they are. Post-depositional processes such as bioturbation also mean that a pure DRM is likely to be a rare paleomagnetic recording mechanism, and that a post-depositional remanent magnetization (pDRM) is a more reasonable concept for explaining the magnetization of sediments. Recent work has significantly improved our understanding of how sediments get magnetized. Key processes that contribute to inefficient sedimentary paleomagnetic recording (e.g., flocculation, deposition of silicate particles with magnetic nano-inclusions) are now better understood. Also, in recent years we have learned that the inorganic remains of magnetotactic bacteria are widely preserved in the geological record. When these bacteria die, their single domain nanomagnetic remains are ideal paleomagnetic recorders. Recognition of the widespread presence of magnetofossils in the geological record is providing a new understanding of the mechanisms by which sediments acquire paleomagnetic signals. Even though we have a much-improved understanding of sedimentary magnetization acquisition, much remains unknown. For example, we still lack a rigorous theory for how relative paleointensity signals are acquired. Thus, much useful work remains to be done to develop a more complete understanding of how sediments get magnetized.

Thermal stability of Palaeomagnetic Recorders.

Abstract ID : 985

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Wyn Williams ,wyn.williams@ed.ac.uk ,(Professor) ,United Kingdom ,Edinburgh ,Not Presenting[1]

Dr. Les Nagy ,l.nagy@ed.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Adrian Muxworthy ,adrian.muxworthy@imperial.ac.uk ,(Convenor) ,United Kingdom ,London ,Not Presenting[3]

Dr. Karl Fabian ,karl.fabian@ngu.no ,(None) ,Norway , ,Not Presenting[4]

Mr. Pádraig Ó Conbhuí ,P.O-Conbhui@sms.ed.ac.uk ,(None) ,United Kingdom , ,Not Presenting[5]

Mr. Jay Shah ,jay.shah109@imperial.ac.uk ,(None) ,United Kingdom , ,Not Presenting[6]

1 - University of Edinburgh 2 - University of Edinburgh 3 - Imperial College 4 - NGU 5 - The Univeristy of Edinburgh 6 - Imperial College, London

Palaeomagnetic recordings of the geomagnetic field have, for more than half a century, provided a rich source of scientific data about the geological evolution of the Earth. The theoretical basis that underpins our understanding of rock magnetic recordings comes from Néel's theory of thermo-magnetic stability in small uniformly magnetised, single domain (SD) particles. Néel demonstrated that for SD grains, signals recorded near the Curie temperature and subsequently cooled to room temperature can remain stable for many billions of years.

Over the last two decades, numerical micromagnetic modelling has allowed us to gain a more detailed understanding of magnetic domain structures and their variation with grain morphology, temperature and mineralogy. These studies have demonstrated that truly uniform SD grains exist only in a very narrow range of grains sizes, and the majority of remanence carriers in palaeomagnetic samples are likely to reside in non-uniformly magnetised pseudo-single-domain (PSD) grains. Hitherto the assumption has been that the recording stability of PSD grains was significantly less than that of SD, although no theoretical basis for these assumptions has been provided.

In this presentation, we will examine domain structure and in particular thermal stability of SD and PSD grains as a function of temperature and grain size for magnetite and iron particles. We will demonstrate that even for grains in the SD size range, deviation from a perfectly uniform domain structure can provide increased magnetic stability. For larger, PSD grains dominated by vortex domain structures, we observe structure-coherent rotation of the vortex domains analogous to coherent rotation observed in SD domains. More significantly, it will be shown that PSD grains have significantly higher magnetic stability than their SD counterparts for equidimensional cuboctahedral magnetite grains. The origin of stable palaeomagnetic remanences is, therefore, more likely to reside in PSD grains than SD magnetite grains, and the grain size range of 'ideal' magnetic recorders is much larger than previously thought. These initial results suggest that simulations of thermomagnetic

processes in assemblages of particles may soon provide a much better constraint of the accuracy of palaeomagnetic observations.

Fluid infiltration in a fault: a rock magnetic, mineralogical, and geochemical assessment of the Yingxiu-Beichuan fault (Longmen Shan thrust belt, China)

Abstract ID : 1129

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Mark Dekkers ,m.j.dekkers@uu.nl ,(Associate professor) ,Netherlands ,Utrecht ,Presenting[1]

Dr. Tao Yang ,t.yang@uu.nl ,(None) ,China , ,Not Presenting[1]

Dr. Xiaosong Yang ,xsyang@ies.ac.cn ,(None) ,China , ,Not Presenting[1]

Dr. Qingbao Duan ,duan_qingbao@126.com ,(None) ,China , ,Not Presenting[1]

Dr. Jianye Chen ,j.chen3@uu.nl ,(None) ,China , ,Not Presenting[1]

1 - None 2 - None 3 - None 4 - None 5 - None

Faults can be weakened or strengthened by action of fluids. Thus understanding fluid migration in fault zones is important in the study of earthquake rupture processes. Magnetic parameters can convey grain-size dependent information which is an essential ingredient to further our understanding of fault rocks. In conjunction with more classic mineralogical (XRD) and geochemical approaches, physicochemical processes that have acted in fault zones can be unveiled. In 2011, two shallow holes (134 and 54 m depth, respectively) were drilled into the Yingxiu-Beichuan fault (Longmen Shan thrust belt, China), which accommodated most of the displacement of the 2008 Mw 7.9 Wenchuan earthquake. Here, fifty-eight drill core samples, including granitic host rock and various fault rocks, were subjected to rock-magnetic, mineralogical, and geochemical analysis. Paramagnetic clay minerals appears to dominate the magnetic behavior of fault rocks. Magnetite in trace amounts is identified as the predominant ferrimagnetic fraction in all samples, decreasing from the host rock, via fault breccia to (proto-)cataclasite. Frequency dependence of susceptibility ranges from 2.5% in the host rock to 6.5% in the (proto-)cataclasite, indicating grain fining. The various fault gouges, remarkably, have a lower frequency dependence ranging 2.5-3.3%. Significant mass-losses (10.7-45.6%) are determined for the fault breccia and (proto-)cataclasite with the "isocon" method (Grant, 1986). Elements in fault rocks are compared against concentrations in unaltered host rock under the premise that a certain element (here Ti) is immobile. Volatile contents and alteration products (i.e., chlorite) are higher toward the fault core relative to the host rocks. Magnetite depletion seem to have occurred in these fault rocks-exhumed from the shallow crust-driven by fluid-assisted processes. Chlorite, a consequence of hydrothermal activity, occurs throughout almost the entire fault core and shows high coefficients of determination (R^2>0.60) with both low and high-field magnetic susceptibility. Close relationships, with R^2>0.70, are also observed between both low and high-field magnetic susceptibility and the immobile elements, H_2O^+, and the calculated mass-losses of fault

rocks. Hence, magnetic properties of fault rocks can serve as proxy indicators of fluid infiltration within shallow fault zones.

Grant, J. A. (1986), Econ. Geol., 81, 1976-1982.

Paleointensity results of Modipe Gabbro of Botswana and implications to future paleomagnetic studies in the region

Abstract ID : 1434

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. James King ,KINGJG@mopipi.ub.bw ,(Senior Lecturer) ,Botswana ,Gaborone ,Not Presenting[1]

Dr. Adrian Muxworthy ,adrian.muxworthy@imperial.ac.uk ,(Convenor) ,United Kingdom ,London ,Not Presenting[2]

Mr. Michael E. Evans ,tedevans.evans403@gmail.com ,(None) ,Canada , ,Not Presenting[3]

1 - University of Botswana 2 - Imperial College 3 - Institute for Geophysical Research, University of Alberta, Edmonton, Alberta, Canada

Paleointensity results of Modipe Gabbro of Botswana and implications to future paleomagnetic studies in the region

JAMES G. KING[1], Adrian R. Muxworthy[2], Michael E. Evans[3]
1. Department of Physics, University of Botswana, Gaborone, Botswana, e-mail: kingjg@mopipi.ub.bw
2. Department of Earth Science and Engineering, Imperial College London, London, UK, e-mail: adrian.muxworthy@imperial.ac.uk,
3. Institute for Geophysical Research, University of Alberta, Edmonton, Alberta Canada, email: tedevans.evans403@gmail.com

The current thinking is that the geodynamo and the geomagnetic field formed as the Earth's inner core solidified creating an inner (solid) and outer (liquid) between 3.9--?3.4 Ga. The intensity of the magnetic field is thought to have increased as the inner core grew. In order to acertain such theories, paleointensity intensity carrier rocks older than about 2.5 Ga are such old rocks. Recent Paleointensity results from Modipe Gabbro (2784 +/- 1.5 Ma) have shown that they contain reliable single domain magnetite carriers. The paleointensity obtained has shown that the Earth's Magnetic Dipole moment in the late Archaean was about 6×10^{22} Am^2. Preliminary rockmagnetic studies (e.g. coercivity of 18 mT for magnetite) of Kanye volcanic rocks whose age is 2784 +/- 4 Ma, is consistent with single domains as the dominant paleomagntic carriers. Since this age is similar to that of Modipe Gabbro which is less than 100 km away from the Kanye volcanic rocks, one would expect the paleointensity to be similar. Future paleointensity studies of Kanye volcanic rocks and others that have reliable magnetic carriers in this region which has some rocks older than 3 Ga would aid to understand the genesis of the Earth's field.

A08 - agnetic and electromagnetic developments in exploration for mineral resources and hydrocarbons in continental and marine environments (DIV I – DIV VI)

Magnetic anisotropy of Silurian organic-rich shales and carbonate concretions from Northern Poland

Abstract ID : 203

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Dominika Niezabitowska ,dominika.niezabitowska@gmail.com ,(PhD candidate) ,Poland ,Warsaw ,Presenting[1]

Prof. Rafal Szaniawski ,rafsz@igf.edu.pl ,(None) ,Poland ,None ,Not Presenting[1]

1 - Institute of Geophysics Polish Academy of Sciences 2 - Institute of Geophysics Polish Academy of Sciences

The research has been performed on Wenlockian shales from the Northern Poland. These organic-rich marine shales were deposited on the western shelf of the Baltica paleo-continent and they currently constitute the cover of East European Platform. Rock magnetic studies have been carried out to recognize magnetic minerals and in further studies the origin of the magnetic anisotropy, which leads to determine the preferred orientation of minerals, what may affect the preferred propagation of hydraulic fractures.
The dark shales and spherical carbonate concretions from two boreholes were sampled. Macroscopic observations suggest that the concretions were formed in the early stage of diagenesis. The results of thermal variation of magnetic susceptibility and hysteresis loops show that the magnetic susceptibility is mainly controlled by paramagnetic minerals. These results are in line with mineral composition, which was also confirmed by SEM analysis, where high content of phyllosilicates were documented. The deposition alignment of phyllosilicates and further compaction determine distinct bedding parallel foliation of the AMS (Anisotropy of Magnetic Susceptibility) in both drill cores. Magnetic lineation is poorly marked in both drill cores what is also reflected in orientation of graptolites branches. However, the SEM statistical analysis of minerals orientation do not exhibit tendency for grouping.
In the case of concretions the magnetic foliation is also evident. However, the magnetic lineation in the both drill cores is better developed and the maximal AMS axes are grouped. In both of the cores the orientation of lineation from concretions complies with the lineation from mudstones.

To summarize, the results imply that the phyllosilicates from shales are typically well aligned in the bedding plane by compaction. In the case of calcareous concretions the foliation is less developed due to their earlier cementation of phyllosicates in the calcareous matrix, which occurred before the end of compaction. A good grouping of the maximal AMS axes within the rigid concretions suggest that weak magnetic lineation is rather sedimentary than tectonic in origin.

This work has been funded by the Polish National Centre for Research and Development within the Blue Gas project (No BG2/SHALEMECH/14). Samples were provided by the PGNiG SA.

Controlled Source Electromagnetic Modelling of Hydraulic Fracturing

Abstract ID : 749

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Matthew Couchman ,mattc1990@tamu.edu ,(PhD Student) ,United States ,College Station ,Presenting[1]

Dr. Mark Everett ,mark.e.everett@gmail.com ,(None) ,United States , ,Not Presenting[2]

1 - None 2 - Texas A&M University

Controlled Source Electromagnetics (CSEM) has been used as a direct hydrocarbon indicator since the 1960s. With a resurgence in marine conventional settings in the new millennium, many studies revolve around detecting a thin resistive layer such as a reservoir at 1-3 km depth. The presence of the resistive layer is characterized by an accumulation of electric charge at the boundaries between the layer and the host sediments. The lessons learned from these studies may be applied to terrestrial unconventional settings. However, unlike in marine settings where resistive hydrocarbon-charged fluids comprise a conventional reservoir, on land recent interest has surged in imaging electrically conductive injected fluids. The work shown here is a development of methods to enable more reliable terrestrial CSEM monitoring of the flow of injected fluids associated with hydraulic fracturing of unconventional reservoirs and to detect subsurface fluids based on their CSEM signature and in turn, to infer the subsurface flow of such fluids. Overall this project attempts to create more efficient fracturing treatments, by determining fluid pathways, hence making projects more cost effective by reducing the cost of extraction. The predictive model developed herein focuses on the mapping of fluid flow in from a horizontal wellbore in a uniform halfspace using a surface-deployed, in-line Horizontal Electric Dipole (HED) transmitter with electric field amplitude recorded by a surface array of electric field sensors. The finite element mesh is optimized for hydraulic fracture simulation, and has been verified against various published solutions. The well casing has also been included due to its large effect on CSEM response.

Modern concepts for exploration and monitoring using CSEM on land

Abstract ID : 1392

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Oliver Ritter ,oritter@gfz-potsdam.de ,(None) ,Germany ,Potsdam ,Not Presenting[1]

Dr. Kristina Tietze ,ktietze@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Cedric Patzer ,cpatzer@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

1 - GFZ Potsdam 2 - GFZ Potsdam 3 - GFZ Potsdam

Electromagnetic (EM) methods have been applied for natural resources exploration for more than a century. Monitoring of subsurface processes by continuous or time-lapse EM measurements has only recently attracted a wider interest, at least in practice. Here, we report on Controlled Source Electromagnetics (CSEM) measurements for exploration and monitoring in Germany. For current injection, horizontal electric tri-poles were deployed at surface and also a horizontal-vertical source using the steel-casing of a 1.3 km deep abandoned oil-well. We developed an integral equation method to describe the influence of inductively and galvanically coupled steel-casings as equivalent source currents which effectively generate a secondary primary field. This new approach also considers electromagnetic interaction between multiple wells. Receivers include normal 5-component (magnetotelluric) sites, but also vertical electric field sensors deployed in a shallow borehole. Besides target sensitivity, crucial requirements for monitoring are sufficient accuracy and repeatability of measurements, which can be achieved with CSEM measurements. But the complex spatial field geometry requires high accuracy with respect to re-positioning of sensors. When compared with surface-only measurements, borehole-to-surface configurations and measurements of the vertical electric field significantly increase the sensitivity of CSEM measurements to deep targets (reservoirs).

A09 - Scientific results from the Swarm constellation mission (DIV I – DIV VI)

An accelerating high-latitude jet in Earth's core

Abstract ID : 135

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Phil Livermore ,p.w.livermore@leeds.ac.uk ,(Associate Professor) ,United Kingdom ,Leeds ,Not Presenting[1]

Prof. Rainer Hollerbach ,rh@maths.leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Chris Finlay ,cfinlay@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[3]

1 - University of Leeds 2 - University of Leeds 3 - DTU Space, Technical University of Denmark

Observations of the change in Earth's magnetic field, the secular variation, provide information on the motion of liquid metal within the core that is responsible for its generation. The very latest high-resolution observations from Swarm show intense field change at high-latitude localised in a distinctive circular daisy-chain configuration centred on the north geographic pole. Here we explain this feature with a localised, nonaxisymmetric, westwards jet of 420 km width on the tangent cylinder, the cylinder of fluid within the core that is aligned with the rotation axis and tangent to the solid inner core.We find that the jet has increased in magnitude by a factor of three over the period 2000-2016 to about 40 km/yr, and is now much stronger than typical large-scale flows inferred for the core. The current accelerating phase may be a part of a longer term fluctuation of the jet causing both eastwards and westwards movement of magnetic features over historical periods, and may contribute to recent changes in torsional wave activity and the rotation direction of the inner core.

Climatology of the polar electrojets using Swarm and older satellites

Abstract ID : 279

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Ashley Smith ,ashley.smith@ed.ac.uk ,(PhD Candidate) ,United Kingdom ,Edinburgh ,Presenting[1]

Prof. Kathy Whaler ,kathy.whaler@ed.ac.uk ,(None) ,United Kingdom ,Edinburgh ,Not Presenting[1]

Dr. Ciaran Beggan ,ciar@bgs.ac.uk ,(None) ,United Kingdom ,Edinburgh ,Not Presenting[3]

Dr. Susan Macmillan ,smac@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - University of Edinburgh 2 - University of Edinburgh 3 - British Geological Survey 4 - British Geological Survey

Among the various ionospheric and magnetospheric currents, the polar electrojets (PEJs) are perhaps the most troublesome to describe and predict. This reflects their origin from the complex solar wind-magnetosphere interaction and subsequent magnetospheric unloading processes and coupling to varying ionospheric conductivity. They are highly variable with several different types of drivers, from partly stochastic variations in the solar wind, to seasonal effects caused by Earth's orbit and its rotational and magnetic axes, to the longer term modulation by the solar cycle. As a key component of space weather, understanding them is important both in terms of furthering space and geophysical research and for practical applications due to their role in the generation of geomagnetically induced currents (GICs) in power grids, atmospheric heating increasing drag on satellites, and disturbances to magnetic navigation systems. With regards to geophysical research, the nature of the PEJs and the associated field-aligned currents which feed them makes them difficult to account for when modelling internal fields (from the core and the crust). As well as introducing noise, models of the core secular variation could be seriously contaminated by time-varying biases in these external fields. We present a study of the electrojet activity using magnetometer data from Swarm and older satellites. We describe the behaviour of the PEJs in response to solar wind driving and seasonal effects, identify hemispheric differences, and attempt to identify long term variation. The relation to magnetospheric processes and the implications for internal field modelling are discussed.

North-south asymmetries in polar ionospheric currents - effects of asymmetries in the main magnetic field

Abstract ID : 641

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Karl Laundal ,karl.laundal@ift.uib.no ,(Researcher) ,Norway ,Bergen ,Presenting[1]

Dr. Chris Finlay ,cfinlay@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[2]

Prof. Nils Olsen ,nio@space.dtu.dk ,(None) ,Denmark ,None ,Not Presenting[3]

Dr. Jone P. Reistad ,one.Reistad@uib.no ,(None) ,Norway , ,Not Presenting[1]

Mr. Paul Tenfjord ,paul.tenfjord@ift.uib.no ,(None) ,Norway , ,Not Presenting[1]

Dr. Nikolai Østgaard ,Nikolai.Ostgaard@ift.uib.no ,(None) ,Norway , ,Not Presenting[1]

Mr. Anders Ohma ,andersohma@gmail.com ,(None) ,Norway , ,Not Presenting[1]

Dr. Kristian Snekvik ,Kristian.Snekvik@ift.uib.no ,(None) ,Norway , ,Not Presenting[1]

Dr. Stein Haaland ,Stein.Haaland@ift.uib.no ,(None) ,Norway , ,Not Presenting[1]

Dr. Steve Milan ,steve.milan@ion.le.ac.uk ,(None) ,United Kingdom , ,Not Presenting[10]

1 - University in Bergen 2 - DTU Space, Technical University of Denmark 3 - DTU 4 - University in Bergen 5 - University in Bergen 6 - University in Bergen 7 - University in Bergen 8 - University in Bergen 9 - University in Bergen 10 - University in Leicester

Ionospheric electrodynamics in the northern and southern hemispheres are often assumed to be approximately mirror images of each other, apart from an opposite variation with seasons and the IMF By component. The global coverage and high precision of magnetic field measurements from the Swarm satellite constellation and the earlier CHAMP mission allow us to challenge this idea. We perform a spherical harmonic analysis of magnetic field measurements from low-Earth-orbit to obtain global patterns of field-aligned and horizontal E-layer ionospheric currents. By using the non-orthogonal magnetic apex coordinate systems, we eliminate the geometric effect of asymmetries in the main magnetic field. Because of this, and by parametrizing the model currents in terms of solar wind and seasonal variations, we can analyze north-south differences in currents during symmetrical (e.g. equinoctial) conditions. We find that the total field-aligned current is slightly stronger in the northern hemisphere during local winter than it is in the southern hemisphere. On the other hand, the total horizontal E-layer current very close to the magnetic pole is strongest in the southern hemisphere during local winter. These paradoxical findings illustrate the very complex influence of

main field asymmetries on ionospheric electrodynamics. Different offsets between magnetic and geographic poles lead to different rates of solar illumination in the two hemispheres in magnetic apex coordinates, and consequently differences in EUV-produced ionospheric conductivity. This does not necessarily directly translate into variations in currents, however, since ionization from auroral precipitation tends to overcompensate for a lack of EUV radiation in certain regions. In addition to the differences due to pole offset, the field strength and inclinations are different at conjugate points, which also can affect the conductivity and magnetosphere-ionosphere coupling. As a consequence, ionospheric electrodynamics is never symmetrical between the hemispheres.

Swarm satellite data analyses for earthquake preparatory phase studies

Abstract ID : 709

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Angelo De Santis ,angelo.desantis@ingv.it ,(Director of Research) ,Italy ,Roma ,Not Presenting[1]

1 - Istituto Nazionale di Geofisica e Vulcanologia

The main goal of the Swarm three-satellite mission is to measure the magnetic signals from the Earth, to improve our knowledge of its planetary magnetic field. The project SAFE (Swarm for Earthquake study; a STSE Swarm + Innovation ESA funded project), aims at applying the new approach of geosystemics to the analysis of Swarm magnetic and electron density data for investigating the preparatory phase of earthquakes as seen from space, with integration of ground based (seismic, ionosonde and GPS/GNSS) data. The main objective of SAFE is to explore the possible link between magnetic/ionospheric anomalies and large earthquakes, and possibly to confirm it. This contribution shows the importance of this novel approach for several large earthquakes. Finally, SAFE project developed also a web exploitation platform has also been developed, in order to show, demonstrate and help scientific stakeholders in understanding and analyzing the possible relations between Swarm, in situ and ancillary data and possible earthquake precursors.

Patrick Alken : None Tammy Maart : None

Global geomagnetic field modelling using three years of the experimental ASM-V vector data on board the Swarm satellites

Abstract ID : 731

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Pierre Vigneron ,vigneron@ipgp.fr ,(Engineer) ,France ,Paris ,Presenting[1]

Mr. Pierre Deram ,deram@ipgp.fr ,(None) ,France , ,Not Presenting[1]

Dr. Gauthier Hulot ,gh@ipgp.fr ,(Deputy Director in charge of research and space activities) ,France ,Paris ,Not Presenting[1]

Prof. Nils Olsen ,nio@space.dtu.dk ,(None) ,Denmark ,None ,Not Presenting[4]

Dr. Jean-Michel Léger ,jean-michel.leger@cea.fr ,(Program manager) ,France ,Grenoble ,Not Presenting[5]

Mr. Thomas Jager ,thomas.jager@cea.fr ,(None) ,France , ,Not Presenting[5]

1 - Institut de Physique du Globe de Paris 2 - Institut de Physique du Globe de Paris 3 - Institut de Physique du Globe de Paris 4 - DTU 5 - CEA, Léti 6 - CEA, Léti

Satellites of the ESA Swarm mission carry Absolute Scalar Magnetometer that provide the nominal 1 Hz scalar data of the mission (except for Swarm Charlie since November 2014), but also deliver 1 Hz experimental vector data (in their own instrument frame). Geomagnetic field models derived from one year of such ASM scalar and experimental vector data have already been published, without resorting to any of the nominal Vector Field Magnetometer (VFM) data of the Swarm mission. These models demonstrated the good reliability of the ASM as a standalone instrument and the strong rigidity of the boom mechanically linking the ASM to the star imager (STR). In this presentation, we will report on our efforts to build a new extended model, now relying on more than three years of ASM-only data, and taking into account lessons learnt from our previous modelling efforts, to further demonstrate the capabilities of the ASM vector mode data for such global geomagnetic field modelling efforts. Discrepancies between the information provided by the ASM experimental vector mode data and the nominal VFM data will also be discussed.

Patrick Alken : None Tammy Maart : None

The Swarm Delta NanoMagSat project, latest news

Abstract ID : 786

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Gauthier Hulot ,gh@ipgp.fr ,(Deputy Director in charge of research and space activities) ,France ,Paris ,Presenting[1]

Dr. Jean-Michel Léger ,jean-michel.leger@cea.fr ,(Program manager) ,France ,Grenoble ,Not Presenting[2]

Mr. Pierre Vigneron ,vigneron@ipgp.fr ,(Engineer) ,France ,Paris ,Not Presenting[1]

Mr. Thomas Jager ,thomas.jager@cea.fr ,(None) ,France , ,Not Presenting[2]

Mr. François Bertrand ,francois1.bertrand@cea.fr ,(None) ,France , ,Not Presenting[2]

Dr. Linda Tomasini ,Linda.Tomasini@cnes.fr ,(None) ,France , ,Not Presenting[6]

1 - Institut de Physique du Globe de Paris 2 - CEA, Léti 3 - Institut de Physique du Globe de Paris 4 - CEA, Léti 5 - CEA, Léti 6 - CNES

ESA's Swarm mission aims at studying all sources of Earth's magnetic field. It consists of two satellites (Alpha and Charlie), which fly side-by-side on near polar orbits at an altitude of slightly less than 500 km, and of a third satellite (Bravo) on a similar but slightly more polar and higher orbit, which progressively drifts with respect to that of Alpha and Charlie. This orbital configuration has proven extremely valuable, as evidenced by the many results obtained from the first three years of the mission. These results, however, also reveal that geomagnetic field modeling and investigation efforts are now hampered by the still limited local time coverage provided by this constellation. Further increasing the scientific return of the Swarm mission by squeezing more out of these data, however, would likely be possible if a fourth "Delta" satellite was to be launched soon enough to join the constellation at a similar altitude but much lower inclination orbit (such as 60°). Such a satellite would provide less geographical coverage but a much faster mapping of all local times over these latitudes. Its inclined orbit would provide "tie points" (with crossings at 60°) that would also be very beneficial. In this presentation, we will report on an on-going CNES Phase 0+ aiming at designing a free-orbiting gradient stabilized 12U nanosatellite, "NanoMagSat", that could be launched on such an orbit before the end of the Swarm mission (currently expected well beyond 2022) and act as the Swarm Delta satellite at a much reduced cost. We will report on progress in the satellite design, instrument miniaturization and performance, as well as on mission simulation activities within the ISSI NanoMagSat/Swarm-Delta end-to-end simulation Working Group team (http://www.issibern.ch/workinggroups/leo60/).

Patrick Alken : None Tammy Maart : None

Study of Substorm associated Pi2 pulsations in different local time sectors

Abstract ID : 836

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Neethal Thomas ,neethalmariyathomas@gmail.com ,(Research Associate) ,India ,Navi Mumbai ,Not Presenting[1]

Dr. Geeta Vichare ,vicharegeeta@gmail.com ,(None) ,India , ,Not Presenting[1]

Prof. Kazuo Shiokawa ,shiokawa@isee.nagoya-u.ac.jp ,(None) ,Japan , ,Not Presenting[3]

Prof. Ashwini Kumar Sinha ,sinha.ashwini@gmail.com ,(None) ,India , ,Not Presenting[1]

1 - Indian Institute of Geomagnetism 2 - Indian Institute of Geomagnetism 3 - Institute for Space-Earth Environmental Research 4 - Indian Institute of Geomagnetism

Pi2 pulsations are the transient oscillations of the Earth's magnetic field with periods 40-150 s, which are commonly observed in association with substorms. Pi2s are observed at low latitude ground stations over a wide range of local time including daytime. Recently, Thomas et al., [JGR, 2015] have confirmed its presence at the top side of the ionosphere during night as well as daytimes. However, its characteristics such as frequency, occurrence time delay with respect to midnight meridian etc. and its origin in different local time sectors is still not well understood. The magnetic field measurements from polar LEO satellite constellation, Swarm and ground observations obtained from ISEE magnetometer chain stations are utilised. The Swarm constellation provides a unique opportunity to study Pi2s from the topside ionosphere at different local times. The characteristics of Pi2s such as frequency, time of occurrence, satellite-to-ground coherence, power ratio, and cross phase will be estimated. Comparison of Pi2 oscillations from satellites and underneath ground stations can provide insight into the propagation of Pi2 pulsations and the possible role of the ionosphere. The investigation of Pi2 oscillations at different latitudes and at different local times would be useful to understand the longitudinal and latitudinal extent of these waves, which may throw some light on the frequency source of Pi2s.

Patrick Alken : None Tammy Maart : None

Scientific results from SIFACIT, Swarm-SECS, Swarm-Aurora and SwarmSuperMAG_2015 projects

Abstract ID : 850

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Lorenzo Trenchi ,Lorenzo.Trenchi@serco.com ,(None) ,Italy ,Roma ,Not Presenting[1]

Dr. Giuseppe Ottavianelli ,giuseppe.ottavianelli@esa.int ,(None) ,Italy , ,Not Presenting[2]

Dr. Rune Floberghagen ,rune.floberghagen@esa.int ,(None) ,Italy , ,Not Presenting[1]

Dr. Roger Haagmans ,roger.haagmans@esa.int ,(None) ,Netherlands , ,Not Presenting[4]

Dr. Tania Casal ,tania.casal@esa.int ,(None) ,Netherlands , ,Not Presenting[4]

Dr. Jens Kristian Jensen ,jkjen@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[6]

Dr. Poul Erik Holmdahl Olsen ,poeho@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[6]

Dr. Octav Marghitu ,marghitu@gpsm.spacescience.ro ,(None) ,Romania , ,Not Presenting[8]

Dr. Adrian Blagau ,blagau@gpsm.spacescience.ro ,(None) ,Romania , ,Not Presenting[8]

Dr. Joachim Vogt ,j.vogt@jacobs-university.de ,(None) ,Germany , ,Not Presenting[10]

Dr. Kirsti Kauristie ,Kirsti.Kauristie@fmi.fi ,(None) ,Finland , ,Not Presenting[11]

Dr. Heikki Vanhamaki ,heikki.vanhamaki@oulu.vi ,(None) ,Finland , ,Not Presenting[12]

Dr. Jesper W. Gjerloev ,Jesper.Gjerloev@jhuapl.edu ,(None) ,United States , ,Not Presenting[13]

Mr Eric Donovan ,edonovan@ucalgary.ca ,(None) ,Canada , ,Not Presenting[14]

Dr. David Knudsen ,knudsen@ucalgary.ca ,(Professor) ,Canada ,Calgary ,Not Presenting[15]

Dr. Darren Chaddock ,dchaddoc@ucalgary.ca ,(None) ,Canada , ,Not Presenting[15]

Dr. Deborah Gillies ,dgillies@ucalgary.ca ,(None) ,Canada , ,Not Presenting[15]

1 - ESA - ESRIN 2 - ESA ESRIN 3 - ESA - ESRIN 4 - ESA - ESTEC 5 - ESA - ESTEC 6 - DTU Space, Technical University of Denmark 7 - DTU Space, Technical University of Denmark 8 - Institute for Space Science 9 - Institute for Space Science 10 - Jacobs University Bremen 11 - Finnish

Meteorological Institute 12 - University of Oulu 13 - Johns Hopkins University 14 - The University of Calgary 15 - University of Calgary 16 - University of Calgary 17 - University of Calgary

This presentation illustrates the results obtained in the context of four different Swarm projects.
The two projects "Swarm data quality Investigation of Field-Aligned Current products, Ionosphere, and Thermosphere system" (SIFACIT) and "Swarm-Spherical Elementary Current Systems" (Swarm-SECS) focus on the study of the Ionospheric current systems, based on plasma and magnetic field data measured by the three Swarm spacecraft.
The SwarmSuperMAG_2015 study is also on the Ionospheric current systems, and it is based on the magnetic field data acquired by the network of ground based magnetometers operated by the SuperMAG collaboration, in combination with the magnetic field data measured by Swarm. In particular, SuperMAG provides the large-scale global context very useful to understand the local measurements of Swarm.
The project Swarm-Aurora is designed to facilitate the use of Swarm data for the study of auroras, and it will provide a web-based tool for an easy access of data from a large array of ground-based All-Sky Imagers (ASIs) operating around the world, as well as Swarm in situ measurements.

Patrick Alken : None

Determining statistical patterns of the auroral electrojet system from Swarm satellite magnetic data

Abstract ID : 856

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Cecilie Drost Aakjær ,cda@space.dtu.dk ,(PhD Student) ,Denmark ,Farum ,Presenting[1]

Prof. Nils Olsen ,nio@space.dtu.dk ,(None) ,Denmark ,None ,Not Presenting[2]

Dr. Chris Finlay ,cfinlay@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[3]

1 - DTU Space 2 - DTU 3 - DTU Space, Technical University of Denmark

Modern geomagnetic reference models give a very good description of the Earth's magnetic field, including its contributions from the core and crust at low and mid-latitudes. The auroral electrojet system causes, however, in the polar region irregular contributions to the magnetic field, not included in present reference models, hampering applications such as directional drilling.
We will present a method to determine the ionospheric auroral electrojet system from Swarm satellite observations. The method gives a robust estimate of the current profile along the satellite track suitable for near-real-time implementation. Residual magnetic field observations provides input for an inverse problem described by a series of infinite line currents along constant magnetic latitude in the polar regions (+/- 50 degrees from the poles) for individual satellite passes.
Position and strength of the auroral electrojet are estimated for investigations of statistical patterns of the auroral electrojet system for the Northern and Southern Hemisphere along with their temporal evolution. Applying the method to data taken by the Swarm satellites Alpha and Beta allows in addition investigation of longitudinal differences of the electrojets.

Patrick Alken : None

Electrical Conductivity of the Earth's Mantle: Time-domain Inversion of Swarm Data

Abstract ID : 860

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jakub Velímský ,velimsky@karel.troja.mff.cuni.cz ,(Assistant Professor) ,Czech Republic ,Prague ,Presenting[1]

Prof. Zden?k Martinec ,zdenek@cp.dias.ie ,(None) ,Ireland , ,Not Presenting[2]

1 - Charles University, Prague 2 - Dublin Institute for Advanced Studies

Recovery of the three-dimensional distribution of electrical conductivity of the Earth's mantle is one of the primary goals of the Swarm mission. However, the results obtained so far in the framework of Swarm Level 2 processing suggest that it is also one of the most challenging tasks. The separation of the spatially and temporally variable magnetospheric magnetic field from its induced counterpart has so far allowed to recover only the 1-D mantle conductivity profile. Here we present a novel approach to Swarm data processing, based on two-dimensional analysis of individual Swarm tracks, with particular attention dedicated to the polar areas. We will then report the mantle conductivity models obtained both by the traditional Level 2 approach, and the alternative method.

Patrick Alken : None

Scientific Results from the Swarm Electric Field Instruments (EFIs)

Abstract ID : 876

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. David Knudsen ,knudsen@ucalgary.ca ,(Professor) ,Canada ,Calgary ,Presenting[1]

Dr. Johnathan Burchill ,jkburchi@ucalgary.ca ,(None) ,Canada , ,Not Presenting[1]

Dr. Stephan Buchert ,scb@irfu.se ,(None) ,Sweden , ,Not Presenting[3]

1 - University of Calgary 2 - University of Calgary 3 - IRF

The Swarm mission is providing a new view of the ionsophere through its unique polar-orbiting constellation, its high-quality magnetic field measurements, and a new type of electric field and plasma meaurement. The Swarm EFIs measure core ion drift ($\mathbf{v}_i$) and temperature via two orthogonal 2-D ion distribution imagers from which electric field can be derived from the relation $\mathbf{E} = -\mathbf{v}_i \times \mathbf{B}$. Two Langmuir probes measure electron density, temperature and spacecraft potential. This talk will provide an overview of scientific findings based on EFI data, both published and in progress. Examples include the the electrodynamic structure of auroral arcs and the region 1/2 current system; extreme ion flows and ionospheric response, magnetosphere-ionosphere-thermosphere energy exchange through Poynting flux, thermodynamic balance between electron, ion and neutral gases; polar cap patches; and equatorial plasma structures.

Swarm - ESA's magnetic field and geospace research constellation explorer: results and perspectives beyond the nominal mission lifetime

Abstract ID : 937

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Rune Floberghagen ,rune.floberghagen@esa.int ,(None) ,Italy , ,Not Presenting[1]

1 - ESA - ESRIN

Launched in November 2013 on a 4.3 years nominal mission, the European Space Agency's Swarm mission has meanwile established itself as a main provider of information to the geomagnetic field research community as well as a host of other scientific disciplines ranging from the deep Earth all the way out to the magnetosphere. At the heart of the mission success lie the excellent quality of the magnetic measurements, delivered by a trio of identical satellite. In particular the magnetic gradient measurements obtained by the lower pair offer unprecedented way to probe Earth. On top, Swarm also clearly demonstrates the value of high-cadence measurements of both the magnetic and electric field, in order to understand the coupling mechanisms and current systems in geospace.
This contribution details the status of the Swarm mission, recalls the main achievements about three and a half years into the nominal mission, and finally outlines the perspectives and plans for an extended mission. It is emphasised that Swarm has resources onboard which may allow a long lifetime, even out to the next solar minimum around 2030. However, aiming for such a long lifetime would not be matching a need to map the magnetic field at the lowest possible altitude during the coming solar minimum. The process of optimising the scientific return from Swarm should therefore also be carefully viewed in light of possible follow-on missions, which per today are very few, if at all existing.

Characteristics of magnetic ripples as observed by Swarm satellites and their relation to micro-barometric and ground magnetic variations

Abstract ID : 1070

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Toshihiko Iyemori ,iyemori@kugi.kyoto-u.ac.jp ,(None) ,Japan , ,Not Presenting[1]

Dr. Tadashi Aoyama ,ff.aoyama@gmail.com ,(None) ,Japan , ,Not Presenting[2]

Dr. Kunihito Nakanishi ,kunihito-nuss.925@hotmail.co.jp ,(None) ,Japan , ,Not Presenting[2]

Ms. Yoko Odagi ,odagi@kugi.kyoto-u.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Mr. Yoshihiro Yokoyama ,yokoyama.yoshihiro.36c@st.kyoto-u.ac.jp ,(None) ,Japan , ,Not Presenting[2]

1 - World Data Center for Geomagnetism, Kyoto, Kyoto Universit 2 - Graduate School of Science, Kyoto University 3 - Graduate School of Science, Kyoto University 4 - Graduate School of Science, Kyoto University 5 - Graduate School of Science, Kyoto University

The small scale magnetic fluctuations observed in upper ionosphere by low altitude satellites such as Swarm constellation are spatial structure of field-aligned currents along satellite orbit. They are observed almost always in mid- and low-latitudes, and we named them as 'magnetic ripples'. They are supposed to be caused by the atmospheric waves which propagates to the ionosphere. One of their remarkable characteristics is the difference in spatial scale between two magnetic components, i.e., meridional and zonal ones. This difference suggests the existence of two independent current circuits. On the other hand, the vertical resonance of acoustic wave between Earth's surface and thermosphere has several modes, and they come from the difference in reflection altitude of the acoustic wave. Because Pedersen and Hall conductivities have different altitude profile, different resonance modes may generate different current circuits and it could appear as the difference in the spatial scale for different magnetic component. In this paper, we analyze the structure of magnetic ripples in detail, in particular, scale difference for different magnetic components, and compare with the spectral characteristic of micro-barometric and ground magnetic variations to identify the structure of the current circuit.

Evolution of the Swarm ASM-Vs: a miniaturized version with enhanced metrological capabilities

Abstract ID : 1246

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jean-Michel Léger ,jean-michel.leger@cea.fr ,(Program manager) ,France ,Grenoble ,Not Presenting[1]

Mr. Thomas Jager ,thomas.jager@cea.fr ,(None) ,France , ,Not Presenting[1]

Mr. François Bertrand ,francois1.bertrand@cea.fr ,(None) ,France , ,Not Presenting[1]

Dr. Gauthier Hulot ,gh@ipgp.fr ,(Deputy Director in charge of research and space activities) ,France ,Paris ,Not Presenting[4]

Dr. Linda Tomasini ,Linda.Tomasini@cnes.fr ,(None) ,France , ,Not Presenting[5]

1 - CEA, Léti 2 - CEA, Léti 3 - CEA, Léti 4 - Institut de Physique du Globe de Paris 5 - CNES

Designed to provide reference 1 Hz scalar measurements for the calibration of the fluxgate magnetometers flown on the ESA's Swarm mission satellites, the Absolute Scalar Magnetometers (ASM) have also demonstrated in flight their ability to simultaneously deliver calibrated vector data of high quality. This specific operational mode, initially intended to be tested only for a technological demonstration, has finally been operated uninterruptedly since the satellites commissioning phase. In addition, high acquisition rate (250 Hz) scalar measurements performed for a few days during the commissioning phase have also recently been exploited to detect geophysical signals such as whistlers generated by lightning activity. Based on the feedback accumulated from more than 3 years of exploitation of the ASMs in orbit, several evolutions of the magnetometer have been implemented, ranging from the correction of a few minor defaults detected in orbit to the definition of a new operational mode offering simultaneously high acquisition rate scalar data with 1 Hz vector measurement (fusion of the previously developed burst and vector modes, which were not intended to be operated together on Swarm). In this presentation we will report on the improvements both in design and in performance of this miniaturized version of the ASM, which could be a candidate for integration on a nanosatellite platform with a nominal magnetic payload restricted to this unique instrument rather than the traditional combination of a scalar and a vector magnetometers.

A10 - Coupling Processes in the Atmosphere-Ionosphere System (DIV II-C/ICMA/SCOSTEP)

Coseismic infrasound in the ionosphere by continuous Doppler sounding

Abstract ID : 83

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited by Petra Koucka Knizova

Dr. Jaroslav Chum ,jachu@ufa.cas.cz ,(senior research scientist) ,Czech Republic ,Prague ,Not Presenting[1]

Mr Miguel Angel Cabrera ,mcabrera@herrera.unt.edu.ar ,(None) ,Argentina , ,Not Presenting[2]

Dr. Jann-Yenq Liu ,jyliu@jupiter.ss.ncu.edu.tw ,(Professor) ,Taiwan ,TaoYuan ,Not Presenting[3]

Dr. Jan Lastovicka ,jla@ufa.cas.cz ,(Head of Department of Aeronomy) ,Czech Republic ,Prague ,Not Presenting[4]

1 - Institute of Atmospheric Physics, CAS, Czech Republic 2 - Laboratorio de Telecomunicaciones. Facultad de Ciencias Exactas y Tecnología, San Miguel de Tucuman 3 - Institute of Space Science, National Central University, Chung-Li 320, Taiwan 4 - Institute of Atmospheric Physics CAS, Czech Republic

Examples and analysis of coseismic infrasound waves observed in the ionosphere by an international network of continuous Doppler sounders are presented. It is documented that the co-seismic infrasound is generated by vertical movement of the ground surface caused by seismic waves propagating at supersonic speeds from strong, M>7, earthquakes. The coseismic infrasound propagates nearly vertically and has usually periods of several tens of seconds far away from the epicenter. However, in the vicinity of the epicenter (up to distance about 1000-1500 km), the large amplitudes might lead to nonlinear formation of N-shaped pulse in the upper atmosphere with much longer dominant period, *e.g.* around 2 min. The experimental observation by continuous Doppler sounding at horizontal distance about 800 km from the epicenter of M 8.3 earthquake and at height around 200 km is in good agreement with full wave numerical modeling that uses as boundary condition the measured vertical velocity of the ground surface. It is also shown that the spectral content can be nonlinearly changed at intermediate distances (around 3000-4000 km), though the N-shaped pulse is not obvious.

Infrasound in the ionosphere from typhoons

Abstract ID : 85

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jaroslav Chum ,jachu@ufa.cas.cz ,(senior research scientist) ,Czech Republic ,Prague ,Not Presenting[1]

Mr Tereza Šindelarova ,tersin@ufa.cas.cz ,(None) ,Czech Republic , ,Not Presenting[2]

Mr Katerina Podolska ,kapo@ufa.cas.cz ,(None) ,Czech Republic , ,Not Presenting[2]

Dr. Jann-Yenq Liu ,jyliu@jupiter.ss.ncu.edu.tw ,(Professor) ,Taiwan ,TaoYuan ,Not Presenting[4]

1 - Institute of Atmospheric Physics, CAS, Czech Republic 2 - Institute of Atmospheric Physics CAS, Czech Republic 3 - Institute of Atmospheric Physics CAS, Czech Republic 4 - Institute of Space Science, National Central University, Chung-Li 320, Taiwan

Infrasound waves associated with seven typhoons that passed over Taiwan or in its close vicinity during the time period 2014-2016 were investigated. The infrasound waves were observed by continuous Doppler sounder at height range approximately from 200 to 300 km. Their spectra differed during the individual events and event from event and covered roughly the spectral range from 3.5 to 20 mHz. The peak of spectral density was usually around 5 mHz. The observed spectra exhibited fine structures that likely resulted from modal resonances. The infrasound was recorded during several hours for strong events, especially for two typhoons in September 2016.

Application of satellite sensing and model study for research acoustic gravity waves in the troposphere-ionosphere coupling system

Abstract ID : 114

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Olga Borchevkina ,opsuslova@gmail.com ,(PhD student Junior Researcher) ,Russia ,Kaliningrad ,Not Presenting[1]

Prof. Ivan Karpov ,ivkarpov@inbox.ru ,(None) ,Russia , ,Not Presenting[2]

Ms. Alexandra Ilminskaya ,a.ilminskaya@mail.ru ,(None) ,Russia , ,Not Presenting[1]

Dr. Fedor Bessarab ,bessarabf@gmail.com ,(None) ,Russia , ,Not Presenting[2]

Mr. Pavel Vasiliev ,pvasiliev93@gmail.com ,(None) ,Russia , ,Not Presenting[1]

1 - Immanuel Kant Baltic Federal University 2 - WD IZMIRAN 3 - Immanuel Kant Baltic Federal University 4 - WD IZMIRAN 5 - Immanuel Kant Baltic Federal University

Theoretical and experimental studies suggest that acoustic gravity waves which generated in the lower atmosphere can propagate to the upper atmosphere altitudes and generate ionospheric disturbances. Here we investigate ionospheric disturbances caused by the processes in the lower and middle atmosphere.

Strong meteorological disturbances are characteristic of the climate of the Baltic region. This allows us to identify meteorological effects in changes of ionospheric conditions. The purpose of this paper is to study disturbances of ionospheric parameters occurring during meteorological storms and to find their features from observations. We consider the meteorological disturbances that took place in the quiet geomagnetic conditions in order to minimize the impact of geomagnetic factors.

The data of vertical sensing and variations of the TEC were used as the ionospheric parameters. The analysis of the observations of ionospheric parameters made has shown that during meteorological storms there are considerable decreases in TEC and F-layer critical frequency. This allows us to consider the revealed ionospheric disturbances as typical signs of disturbances driven by meteorological processes.

Ionospheric disturbances develop quite rapidly, within several hours after meteorological disturbances. Can be assumed that the physical mechanisms realizing ionosphere-troposphere connections are defined by AGW propagation.

The spectrum of ionospheric variations demonstrate harmonics with periods of AGW in periods of meteorological disturbances. The spectrum of the TEC variations shows the increasing in the harmonic amplitudes with AGWs period with a maximum in day weather storm and in the day after.

The propagation of AGW in the lower atmosphere is theoretically studied using numerical models that take into account a variety of physical processes involved in the propagation of waves.
A theoretical study of the propagation of AGW from land-based sources into the upper atmosphere showed that this waves effectively penetrate into the upper atmosphere. The dissipating of this waves cause a perturbation in the atmosphere at altitudes ~ 200 km. The influence of this perturbations on the atmosphere and ionosphere parameters are studied in the numerical experiments. The results of these experiments are discussed.

Impacts of SABER CO2-based Eddy Diffusion Coefficients in the Lower Thermosphere on the Ionosphere/Thermosphere

Abstract ID : 124

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Cornelius Csar Jude Salinas ,ccjsalinas@gmail.com ,(PhD Candidate) ,Taiwan ,Taipei ,Not Presenting[1]

Dr. James Russel III ,JAMES.RUSSELL@hamptonu.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Jia Yue ,JIA.YUE@hamptonu.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Mao-chang Liang ,mcl@rcec.sinica.edu.tw ,(None) ,Taiwan , ,Not Presenting[4]

Dr. Loren Chang ,loren@ncu.edu.tw ,(Associate Professor) ,Taiwan ,Taoyuan City ,Not Presenting[1]

Dr. Marty Mlynczak ,m.g.mlynczak@nasa.gov ,(None) ,United States , ,Not Presenting[6]

1 - National Central University 2 - Hampton University 3 - Hampton University 4 - Academia Sinica 5 - National Central University 6 - NASA Langley Research Center

This work estimates global-mean Kzz using SABER/TIMED monthly global-mean CO2 profiles and a one-dimensional transport model. It is then specified as a lower boundary into the Thermosphere Ionosphere Electrodynamics General Circulation Model (TIE-GCM). Results first show that global mean CO2 in the MLT region has an Annual and Semi-annual Oscillation (AO and SAO) with maxima during solstice seasons along with a primary maximum in boreal summer. Our calculated AO and SAO in global-mean CO2 are then modeled by an AO and SAO in global-mean Kzz. It is then shown that our estimated global-mean Kzz is lower in magnitude than the suggested global-mean Kzz from *Qian et al* [2009] that can model the observed AO and SAO in the IT region. However, our estimated global-mean Kzz is similar in magnitude with recent suggestions of global-mean Kzz in models with explicit gravity wave parameterization. Our work therefore concludes that global-mean Kzz from global-mean CO2 profiles cannot model the observed AO and SAO in the IT region because our estimated global-mean Kzz may only be representing eddy diffusion due to gravity wave breaking. The difference between our estimated global-mean Kzz and the global-mean Kzz from *Qian et al* [2009] thus represents diffusion and mixing from other non-gravity wave sources not directly accounted for in the TIE-GCM lower boundary conditions. These other sources may well be the more dominant lower atmospheric forcing behind the AO and SAO in the IT region.

Interhemispheric coupling and its influence on the mesosphere

Abstract ID : 140

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Bodil Karlsson ,bodil@misu.su.se ,(Department of Meteorology Stockholm University) ,Sweden ,Stockholm ,Not Presenting[1]

1 - Stockholm University

The observed hemispheric differences in the middle atmosphere are at this point not fully understood. This is particularly true when it comes to the summer mesopause regions. We suggest that interhemispheric coupling is a central mechanism behind each hemisphere's summer seasonal characteristics. The interhemispheric coupling signal is initiated in the winter hemisphere and communicated to the summer polar mesosphere via a chain of wave - mean flow interactions. Using the Kühlungborn Mechanistic General Circulation Model (KMCM) we show that both summer mesopauses would be significantly warmer without the effect of the interhemispheric coupling. We also show that - as opposed to what has been discussed in literature before - it is mostly the northern hemisphere summer that is affected by the calm and cool southern hemispheric winter.

On the Relationship between Sporadic-E and ENSO Observed by FORMOSAT-3/COSMIC

Abstract ID : 144

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Loren Chang ,loren@ncu.edu.tw ,(Associate Professor) ,Taiwan ,Taoyuan City ,Not Presenting[1]

Dr. Jann-Yenq Liu ,jyliu@jupiter.ss.ncu.edu.tw ,(Professor) ,Taiwan ,TaoYuan ,Not Presenting[2]

Ms. Pei-Yun Chiu ,runinto_initial@hotmail.com ,(None) ,Taiwan , ,Not Presenting[1]

Dr. Chien-Hung Lin ,charles@mail.ncku.edu.tw ,(None) ,Taiwan , ,Not Presenting[4]

Mr. Cornelius Csar Jude Salinas ,ccjsalinas@gmail.com ,(PhD Candidate) ,Taiwan ,Taipei ,Not Presenting[1]

1 - National Central University 2 - Institute of Space Science, National Central University, Chung-Li 320, Taiwan 3 - National Central University 4 - National Cheng Kung University 5 - National Central University

Sporadic E (Es) refers to dense layers of metallic ions that can form in the ionospheric E region due to the effects of vertical neutral wind shear, influencing terrestrial and satellite radio propagation. The effects of Es can be observed by means of GPS scintillation in the E region, parametrized as the S4 phase fluctuation index. Here we present a report on the long term variation of Es using S4 indices and the zonal mean tropopause height measured by the FORMOSAT-3/COSMIC satellite constellation from 2007 - 2014. We find that the monthly global median S4 index extremes in the E region shows a prominent dependence on variation of the El Niño-Southern Oscillation (ENSO) in the troposphere that has not been previously reported. The ENSO related variation of the E region global median S4 indices varies in phase with that of the zonal mean tropopause height, with both parameters lagging the Oceanic Niño index by four to five months. Taken together, these results indicate that ENSO signatures can be transmitted to Es formation mechanisms, potentially through modulation of the atmospheric waves and tides that alter lower thermospheric neutral wind shears by vertically propagating and breaking in that region.

KELVIN WAVE COUPLING FROM TIMED AND GOCE: INTER/INTRA-ANNUAL VARIABILITY AND SOLAR ACTIVITY EFFECTS.

Abstract ID : 160

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Federico Gasperini ,gasperini@usu.edu ,(Postdoctoral Research Fellow) ,United States ,Logan ,Not Presenting[1]

Prof. Jeffrey M Forbes ,forbes@colorado.edu ,(Professor) ,United States ,Boulder ,Not Presenting[2]

Prof. Maura E Hagan ,maura.hagan@usu.edu ,(None) ,United States , ,Not Presenting[1]

1 - Utah State University 2 - University of Colorado 3 - Utah State University

The primary mechanism through which energy and momentum are transferred from the lower atmosphere to the thermosphere is through the generation and propagation of global-scale waves. It is becoming increasing evident that a few waves from the tropical wave spectrum preferentially propagate into the thermosphere, and modify satellite drag to a significant degree. Two of the more prominent and well-established tropical waves are two Kelvin waves: the eastward-propagating 3-day ultra-fast Kelvin wave (UFKW) and the eastward-propagating diurnal tide with zonal wave number 3 (DE3). In this work, Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) temperatures at 110 km and Gravity field and steady-state Ocean Circulation Explorer (GOCE) neutral densities and cross-track winds near 260 km are used to demonstrate vertical coupling in this height regime due to the UFKW and DE3. Significant inter- and intra-annual variability is found in DE3 and the UFKW, with evidence of latitudinal broadening and filtering of the latitude structures with height due to the effect of dissipation and mean winds. Additionally, anti-correlation between the vertical penetration and broadening of these waves and solar activity level is established and explained through the effect of molecular dissipation.

Geomagnetic activity and polar surface air temperature variability - energetic particle precipitation coupling between the magnetosphere, ionosphere and the atmosphere

Abstract ID : 352

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Mark Clilverd ,macl@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Annika Seppala ,Annika.Seppala@fmi.fi ,(None) ,New Zealand , ,Not Presenting[2]

Prof. Craig Rodger ,craig.rodger@otago.ac.nz ,(Head of Department) ,New Zealand ,None ,Not Presenting[2]

Dr. Pekka Verronen ,pekka.verronen@fmi.fi ,(None) ,Finland , ,Not Presenting[4]

Dr. Monika Andersson ,monika.andersson@fmi.fi ,(None) ,Finland , ,Not Presenting[4]

1 - British Antarctic Survey 2 - University of Otago 3 - University of Otago 4 - Finnish Met. Institute 5 - Finnish Met. Institute

Previous modelling work has suggested that Odd Nitrogen (NOx) produced at high latitudes by energetic particle precipitation can eventually lead to detectable changes in surface air temperatures (SATs). Analysis of the ERA-40 and ECMWF operational surface level air temperature data sets from 1957 to 2006 found that during winter months, polar SATs in years with high geomagnetic activity are different than in years with low geomagnetic activity; the differences are statistically significant at the 2-sigma level and range up to about +-4.5 K depending on location (Seppälä et al., [JGR, 114, A10312, doi:10.1029/2008JA014029, 2009}). Further work has been undertaken by the authors which investigates the geomagnetically-controlled coupling between the ionosphere and the atmosphere that leads to such surface temperature modulations. This talk will describe developments in the understanding of the coupling mechanism, including the observations of chemical composition changes such as those driven by Odd Hydrogen (Verronen et al., [JGR, 118, doi:10.1002/jgrd.50845, 2013]), directly associated with the source energetic electron precipitation into the upper atmosphere (Andersson et al. [Nature Comm., doi:10.1038/ncomms6197, 2014]), and the mechanism for dynamical transfer of the perturbation signals to lower in the atmosphere (Seppälä et al. [JGR, 118, doi:10.1002/jgrd.50236, 2013]; Seppälä and Clilverd [Frontiers in Physics, 2, 25, 6, pp. 10.3389/fphy.2014.00025, 2014]).

Satellite observations of atmosphere-ionosphere vertical coupling by gravity waves

Abstract ID : 375

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Thai Trinh ,t.trinh@fz-juelich.de ,(Postdoc) ,Germany ,Juelich ,Presenting[1]

Dr. Manfred Ern ,m.ern@fz-juelich.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Eelco Doornbos ,e.n.doornbos@tudelft.nl ,(None) ,Netherlands , ,Not Presenting[3]

Dr. Peter Preusse ,p.preusse@fz-juelich.de ,(None) ,Germany , ,Not Presenting[1]

Prof. Martin Riese ,m.riese@fz-juelich.de ,(None) ,Germany , ,Not Presenting[1]

1 - Juelich research center 2 - Juelich research center 3 - Delft University of Technology, Aerospace Engineering, Astrodynamics & Space Missions 4 - Juelich research center 5 - Juelich research center

Atmospheric gravity waves (GWs), which are mainly excited in the troposphere and tropopause region, are essential for the dynamics of the middle atmosphere. Recent studies, however, have shown that these waves are likely important also for the thermosphere/ionosphere (T/I) system. Via vertical coupling, GWs can significantly influence the mean state of the T/I system. The penetration of GWs into the T/I system is however not well understood in modeling as well as observations. In the current study, we analyze the correlation between different GW parameters in the middle atmosphere (30-90 km) and GW induced perturbations in the T/I. In the middle atmosphere, GW parameters are derived from temperature observations of the Sounding of the Atmosphere using Broadband Emission Radiometry (SABER). In the T/I, GW induced perturbations of neutral density measured by Gravity field and Ocean Circulation Explorer (GOCE) and CHAllenging Minisatellite Payload (CHAMP) are analyzed. Interestingly, we find positive correlations between the spatial distributions at low altitudes (i.e. below 90km) and the spatial distributions of GW-induced density fluctuations in the T/I (at 200km and above). This suggests that many waves seen in the T/I have their origins in the troposphere or lower stratosphere. It is also indicated that mountain waves generated near the Andes and Antarctic Peninsula propagate up to the T/I. Strong positive correlations between GW perturbations in the T/I and GW parameters at 30 km are mainly found at mid latitudes, which may be an indicator of propagation of convectively generated GWs. Increase of correlation starting from 70 km in many cases shows that filtering of the GW distribution by the background atmosphere is very important. Processes that are likely involved are GW dissipation, generation of secondary GWs, as well as horizontal propagation of GWs. Limitations of our method and of the observations are also discussed.

Turbulence and Wave Transport in the Mesopause Region

Abstract ID : 376

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Alan Liu ,alan.liu@erau.edu ,(Professor) ,United States ,Daytona Beach ,Not Presenting[1]

Dr. Chester Gardner ,cgardner@illinois.edu ,(None) ,United States , ,Not Presenting[2]

Ms. Yafang Guo ,guoy1@my.erau.edu ,(None) ,United States , ,Not Presenting[1]

1 - Embry-Riddle Aeronautical Univ 2 - University of Illinois at Urbana-Champaign 3 - Embry-Riddle Aeronautical Univ

We report recent advances of the Na lidar measurements of wave and turbulence in the mesopause region. Thanks to the improvement in lidar technology and recent upgrades, the Na lidar at Andes Lidar Observatory has now achieved signal levels high enough to detect turbulence scale perturbations, even with a moderate 70-cm diameter mirror. Reliable operation of the lidar has resulted in over 900 hours of high-quality data in two years. This has enabled a variety of MLT studies not possible before. One study will be presented in more detail is the simultaneous measurements of vertical heat transport by both gravity wave and turbulence. Using the lidar measurements, the gravity wave heat flux, energy flux, and turbulence heat flux, energy dissipation rate are all derived. These measurements provide insights to the dynamics and energetics of gravity wave breaking and turbulence dissipation.

Energetic particle influence on the Earth's atmosphere

Abstract ID : 808

Conflict Declaration : None

Content Motivation : Invited presentation

Additional Information : None

Dr. Irina Mironova ,irini.mironova@gmail.com ,(Senior Scientist) ,Russia ,St. Petersburg ,Not Presenting[1]

1 - St. Petersburg State University

Review will summarize the present knowledge on ionization of the atmosphere by energetic particle precipitation: galactic cosmic rays, solar energetic particles, middle and relativistic energy electrons. Ionization created by Bremsstrahlung will be also taken into account.
The main advances will cover subjects defined:
- Atmospheric ionization by energetic particles.
- Definition of energetic particles inputs for climate modeling.
- Impact of energetic particles on chemistry of the upper and middle atmosphere.
Finally open questions and summary coming out will be presented as a conclusion.

Radar observations of atmospheric gravity waves in the MLT region from low latitudes

Abstract ID : 874

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Subramanian Gurubaran ,gurubara@iigs.iigm.res.in ,(Professor) ,India ,Navi Mumbai ,Not Presenting[1]

Dr. P T Patil ,ptpatil@iigs.iigm.res.in ,(None) ,India , ,Not Presenting[1]

Dr. Sundararaman Sathishkumar ,sathishmaths@gmail.com ,(Reader/Scientist) ,India ,Tirunelveli ,Not Presenting[1]

1 - Indian Institute of Geomagnetism 2 - Indian Institute of Geomagnetism 3 - Indian Institute of Geomagnetism

The characteristics of high frequency atmospheric gravity waves (AGW) in the mesosphere-lower thermosphere (MLT) region as observed by an MF radar at Kolhapur (16.8^{o}N, 74.2^{o}E) over a period of two years are presented in this work. The mean zonal winds over Kolhapur exhibit a strong semi-annual oscillation at altitude between 75 and 80 km which weaken at higher altitudes. While computing the variances of small-period gravity wave motions, we grouped them into two categories: 10 min-2.5 min period range and 2-10 hour period range. Results from this analysis reveal that the AGW activity during equinoxes is stronger than during solstices. As expected, gravity wave perturbations grow in amplitude in the altitude range examined (75-98 km). An important feature noticed in the analysis is a significant anisotropy in wave characteristics with amplitudes in meridional wind being stronger than in the zonal wind indicating the importance of wave filtering in the zonal component. The results are discussed in the context of our understanding of the propagation of atmospheric gravity waves at low latitudes.

Unexpected occurrence of mesospheric frontal events over South Pole (90S)

Abstract ID : 932

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Pierre-Dominique Pautet ,dominiquepautet@gmail.com ,(Senior researcher) ,United States ,Logan ,Not Presenting[1]

Mrs. Christina Solorio ,christina.wittwer@aggiemail.usu.edu ,(None) ,United States , ,Not Presenting[1]

Prof. Michael Taylor ,mike.taylor@usu.edu ,(None) ,United States , ,Not Presenting[1]

1 - Utah State University 2 - Utah State University 3 - Utah State University

During the wintertime, the South Pole lies at the center of the giant Antarctic polar vortex that isolates it from the rest of the world. Since 2010, Utah State University (USU) has operated an Advanced Mesospheric Temperature Mapper (AMTM) at the Amundsen-Scott South Pole Station to investigate the mesospheric temperature variability and the dynamics associated with small-scale gravity waves within the vortex. This presentation will focus on the surprisingly large number of frontal events (>80) observed during four Austral winter seasons (mid-April to end of August 2012-2015). Frontal events are defined by a sharp front followed by several distinct trailing waves. A particular type is called "bore" and is associated with mesospheric inversion layers. Bores have been observed in tropospheric clouds, but to date, observations are rare in the upper atmosphere, especially at high-latitudes. Examples of these events will be presented together with measurements of their propagation characteristics. These results provide important new information on the generation and propagation of gravity waves and the structure of the upper atmosphere within the winter polar vortex.

Characteristics of the small-scale mesospheric gravity waves observed with an airborne Advanced Mesospheric Temperature Mapper (AMTM) during the DEEPWAVE Project

Abstract ID : 933

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Pierre-Dominique Pautet ,dominiquepautet@gmail.com ,(Senior researcher) ,United States ,Logan ,Not Presenting[1]

Prof. Michael Taylor ,mike.taylor@usu.edu ,(None) ,United States , ,Not Presenting[1]

Dr. David Fritts ,dave@gats-inc.com ,(None) ,United States , ,Not Presenting[3]

1 - Utah State University 2 - Utah State University 3 - GATS Inc.

During the months of June and July 2014, a large-scale project named DEEPWAVE took place in New Zealand. This international program focused on investigating the generation and deep propagation of atmospheric gravity waves. A series of instruments was operated at several ground-based locations and on-board the NSF Gulfstream V aircraft. 25 nighttime research flights were performed to explore possible wave sources and their effects on the middle and upper atmosphere. They covered a large region, enabling measurements over various types of topography (mountains: New Zealand South Island, Tasmania, isolated islands, or open ocean: Tasman Sea, Southern Ocean, Pacific Ocean), and under different forcing conditions. An Advanced Mesospheric Temperature Mapper (AMTM) measured the temperature perturbations associated with small-scale gravity waves propagating around 85 km. This presentation will focus on the power and direction of propagation of these waves, their correlation with the terrain over which they were observed, as well as the tropospheric forcing present at the time.

Atmosphere-Ionosphere Coupling during the 11 March 2011 M9.0 Tohoku Earthquake and Tsunami

Abstract ID : 1009

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jann-Yenq Liu ,jyliu@jupiter.ss.ncu.edu.tw ,(Professor) ,Taiwan ,TaoYuan ,Presenting[1]

Mr. Chao-Yen Chen ,cychen@jupiter.ss.ncu.edu.tw ,(None) ,Taiwan , ,Not Presenting[2]

Dr. Yang-Yi Sun ,yysun0715@gmail.com ,(None) ,Taiwan , ,Not Presenting[2]

Dr. I-Te Lee ,ikkyu.itlee@gmail.com ,(None) ,Taiwan , ,Not Presenting[2]

1 - Institute of Space Science, National Central University, Chung-Li 320, Taiwan 2 - National Central University 3 - National Central University 4 - National Central University

The GPS radio occultation of FORMOSAT-3/COSMIC (F3/C) with 1-2.5 km altitude resolution scans fluctuations on vertical profiles of the ionospheric electron density induced by seismic and tsunami waves of the 11 March 2011 M9.0 Tohoku earthquake. Hilbert-Huang transform (HHT) is applied to derive the instantaneous wavenumber and amplitude of the fluctuations in 35 (7 before and 28 after) F3/C profiles within 3000 km in radius from the epicenter during the earthquake. It is found that the seismic and tsunami waves significantly activate the fluctuations on the vertical profiles of the ionospheric electron density, and prominent fluctuations mainly appear in the poleward (North) side of the epicenter. Results demonstrate that the radio occultation is a powerful tool which is suitable to probe vertical fluctuations in the ionospheric electron density.

Ionospheric Irregularities and Plasma Bubbles Observed by GPS TEC and OI 630 nm Airglow: Signature of Troposphere-Ionosphere Coupling

Abstract ID : 1161

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Hisao Takahashi ,hisao.takahashi@inpe.br ,(None) ,Brazil ,São José dos Campos ,Not Presenting[1]

1 - INPE

Propagating ionospheric oscillations and equatorial plasma bubbles (EPBs) have been observed by groundbased GPS sensor network and airglow 6300 imagers over Brazil in 2014 and 2015. Characteristics of the periodic oscillation of TEC (most probably the medium scale travelling ionospheric disturbances (MSTID)) and EPBs were obtained and studied the relation between the two processes. Frequently we observed that a MSTID occurred during the afternoon to sunset side was followed by development of plasma bubbles in the evening side. Possible mechanism of the bubble seeding process will be discussed considering a coupling process from troposphere - mesosphere to ionosphere by gravity waves.

Small-scale gravity wave effects on the thermospheric diurnal migrating tide

Abstract ID : 1192

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Erdal Yigit ,eyigit@gmu.edu ,(None) ,United States ,Fairfax ,Presenting[1]

Dr. Alexander S. Medvedev ,medvedev@mps.mpg.de ,(None) ,Germany , ,Not Presenting[2]

1 - George Mason University 2 - Max Planck Institute for Solar System Research

For the first time, the direct effects of lower atmospheric small-scale gravity waves (GWs) on the diurnal migrating tide have been studied from the mesosphere to the upper thermosphere. For this, a general circulation model that account for the whole atmosphere GW parameterization of Yi?it et al. [2008] has been used to account for direct GW propagation from the lower atmosphere to the upper thermosphere. Two control simulations have been performed, (1) excluding GW effects above the turbopause and (2) including GWs in the entire thermosphere and model output for September conditions have been analyzed. GWs appreciably impact the mean circulation and cool the thermosphere. They significantly affect the mean winds, which are modulated by the diurnal migrating tide, in particular in the low-latitude mesosphere and lower thermosphere and in the high-latitude thermosphere. GW-tidal interactions depend on the mutual correlation of the diurnal phases of the GW forcing and tides: GWs can either enhance or reduce the migrating tidal amplitude. Low-latitude and high-latitude thermosphere behave differently in terms of GW-tide interactions. In the low-latitude MLT, the correlation between the direction of the deposited GW momentum and the tidal phase is positive due to propagation of a broad spectrum of GW harmonics through the alternating winds. In the Northern Hemisphere high-latitude thermosphere, GWs act against the tide due to an anti-correlation of tidal and GW phases, while in the Southern high-latitudes they weakly enhance the tidal amplitude via a combination of a partial correlation of phases and GW-induced changes of the circulation. The necessary conditions that are needed in order to capture the variable nature GW effects on the migrating tide include: (1) A broad spectrum of harmonics, (2) proper description of GW propagation, and (3) correct estimation of the physics of wave breaking/saturation.

Reference:

Yi?it, E., A. D. Aylward, and A. S. Medvedev (2008), Parameterization of the effects of vertically propagating gravity waves for thermosphere general circulation models: Sensitivity study, J. Geophys. Res., 113, D19106, doi:10.1029/2008JD010135.

The strong ULF/ELF/VLF emissions in the ionosphere and upper atmosphere associated with the fluxes of the energetic electrons

Abstract ID : 1302

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Jan Blecki ,jblecki@cbk.waw.pl ,(None) ,Poland ,Warsaw ,Not Presenting[1]

Mr. Jan S?omi?ski ,jani@cbk.waw.pl ,(None) ,Poland , ,Not Presenting[1]

Mr. Roman Wronowski ,roman@cbk.waw.pl ,(None) ,Poland , ,Not Presenting[1]

Dr. Ewa S?omi?ska ,evvaes@icloud.com ,(None) ,Poland , ,Not Presenting[4]

Dr. Janusz M?ynarczyk ,janusz.mlynarczyk@agh.edu.pl ,(None) ,Poland , ,Not Presenting[5]

Prof. Andrzej Ku?ak ,radiol1@wp.pl ,(None) ,Poland , ,Not Presenting[5]

Dr. Roger Haagmans ,roger.haagmans@esa.int ,(None) ,Netherlands , ,Not Presenting[7]

1 - Space Research Centre PAS 2 - Space Research Centre PAS 3 - Space Research Centre PAS 4 - OBSEE 5 - AGH 6 - AGH 7 - ESA - ESTEC

Abstract

The emissions with extremely high intensity around electron cyclotron frequency have been sometimes registered by satellite Magion 4 - companion of Interball 1 in the polar cusps. These waves correlate with strong fluxes of high energetic electrons often observed within the polar cusp by Interball 1 and Magion 4 as well as by Polar and CLUSTER satellites. Similar effects have been registered by DEMETER satellite in the polar cusp at the ionospheric altitudes as well in the ionosphere over the thunderstorm regions. The fluxes of the superthermal electrons likely are the sources of these emissions in both cases. Beam instability of the fluxes of electrons with energy up to 100keV interacting with the ionosphere and upper atmosphere will be discussed in the presentation. The discussion of the cross correlation between the ground based and Swarm registration of the ULF waves related to the thunderstorm and TLE's will additionally be presented.

Acknowledgments.

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Dynamical Response of the Northern Middle- and High-Latitude Mesosphere to Local and Global Variations

Abstract ID : 1347

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Fazlul Laskar ,laskar@iap-kborn.de ,(Post Doctoral Fellow) ,Germany ,Kuehlungsborn ,Presenting[1]

Mr. Jorge L. Chau ,chau@iap-kborn.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Gunter Stober ,stober@iap-kborn.de ,(None) ,Germany , ,Not Presenting[1]

Prof. Chris Hall ,chris.hall@uit.no ,(None) ,Norway , ,Not Presenting[4]

Prof. Masaki Tsutsumi ,tutumi@nipr.ac.jp ,(None) ,Japan , ,Not Presenting[5]

Prof. J.P. St-Maurice ,jp.stmaurice@usask.ca ,(None) ,Canada , ,Not Presenting[6]

Dr. Peter Hoffmann ,hoffmann@iap-kborn.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Josef Höffner ,hoeffner@iap-kborn.de ,(None) ,Germany , ,Not Presenting[1]

1 - Leibniz Institute of Atmospheric Physics 2 - Leibniz-IAP at the University of Rostock 3 - Leibniz Institute of Atmospheric Physics 4 - Tromsø Geophysical Observatory, UiT 5 - National Institute of Polar Research 6 - University of Saskatchewan, Saskatoon 7 - Leibniz Institute of Atmospheric Physics 8 - Leibniz Institute of Atmospheric Physics

The Northern middle- and high- latitude mesosphere lower thermosphere dynamics were investigated using radar, lidar, satellite, and reanalysis datasets. We investigated the variabilities of various waves in response to seasonal, quasi-biennial, and transition time changes. More than 12 years of nearly continuous wind measurements over Andenes (69°N, 16°E) and Tromsø (70°N, 19°E) and 8 years over Juliusruh (54°N, 13°E) are used as primary datasets. Interesting results from mesospheric wind demonstrate that the semidiurnal tidal amplitudes during August-September are stronger during eastward phase of QBO and weaker for the westward phase. We discuss the role of interhemispheric planetary waves and wave-wave interaction for a possible explanation. Also, the 3-dimensional gradients in wind fields derived from combined meteor detections at the common volume over Andenes and Tromsø were used to derived horizontal divergence in wind. Interestingly the altitude corresponding to zero horizontal divergence show strong anti-correlation with summer mean mesopause level temperature. We propose that the adiabatic cooling related to wind divergence is the cause of this behavior. We will discuss these results in the context of local and global sources of variabilities.

Coupling of the gravity wave activity, climate phenomena and middle atmospheric dynamics

Abstract ID : 1431

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Petr Pisoft ,petr.pisoft@mff.cuni.cz ,(Associate professor, scientist) ,Czech Republic ,Prague ,Not Presenting[1]

Dr. Petr Sacha ,petr.sacha@mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

Dr. Jiri Miksovsky ,jiri.miksovsky@mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

Mr. Ales Kuchar ,kuchara@mbox.troja.mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

1 - Charles University, Faculty of Mathematics and Physics, Department of Atmospheric Physics 2 - Charles University, Faculty of Mathematics and Physics, Department of Atmospheric Physics 3 - Charles University, Faculty of Mathematics and Physics, Department of Atmospheric Physics 4 - Charles University, Faculty of Mathematics and Physics, Department of Atmospheric Physics

In the atmosphere, the internal gravity waves (IGW) are one of the fastest ways of natural information transfer in the vertical direction. Tropospheric changes that result in modification of sourcing, propagation or breaking conditions for IGWs almost immediately influence the distribution of gravity wave drag in the stratosphere. So far most of the related studies deal with IGW impacts higher in the upper stratospheric/mesospheric region and with the modulation of IGWs by planetary waves. This is most likely due to the fact that IGWs induce highest accelerations in the mesosphere and lower thermosphere region. However, the imposed drag force is much bigger in the stratosphere.
In the presented analysis, we have analyzed how much of orographic gravity wave drag (OGWD) variance can be explained by lower tropospheric conditions and then we assessed the relationship between the gravity wave activity in the stratosphere and other climatic phenomena through statistical techniques. Multivariable regression has been applied to investigate the IGW-related eastward and northward wind tendencies in the CMAM30-SD data, subject to the explanatory variables involving local circulation characteristics as well as the phases of the large-scale internal climate variability modes (ENSO, NAO, QBO). We have found several statistically significant responses of the OGWD to each of the variability modes under investigation.
Furthermore we analyzed the influence of OGWD distribution on the Brewer-Dobson circulation (BDC) and stratospheric polar vortex events (SPV). We have applied composite analysis of displacement and split SPVs from CMAM30-SD to focus on how the strength and horizontal distribution of OGWD can play a role in SPV occurrence and frequency. From CMAM refC2 simulation we analyzed the mean stratospheric age of air time evolution as a proxy for a BDC change which is then contrasted with a change in wave driving to highlight an important role of OGWD in acceleration of the BDC.

Study on gravity waves using ground based and satellite measurements

Abstract ID : 1446

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Igo Paulino ,igopaulino@gmail.com ,(Lecturer and researcher) ,Brazil ,Campina Grande ,Presenting[1]

Dr. Ana Roberta Paulino ,arspaulino@gmail.com ,(None) ,Brazil , ,Not Presenting[1]

Dr. Ricardo Buriti ,rburiti@df.ufcg.edu.br ,(None) ,Brazil , ,Not Presenting[1]

Dr. Cristiano Wrasse ,cristiano.wrasse@inpe.br ,(Professor) ,Brazil ,Campina Grande ,Not Presenting[4]

Prof. Hisao Takahashi ,hisao.takahashi@inpe.br ,(None) ,Brazil ,São José dos Campos ,Not Presenting[4]

Dr. Medeiros Amauri ,afragoso@df.ufcg.edu.br ,(Professor) ,Brazil ,Campina Grande ,Not Presenting[1]

1 - UFCG 2 - UFCG 3 - UFCG 4 - INPE 5 - INPE 6 - UFCG

Four medium-scale gravity waves were studied using images of the NIR OH airglow emission obtained from an all sky imager deployed at São João do Cariri (36.5 ^{o}W; 7.4 ^{o}S) and mesospheric temperature profiles from the TIMED/SABER satellite. The coincident measurements were made on 11 and 14 April 2007, 08 February and 28 August 2008. The horizontal parameters of the gravity waves were estimated using the keogram analysis and the vertical ones were calculated from the coincident temperature profiles collected into the area of 15^{o} x 15^{o} degrees (longitude X latitude), centered at the observatory. The horizontal wavelength were 190, 138, 171 and 355 km, respectively. The observed periods were 50, 20, 33 and 20 min. The vertical wavelength were 15, 10, 15 and 30 km. Comparisons to the dispersion relation for the gravity waves were done and the results are in agreement to the theory. Thus, the SABER satellite measurements may be used to study the gravity wave activity in the mesosphere and lower thermosphere with good precision.

Application of the phase velocity spectral analysis of the airglow imaging to the gravity waves studies

Abstract ID : 1479

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Takuji Nakamura ,nakamura.takuji@nipr.ac.jp ,(Professor) ,Japan ,Tachikawa ,Not Presenting[1]

Mr. Takashi S. Matsuda ,matsuda.takashi@nipr.ac.jp ,(None) ,Japan , ,Not Presenting[1]

Dr. Mitsumu K. Ejiri ,ejiri.mitsumu@nipr.ac.jp ,(None) ,Japan , ,Not Presenting[1]

Prof. Masaki Tsutsumi ,tutumi@nipr.ac.jp ,(None) ,Japan , ,Not Presenting[4]

Dr. Yoshihiro Tomikawa ,tomikawa@nipr.ac.jp ,(Associate Professor) ,Japan ,Tokyo ,Not Presenting[5]

Mr. Masaru Kogure ,kogure.masaru@nipr.ac.jp ,(None) ,Japan , ,Not Presenting[1]

Dr. Sepri Perwitasari ,sperwitasari@gmail.com ,(None) ,Japan , ,Not Presenting[1]

1 - NIPR 2 - NIPR 3 - NIPR 4 - National Institute of Polar Research 5 - Japan 6 - NIPR 7 - NIPR

Phase velocity, or phase speed and direction, is one of the important parameters of gravity waves because it characterizes possibility of vertical propagation through the background horizontal wind profile. However, the observation of horizontal phase velocities is not easy. Vertical sounding by radars and lidars can derive time height cross-section of wind velocities, temperatures etc. Horizontal structure of the gravity waves or the propagation characteristics are, however, difficult to measure directly. Satellite observations are suitable to observe horizontal structures and global distributions of the gravity waves. However, phase velocity measurement is usually difficult due to the lack of information on temporal variation. Ground-based airglow imaging observations are suitable for deriving phase velocity of gravity wave packets. However, most of the past analyses determined phase velocities of gravity wave events which are manually defined and picked up from the huge amount of airglow images. Quantitative analyses of phase velocity distribution have been difficult, because the number of samples of gravity waves are limited due to the manpower of the analyzers. The phase velocity spectral analysis, or the spectral analysis in the horizontal phase velocity domain, of the airglow intensity variations observed by airglow imagers, is a powerful tool to analyze phase velocity distribution of the gravity wave energy. The most outstanding advantage is that it enables to pick up all the small fragment of the gravity waves in any piece of the airglow image, and the obtained power density is proportional to the wave amplitude squared, the horizontal extent of the wave packet, and the duration of wave events. Thus, it can estimate the phase velocity distribution of gravity wave net energy. The paper will present the analysis method and its applications, including results from airglow imaging data in the Antarctic region. The results indicate various aspects of gravity waves,

such as critical filtering effects and wave source heights, effect of temporal variations of background winds and wave sources, dependency on wave periods, and intermittencies.

Survey of CIR-related minor-to-moderate magnetic storm effects on ionosphere: American sector

Abstract ID : 1527

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Dalia Buresova ,buresd@ufa.cas.cz ,(Deputy Director, senior scientist) ,Czech Republic ,Prague ,Presenting[1]

Dr. Jan Lastovicka ,jla@ufa.cas.cz ,(Head of Department of Aeronomy) ,Czech Republic ,Prague ,Not Presenting[2]

Dr. Jaroslav Chum ,jachu@ufa.cas.cz ,(senior research scientist) ,Czech Republic ,Prague ,Not Presenting[3]

Dr. Inez Batista ,inez.batista@inpe.br ,(Senior Researcher) ,Brazil ,Sao Jose dos Campos ,Not Presenting[4]

Mr. Jaroslav Urbar ,urbar@ufa.cas.cz ,(None) ,Czech Republic , ,Not Presenting[5]

Dr. Pezzopane Michael ,michael.pezzopane@ingv.it ,(Professor) ,Italy ,Sao Jose dos Campos ,Not Presenting[6]

Dr. Daniel Kouba ,kouba@ufa.cas.cz ,(None) ,Czech Republic , ,Not Presenting[7]

Dr. Zbysek Mosna ,zbn@ufa.cas.cz ,(None) ,Czech Republic , ,Not Presenting[7]

1 - Institute of Atmospheric Physics CAS 2 - Institute of Atmospheric Physics CAS, Czech Republic 3 - Institute of Atmospheric Physics, CAS, Czech Republic 4 - Instituto Nacional de Pesquisas Espaciais, Brazil 5 - Institute of Atmospheric Physics ASCR, Prague, Czech Republic 6 - Istituto Nazionale di Geofisica e Vulcanologia 7 - Institute of Atmospheric Physics, CAS 8 - Institute of Atmospheric Physics, CAS

The paper deals with ionospheric reaction to recurrent CIR-related magnetic storms above selected ionospheric stations located across the Northern and Southern America. Most of the storms involved in the analysis occurred during the prolonged declining phase of the 23rd solar cycle and extremely low solar activity conditions of 2007-2009. We analysed changes in the course of the main *F2* layer parameters *foF2* (peak frequency) and *hmF2* (height of the peak) against 27-day running mean obtained for different latitudinal and longitudinal sectors for the entire period of selected minor storms. Observations were compared with the effects of strong magnetic storms and with the results for European-African sector. We analysed ionospheric reaction during each storm phase with main emphasis paid on the recovery phase. In general, storm recovery phase is characterized by an

abatement of perturbations and a gradual return to the "ground state" of ionosphere. Magnetospheric substorms, typical for the main phase, as a rule cease during the storm recovery phase. However, observations of stormy ionosphere show significant departures from the climatology also within this phase, which are comparable with those usually observed during the storm main phase. Hemispheric asymmetry of ionospheric response along the America sector seems to be not a dominant and/or strong feature. The asymmetry in individual events may be well pronounced both in *foF2* and *hmF2*, but likely it is an impact of other factors like seasonal variation, magnetic coordinates or local time. Both positive and negative deviations of *foF2* and *hmF2* have been observed independent on season and location. In general, the positive deviations prevailed.

Keywords: Ionospheric storms; hemispheric dependence; solar minimum 23/24.

A11 - Advances in Low latitude and Equatorial Aeronomy (DIV II)

Electrodynamic disturbances in the Brazilian equatorial and low-latitude ionosphere on St. Patrick's Day storm of 17 March 2015

Abstract ID : 84

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Additional Information : None

Dr. Venkatesh Kavutarapu ,venkatkau@gmail.com ,(Post-Doctoral Fellow) ,Brazil ,Sao Jose dos Campos ,Presenting[1]

Dr. Inez Batista ,inez.batista@inpe.br ,(Senior Researcher) ,Brazil ,Sao Jose dos Campos ,Not Presenting[2]

Dr. Paulo Roberto Fagundes ,fagundes@univap.br ,(Professor) ,Brazil ,Sao Jose dos Campos ,Not Presenting[3]

Mr Seemala Gopi.K ,toyoursgopi@gmail.com ,(None) ,India , ,Not Presenting[4]

Mr Tulasi Ram S ,s.tulasiram@gmail.com ,(None) ,India , ,Not Presenting[4]

1 - UNIVAP 2 - Instituto Nacional de Pesquisas Espaciais, Brazil 3 - Universidade do Vale do Paraiba (UNIVAP) 4 - Indian Institute of Geomagnetism, India 5 - Indian Institute of Geomagnetism, India

The St. Patrick's Day storm of 17th March, 2015 has a long lasting main phase with the Dst reaching a minimum of -223 nT. During the main phase, there are two strong prompt penetration phases took place; first with the southward turning of IMF Bz around ~1200 UT and the second with the onset of a substorm around ~1725 UT leading to strong equatorial zonal electric field enhancements. The consequent spatio-temporal disturbances in the ionospheric Total Electron Content (TEC) and the resultant modifications in the Equatorial Ionization Anomaly (EIA) over the Brazilian longitudinal sector are investigated in detail. The simultaneous measurements from a large network of 120 GPS receivers in Brazil, Ionosonde and magnetometers in the Brazilian longitudinal sector are used for this study. The TEC measurements from Madrigal data base in the northern and southern hemispheres along the Brazilian longitudes has also been used in this paper to investigate the interhemispheric response of EIA during the storm. In the presence of enhanced zonal electric field, the equatorial F2-layer peak (hmF2) experienced a rapid uplift without any significant change in the base height (h?F); while the F2 layer is redistributed into F2 and F3 layers. It is further observed that the PPEF induced enhanced zonal electric field resulted in a strong super fountain effect in the Brazilian sector with the

anomaly crest around 40o S latitudes. Further, the hemispheric asymmetry in the storm time response of EIA during both PPEF phases and the influence of coexisting disturbance neutral winds and dynamo electric fields has also been discussed.

COMPARATIVE STUDY ON THE IONOSPHERIC RESPONSE TO MINOR AND MAJOR SUDDEN STRATOSPHERIC EVENTS IN THE BRAZILIAN EQUATORIAL AND LOW LATITUDES

Abstract ID : 97

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Additional Information : None

Dr. Paulo Roberto Fagundes ,fagundes@univap.br ,(Professor) ,Brazil ,Sao Jose dos Campos ,Not Presenting[1]

Dr. Venkatesh Kavutarapu ,venkatkau@gmail.com ,(Post-Doctoral Fellow) ,Brazil ,Sao Jose dos Campos ,Not Presenting[2]

Mr Valdir Gil Pillat ,valdirgp@univap.br ,(None) ,Brazil , ,Not Presenting[3]

Mr Francisco Vieira ,francisco.vieira478@gmail.com ,(None) ,Brazil , ,Not Presenting[4]

Mr Larisa P Goncharenko ,lpg@haystack.mit.edu ,(None) ,United States , ,Not Presenting[5]

1 - Universidade do Vale do Paraiba (UNIVAP) 2 - UNIVAP 3 - Universidade do Vale do Paraiba (UNIVAP), São José Dos Campos, Brazil 4 - Observatório de Física Espacial, Instituto Federal de Tocantins, Araquatins, BrazilNone 5 - MIT Haystack Observatory, Massachusetts Institute of Technology, Westford, Massachusetts, USA

The Total electron Content (TEC), derivate from GPS, becomes one of the most powerful techniques to study the space-time ionospheric (F-region) electrodynamics, during the quiet and disturbed periods. The number of GPS stations in Brazil increased significantly during the last few years; currently more than 100 GPS stations are in operation over the Brazilian region. The GPS-TEC values are derived using the differential delay technique from the dual frequency measurements at L1 and L2 frequencies over the considered locations at equatorial and low latitudes. The present study investigates the ionospheric total electron content (GPSTEC) response in the Southern Hemisphere equatorial and low latitudes, due to major and minor sudden stratospheric warming (SSW) events, which took place during 2009 and 2012. During both the SSW events, the TEC values are depleted to the order of 20-30% all over the Brazil from equator to beyond Equatorial Ionization Anomaly (EIA) regions. In addition, the EIA were suppressed during the SSW events for several days. However, the TEC depletion and EIA suppression lasted for a longer period during SSW-2012 when compared with the SSW-2009; despite the SSW-2012 is considered as a minor event.

Analysis of ionospheric features in middle and low latitude region of China during the geomagnetic storm in March 2015

Abstract ID : 187

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Additional Information : None

Mr. Sun Wenjie ,sunwenjie@mail.iggcas.ac.cn ,(Beijing) ,China ,Beijing ,Not Presenting[1]

1 - IGGCAS, China

The strongest geomagnetic storm of the current solar cycle occurred on 17 March 2015, with a minimum Dst index of -233nT. In this paper, we reported the ionospheric disturbances in the middle and low latitude region of China during this storm. Here we utilized ionosondes data (foF2 and hmF2) and BDS GEO TEC from our 4 stations in Beijing, Wuhan, Shaoyang and Sanya, along with GPS S4 index. Possible mechanisms responsible for the ionospheric disturbances characterized by a positive storm followed by a long duration strong negative storm were discussed. Observations and analysis showed that during the daytime of March 17, the positive storm in the middle latitude was caused by neutral wind which uplifted the ionosphere, while the positive storm in the low latitude and near the northern equatorial ionization anomaly (EIA) was mainly caused by eastward prompt penetration electric field (PPEF). The long-lasting negative storm during the daytime of March 18 was due to westward disturbance dynamo electric field (DDEF) as well as neutral composition disturbances. During the nighttime of March 17 and 18, the negative storm and the absence of spread-F and ionospheric scintillation could be caused by the suppression of eastward electric field after the sunset and the equatorward wind surge, which pushed the EIA towards the equator. This was the first research related to ionospheric storm based on BDS GEO TEC network.

Recent developments in the understanding of the low latitude ionosphere

Abstract ID : 268

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Additional Information : None

Prof. Balan Nanan ,balannanan@gmail.com ,(Senior Researcher) ,United Kingdom ,Derby ,Not Presenting[1]

1 - ISEE, Nagoya University, Japan

This paper presents the recent developments in the understanding of the equatorial plasma fountain (EPF) and equatorial ionization anomaly (EIA) under quiet and active conditions. A recently revealed tropical ionospheric trough is also modelled. It is clarified that (1) EPF is the resultant of the field perpendicular **E**x**B** plasma drift and field-aligned plasma diffusion acting together all along the geomagnetic field lines. (2) EIA arises mainly from the removal of plasma from around the equator by the upward **E**x**B** drift with small accumulation when the crests are within ~±15º magnetic latitudes, and amount of accumulation reduces with latitude and vanishes by ~±25º. (3) During early stages of daytime main phase of super geomagnetic storms plasma fountain becomes a super fountain and EIA becomes strong due to the combined effect of eastward prompt penetration electric field (PPEF) and storm-time equatorward winds and waves (SEW). (4) SEW alone can produce strong IEA while PPEF alone is unlikely. (5) During later stages of the storms, EIA gets inhibited with a peak over the equator due to plasma convergence caused by SEW with minor contributions from westward electric fields and increase in O/N2 ratio associated with the downwelling effects of SEW.

VHF radar observations of F region irregularities over low latitude Sanya

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Conflict Declaration : None

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Additional Information : None

Dr. Baiqi Ning ,nbq@mail.iggcas.ac.cn ,(Research Professor) ,China ,Beijing ,Not Presenting[1]

Dr. Guozhu Li ,gzleel@mail.iggcas.ac.cn ,(None) ,China , ,Not Presenting[2]

1 - Institute of Geology and Geophysics,CAS 2 - Institute of Geology and Geophysics, CAS

A 47.5 MHz VHF coherent backscatter radar with a peak power of 24 kW has been operated at a low latitude station Sanya (18.4°N, 109.6°E, dip lat. 12.8°N), China since 2009. The long-term continuous observations with the radar have revealed several intriguing aspects of F region irregularities. We report here observations of a clear shear structure in the zonal drifts of 3-m irregularities inside ESF backscatter plumes. The vertical shear was centered at ~300 km altitude over Sanya, which maps to an apex altitude of ~650 km at magnetic equator and is thus apparently higher than the apex altitudes 250−450 km where the zonal velocity shear has usually been observed. We also show the observations of bottom-type irregularity scattering layer (BSL) generated before sunset extending until the appearance of ESF backscatter plume. The altitude morphology and the extremely narrow spectral width of the BSL echoes resemble closely those of BSL observed at magnetic equator. However, the present BSL occurred well before sunset, much earlier than that reported previously. This indicates that the source responsible for the pre-sunset BSL is different from that of the equatorial post-sunset BSL, which usually thought to be generated through the equatorial plasma shear vortex driven instability. Based on a preliminary statistics from the Sanya radar and collocated ionosonde observations, we found that the pre-sunset BSL were observed on the days with F layer height oscillations presenting downward phase propagation. Possible mechanisms responsible for the zonal drifts shear and the occurrence of pre-sunset BSL are discussed.

Large scale TIDs possibly generated by low latitude electrodynamics

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Additional Information : None

Dr. John Bosco Habarulema ,jhabarulema@sansa.org.za ,(Researcher) ,South Africa ,Hermanus ,Not Presenting[1]

1 - South African National Space Agency

Large scale travelling ionospheric disturbances (TIDs) are usually associated with auroral region processes during geomagnetic storms. This talk will focus on a different source of such disturbances believed to be around the geomagnetic equator with driving mechanism believed to be changes in low latitude electrodynamics during storm conditions. The launching of large scale TIDs in low latitudes requires modification of the electric field to enhance Lorentz force which would later contribute to the coupling between the ionised components and neutral atmosphere.

Influence of ambient conditions on the development of scintillation-producing irregularities in equatorial plasma bubbles

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Additional Information : None

Dr. Archana Bhattacharyya ,archana.bhattacharyya@gmail.com ,(INSA Senior Scientist (Emeritus Scientist)) ,India ,Navi Mumbai ,Not Presenting[1]

Dr. Surendra Sunda ,ssunda@sac.isro.gov.in ,(None) ,India , ,Not Presenting[2]

Ms. Padma Gurram ,padma14@iigs.iigm.res.in ,(None) ,India , ,Not Presenting[1]

Dr. Bharati Kakad ,bkakad9@gmail.com ,(None) ,India , ,Not Presenting[1]

Dr. Samireddipalle Sripathi ,sripathi@iigs.iigm.res.in ,(None) ,India , ,Not Presenting[1]

1 - Indian Institute of Geomagnetism 2 - Space Application Centre 3 - Indian Institute of Geomagnetism 4 - Indian Institute of Geomagnetism 5 - Indian Institute of Geomagnetism

Past studies of the conditions required for occurrence of equatorial plasma bubbles (EPBs) have been mostly based on the theoretical linear growth rate of the Rayleigh-Taylor instability on the bottom-side of the post-sunset equatorial F layer, and height of the post-sunset equatorial F layer has emerged as a key parameter for the occurrence of an EPB. This is an important issue as intermediate scale length (~ few km - 100 m) irregularities that develop inside an EPB can cause scintillations on VHF or higher frequency radio signals propagating through them. However, it has generally not been considered that an EPB rises to the top-side of the equatorial F-layer and develops structure only in the non-linear phase of its growth. The height above the dip equator to which an EPB extends and the spectrum of the intermediate scale irregularities that develop at different altitudes within the EPB determine the latitudinal distribution of scintillations on Global Navigation Satellite System (GNSS) L-band radio signals. In this paper, we use the latitudinal distribution of amplitude scintillations on a VHF (251 MHz) signal and L-band (1.575 GHz) signal and their theoretical modelling, along with ionosonde data from an equatorial station in the 70-90 ^{o}E longitude region, on magnetically quiet as well as disturbed days, to study the effect of parameters other than the height of the post-sunset equatorial F layer on the development of intermediate scale irregularities within EPBs. A major magnetic storm can alter the height of the night-time equatorial F layer through prompt penetration of a convection or over-shielding electric field into the equatorial ionosphere, and through the effect of a disturbance dynamo, depending on the time of occurrence of the storm. The storm can also affect the thermospheric density distribution and hence the altitudinal profile of the ion-neutral collision frequency over the dip equator, which is also expected to play an important role in the development of

irregularities within the EPB. The influence of this factor on the development of scintillation-producing irregularities in EPBs is the focus of the present paper.

Latitudinal variation of F3 layer at Brazilian region during quiet and disturbed periods

Abstract ID : 651

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Additional Information : None

Dr. Inez Batista ,inez.batista@inpe.br ,(Senior Researcher) ,Brazil ,Sao Jose dos Campos ,Presenting[1]

Dr. Jonas R. Souza ,jonas.souza@inpe.br ,(None) ,Brazil , ,Not Presenting[2]

Dr. M. A. Abdu ,ma.abdu@inpe.br ,(None) ,Brazil , ,Not Presenting[2]

Mr. Angela Santos ,angela.santos@inpe.br ,(None) ,Brazil , ,Not Presenting[2]

Dr. Claudia Candido ,claudia.candido@inpe.br ,(Researcher/Post doc) ,Brazil ,Sao Jose dos Campos ,Not Presenting[5]

Dr. Laysa Cristina Araujo Resende ,laysa.resende@gmail.com ,(None) ,Brazil , ,Not Presenting[6]

Dr. Rodolfo de Jesus ,rodolfo.jesus@inpe.br ,(None) ,Brazil , ,Not Presenting[2]

Dr. R. C. de Araujo ,camara@dfis.ufrr.br ,(None) ,Brazil , ,Not Presenting[8]

1 - Instituto Nacional de Pesquisas Espaciais, Brazil 2 - INPE 3 - INPE 4 - INPE 5 - National Institute for Space Research - INPE 6 - National Institute for Space Research – INPE - MCTIC, São José dos Campos, SP, Brazil 7 - INPE 8 - UFRR

The F3 layer is a low-latitude phenomenon that occurs under the combined effect of three factors: (1) upward vertical drift (eastward electric field), (2) equatorward meridional wind and (3) the usual photochemical and dynamical processes that form the regular F layer. The F3 layer will be formed at the region where the flux vectors are vertically upward or, in other words, at the region where the combined effect of vertical ExB drift, diffusion along the magnetic field lines and magnetic meridional component of the wind produces a net upward vertical component. Modelling results and satellite observations show that region of occurrence of the layer extends to $\pm 15^{o}$ dip latitude with the highest occurrences centered at around 7-8 degrees north or south of the magnetic equator, mainly in the summer hemisphere. In this work we use a chain of ionosondes in the Brazilian region to study the latitudinal occurrence of the F3 layer and its time evolution. We have observed some events in which the layer occur first at the southernmost station and later at the station closest to the magnetic equator. These events occurred under conditions of week magnetic disturbances (when Dst index is considered), but under more intense disturbance when the auroral parameters are considered. They

have being interpreted as further evidence of the ubiquitous role of the meridional wind in the F3 layer formation mechanism in the Brazilian region.

Study of dynamics of low-mid latitude E-region irregularities during magnetically quiet and disturbed days

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Additional Information : None

Mr. Virendra Yadav ,virendray.iig@gmail.com ,(Research Associate) ,India ,Navi Mumbai ,Presenting[1]

Ms. Padma Gurram ,padmagurram123@gmail.com ,(None) ,India , ,Not Presenting[1]

Dr. Bharati Kakad ,bkakad9@gmail.com ,(None) ,India , ,Not Presenting[1]

Dr. Archana Bhattacharyya ,archana.bhattacharyya@gmail.com ,(INSA Senior Scientist (Emeritus Scientist)) ,India ,Navi Mumbai ,Not Presenting[1]

1 - Indian Institute of Geomagnetism 2 - Indian Institute of Geomagnetism 3 - Indian Institute of Geomagnetism 4 - Indian Institute of Geomagnetism

Sporadic E (Es) and blanketing sporadic E (Esb) layers are thin and dense layers of enhanced ionization in the E-region. At low- and mid-latitudes, these layers are formed by wind shear mechanism; to which both zonal and horizontal wind shear contribute with changing altitude. E-region irregularities observed during daytime at low- and mid-latitudes are generated through instabilities linked to the wind shear mechanism. Such irregularities can cause amplitude scintillations on VHF signals (251MHz) during the daytime at mid-latitudes as well as equator. However these scintillations are not frequently seen on VHF as it requires presence of irregularities with strong density perturbations. In this study we use such sparse daytime VHF scintillation events to get information about long wavelength E-region irregularities at low-mid latitude station Allahabad (25.3°N, 81.5°E, dip latitude 16.3°N) in Indian longitude. For this, we use spaced receiver scintillation data on 251 MHz radio signal from Allahabad during 2011-2016 and CADI ionograms to ascertain presence of Es/Esb. A key change at mid latitude E-region from equatorial E-region is the lack of EEJ. We explore the differences between the characteristics of E-region irregularities at mid latitudes and equator. We investigate the spatial scales of the irregularities associated using the technique introduced by Bhattacharyya et al. (2003). We carry out power spectral analysis of the scintillation events and use the resulting information as input in a theoretical model to get information about the background conditions in the E-region.

New aspects of low-latitude ionospheric F region response to geomagnetic storms

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Additional Information : None

Dr. Maxim Klimenko ,maksim.klimenko@mail.ru ,(Senior Resear?her) ,Russia ,Kaliningrad ,Not Presenting[1]

Dr. Vladimir Klimenko ,vvk_48@mail.ru ,(None) ,Russia , ,Not Presenting[2]

Dr. Alexei Dmitriev ,dalex@jupiter.ss.ncu.edu.tw ,(None) ,Taiwan , ,Not Presenting[3]

Dr. Alla Suvorova ,suvorova_alla@yahoo.com ,(None) ,Taiwan , ,Not Presenting[3]

Dr. Irina Zakharenkova ,zakharenkova@mail.ru ,(None) ,Russia , ,Not Presenting[5]

Dr. Konstantin Ratovsky ,ratovsky@iszf.irk.ru ,(None) ,Russia , ,Not Presenting[6]

1 - WD IZMIRAN 2 - West Department of Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, RAS, Kaliningrad, Russia 3 - Institute of Space Science, National Central University, Jhongli, Taiwan 4 - Institute of Space Science, National Central University, Jhongli, Taiwan 5 - West Department of Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS, Kaliningrad, Russia 6 - Institute of Solar-Terrestrial Physics, SB RAS, Irkutsk, Russia

Previously performed the theoretical and experimental investigations of the positive and negative ionospheric storms allowed to explain many aspects of the low-latitude ionosphere disturbances and their formation mechanisms. However, there are still some important hot discussion and outstanding questions about the formation of these disturbances, which answers can be obtained using first-principles models such as the Global Self-consistent Model of the Thermosphere, Ionosphere and Protonosphere (GSM TIP). Using GSM TIP model calculation results we revealed the role of various mechanisms of ionospheric disturbances at low and equatorial latitudes during different geomagnetic storm events (7-8 March 2008, 26-30 September 2011 and 17-23 March 2013, 2015). We studied the formation mechanism of positive and negative ionospheric disturbances at low and middle latitudes during different phases of geomagnetic storms. It is shown the significant role of disturbances in the zonal electric field, thermospheric wind and neutral composition in the low-latitude positive ionospheric disturbances at different geomagnetic storm phases. We showed the significant role of the variations in the neutral thermosphere composition in formation of the mid- and low-latitude positive ionospheric disturbances during recovery storm phase. The difficulties in model prediction of the positive ionospheric storms at low latitudes can be explained by effects of additional ionization produced by forbidden electron enhancements over the Pacific region. In addition we considered the

occurrence and variability of the additional layer during geomagnetic storm events using GSM TIP model results and ground-based ionosonde measurements.

The Limb Imaging Ionospheric and Thermospheric EUV Spectrograph (LITES): Early Results

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Content Motivation : None

Additional Information : None

Prof. Supriya Chakrabarti ,supriya_chakrabarti@uml.edu ,(Professor of Physics and Applied Physics) ,United States ,Lowell ,Presenting[1]

Prof. Timothy Cook ,timothy_cook@uml.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Andrew Stephan ,andrew.stephan@nrl.navy.mil ,(None) ,United States , ,Not Presenting[3]

Dr. Susanna Finn ,susanna_finn@uml.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Scott Budzien ,scott.budzien@nrl.navy.mil ,(None) ,United States , ,Not Presenting[3]

Dr. Steven Powell ,sp35@cornell.edu ,(None) ,United States , ,Not Presenting[6]

1 - University of Massachusetts, Lowell 2 - University of Massachusetts, Lowell 3 - Naval Research Laboratory 4 - University of Massachusetts, Lowell 5 - Naval Research Laboratory 6 - None

The Limb-Imaging Ionospheric and Thermospheric Extreme-ultraviolet Spectrograph (LITES) was launched aboard the SpaceX launcher on February 19, 2017 and was subsequently installed on the International Space Station (ISS). The GPS Radio Occultation and Ultraviolet Photometry - Colocated (GROUP-C) experiment and LITES were designed to collect new information on the thermosphere and the ionosphere using UV and radio emissions.

LITES is a limb-viewing (150 - 350 km tangent altitude) imaging spectrograph that measures airglow emissions in the 60 - 140 nm region with 0.25° angular and 0.4 nm spectral resolutions. One of the major scientific objectives of LITES is a comprehensive study of the seeds of Equatorial Spread F (ESF) and the coupling of the ionosphere and thermosphere through coordinated space- and ground-based multispectral observations.

During the daytime, LITES observes the O+ 61.7 and 83.4 nm emissions from which the ionospheric profile can be inferred. At night, recombination emissions at 91.1 and 135.6 nm provide a direct measure of the electron content along the line of sight.

We will present an overview of the LITES experiment and some early results from the first few months of operations, the challenges and opportunities presented by making ionospheric measurements from the ISS, and the advantages in calibration and validation that are possible through a combination of LITES measurements, GROUP-C measurements, and ground-based optical and radar systems. We welcome collaborations and participation in the analysis of LITES data.

On the Dependence of the Ionospheric E-Region Electric Field of the Solar Activity

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Dr. Clezio Marcos De Nardin ,clezio.denardin@inpe.br ,(Head of the Embrace Space Weather Program/INPE Head of the Aeronomy Division/INPE) ,Brazil ,Sao Jose dos Campos ,Not Presenting[1]

Dr. Juliano Moro ,julianopmoro@gmail.com ,(Postdoctoral Researcher) ,Brazil ,Santa Maria, RS ,Not Presenting[2]

Dr. Laysa Resende ,laysa.resende@inpe.br ,(None) ,Brazil , ,Not Presenting[3]

Prof. Sony Chen ,sony.chen@inpe.br ,(None) ,Brazil , ,Not Presenting[3]

Dr. Nelson Jorge Schuch ,njschuch@gmail.com ,(None) ,Brazil , ,Not Presenting[5]

Dr. Joaquim Costa ,joaquim.costa@inpe.br ,(None) ,Brazil , ,Not Presenting[3]

1 - National Institute for Space Research – INPE - MCTIC, São José dos Campos, SP, Brazil 2 - National Space Science Center, Chinese Academy of Science, Beijing, China & Southern Regional Space Research Center – CRS/INPE – MCTIC 3 - National Institute for Space Research 4 - National Institute for Space Research 5 - Southern Regional Space Research Center – CRS/INPE – MCTIC, in collaboration with the Santa Maria Space Science Laboratory – LACESM/CT – UFSM, Santa Maria, RS, Brazil 6 - National Institute for Space Research

We have being studying the zonal and vertical E region electric field components inferred from the Doppler shifts of type 2 echoes (gradient drift irregularities) detected with the 50 MHz backscatter coherent (RESCO) radar set at Sao Luis, Brazil (SLZ, 2.3º S, 44.2º W) during the solar cycle 24. In this report we present the dependence of the vertical and zonal components of this electric field with the solar activity, based on the solar flux F10.7. For this study we consider the geomagnetically quiet days only ($Kp \leq 3^+$). A magnetic field-aligned-integrated conductivity model was developed for proving the conductivities, using the IRI-2007, the MISIS-2000 and the IGRF-11 models as input parameters for ionosphere, neutral atmosphere and Earth magnetic field, respectively. The ion-neutron collision frequencies of all the species are combined through the momentum transfer collision frequency equation. The mean zonal component of the electric field, which normally ranged from 0.19 to 0.35 mV/m between the 8 and 18 h (LT) in the Brazilian sector, show a small dependency with the solar activity. Whereas, the mean vertical component of the electric field, which normally ranges from 4.65 to 10.12 mV/m, highlight the more pronounced dependency of the solar flux.

KEYWORDS: Space Weather; Aeronomy, Ionospheric Electric Field; Equatorial Dynamics

Ionospheric response to 17 March 2013 geomagnetic storm identified by data assimilation result

Abstract ID : 1208

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Xinan Yue ,yuexinan@mail.iggcas.ac.cn ,(None) ,China ,Beijing ,Not Presenting[1]

1 - None

Based on slant total electron content (TEC) observations made by ~10 satellites and ~450 ground IGS GNSS stations, we constructed a 4-D ionospheric electron density reanalysis during the March 17, 2013 geomagnetic storm. Four main large-scale ionospheric disturbances are identified from reanalysis: (1) The positive storm during the initial phase; (2) The SED (storm enhanced density) structure in both northern and southern hemisphere; (3) The large positive storm in main phase; (4) The significant negative storm in middle and low latitude during recovery phase. We then run the NCAR-TIEGCM model with Heelis electric potential empirical model as polar input. The TIEGCM can reproduce 3 of 4 large-scale structures (except SED) very well. We then further analyzed the altitudinal variations of these large-scale disturbances and found several interesting things, such as the altitude variation of SED, the rotation of positive/negative storm phase with local time. Those structures could not be identified clearly by traditional used data sources, which either has no gloval coverage or no vertical resolution. The drivers such as neutral wind/density and electric field from TIEGCM simulations are also analyzed to selfconsistantly explain the identified disturbance features.

An investigation of ionospheric upper transition height variations at low and equatorial latitudes deduced from combined COSMIC and C/NOFS measurements

Abstract ID : 1255

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Biqiang Zhao ,zbqjz@mail.iggcas.ac.cn ,(Senior Researcher) ,China ,Beijing ,Not Presenting[1]

1 - INSTITUTE OF GEOLOGY AND GEOPHYSICS CHINESE ACADEMY OF SCIENCES

In this study we propose the combination of topside in-situ ion density data from the Communication/Navigation Outage Forecast System (C/NOFS) along with the electron density profile measurement from Constellation Observing System for Meteorology, Ionosphere & Climate (COSMIC) satellites Radio Occultation (RO) for studying the spatial and temporal variations of the ionospheric upper transition height (hT) and the oxygen ion (O+) density scale height. The latitudinal, local time and seasonal distributions of upper transition height show more consistency between hT re-calculated by the profile of the O+ using an a-Chapman function with linearly variable scale height and that determined from direct in-situ ion composition measurements, than with constant scale height and only the COSMIC data. The discrepancy in the values of hT between the C/NOFS measurement and that derived by the combination of COSMIC and C/NOFS satellites observations with variable scale height turns larger as the solar activity decreases, which suggests that the photochemistry and the electrodynamics of the equatorial ionosphere during the extreme solar minimum period produce abnormal structures in the vertical plasma distribution. The diurnal variation of scale heights (Hm) exhibits a minimum after sunrise and a maximum around noon near the geomagnetic equator. Further, the values of Hm exhibit a maximum in the summer hemisphere during daytime, whereas in the winter hemisphere the maximum is during night. Those features of Hm consistently indicate the prominent role of the vertical electromagnetic (E×B) drift in the equatorial ionosphere.

A12 - Long-term trends and changes in the stratosphere-mesosphere-thermosphere-ionosphere system (DIV II – ICMA)

Low-latitude mesospheric wave dynamical variability over large- and short-timescales

Abstract ID : 482

Conflict Declaration : The authors declare that there is no conflict of interest.

Content Motivation : Large- and short-timescale variations in the mesospheric nightglow emission intensities and their corresponding rotational temperatures will be presented. Please see the attached file for the letter of motivation.

Additional Information : I would like to make an Oral presentation. Please see the attached file for grant application.

Mr. Ravindra P Singh ,ravindra@prl.res.in ,(Scientist) ,India ,Ahmedabad ,Not Presenting[1]

Prof. Duggirala Pallamraju ,raju@prl.res.in ,(None) ,India , ,Not Presenting[1]

1 - Physical Research Laboratory 2 - Physical Research Laboratory

Low-latitude mesospheric wave dynamical variability over large- and short-timescales

Ravindra Pratap Singh[1,2], Duggirala Pallamraju[1]
ravindra@prl.res.in*, *raju@prl.res.in
[1]*Space and Atmospheric Sciences Division, Physical Research Laboratory, Navrangpura, Ahmedabad, 380009, India*
[2]*Department of Physics, Sardar Patel University, Vallabh Vidyanagar, 388120, India*

We present the large- and short-timescale variations in the mesospheric nightglow emission intensities and their corresponding rotational temperatures which have been measured from Gurushikhar, Mount Abu (24.6^{o}N, 72.8^{o}E), in India using O_2(0-1) and OH(6-2) band emissions that emanate from 94 and 87 km altitudes. Spectral analysis on 437 nights of observations (during Jan 2013 to Nov 2015) showed periodicities of both solar and atmospheric origin. Coherent periodicities of around 150, 195, 270, and 420 days were obtained both in the solar parameters (number of sunspots and F10.7 cm flux) and in the mesospheric parameters (airglow intensities and temperatures) indicating a strong solar influence on mesospheric wave dynamics. In addition, both mesospheric airglow intensities also showed periodicities of 84, 95, and 122 days which are of atmospheric origin. Influence of solar variability on the behaviour of mesospheric intensity has also been investigated in shorter durations which showed that the O_2 and OH intensity variations are correlated with each other

for most of the nights. Gravity wave behaviour over long term is investigated using the periodicities derived from the nocturnal variations in all the four parameters (O_2 and OH intensities and their respective temperatures). It was found that the major wave periodicity of around 2 h duration is present in all the four parameters. Our analyses also reveal that the range of periods in O_2 and OH intensities and temperatures are 11 to 24 min and 20 to 60 min, respectively. Periods less than 15 min were not present in the temperatures, but were prevalent in both emission intensities. The results obtained in this study thus provide a comprehensive picture of mesospheric wave dynamics and these new findings will be discussed.

Long-term temperature trends in the 35-65 km range by Rayleigh Lidar measurements at 23° S from 1993 to 2016

Abstract ID : 513

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Paulo Batista ,paulo.batista@inpe.br ,(Senior Researcher) ,Brazil ,São José dos Campos ,Not Presenting[1]

Dr. Dale Simonich ,dale.simonich@inpe.br ,(None) ,Brazil , ,Not Presenting[2]

Dr. Barclay Clemesha ,barclay.clemesha@inpe.br ,(None) ,Brazil , ,Not Presenting[2]

1 - National Institute for Space Research (INPE) 2 - INPE (Retired) 3 - INPE (Retired)

A Lidar tuned to sodium resonance line at 589 nm has been operated at São José dos Campos, Brazil (23?S, 46? W) since 1993 processing the Rayleigh signal from which the temperatures from ~35 to ~65 km are retrieved in a nightly mean basis. In order to remove tidal effects only profiles obtained from 18:30 LT to 23:30 LT were considered in this analysis. We used these nightly profiles to determine the monthly temperature profiles from April 1993 to September 2016. The mean temperature characteristics for every year and for the whole period are obtained and do not differ too much from the previous climatology using shorter data series. A model including solar cycle, southern oscillation index, QBO, Annual and Semiannual oscillations and Linear trends has been fitted to the monthly temperatures every 3 km from 36 to 63 km. Variable linear trends with altitudes are determined with a maximum negative trends at 54-55 km attaining 3.15 K/decade.

Progress in investigating long-term trends in the mesosphere-thermosphere-ionosphere system

Abstract ID : 672

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jan Lastovicka ,jla@ufa.cas.cz ,(Head of Department of Aeronomy) ,Czech Republic ,Prague ,Presenting[1]

1 - Institute of Atmospheric Physics CAS, Czech Republic

The increasing atmospheric concentration of greenhouse gases results in long-term change snot only in the troposphere; it affects also the upper atmosphere including the embedded ionosphere. Progress in investigating long-term trends in the mesosphere-thermosphere-ionosphere system will briefly be reviewed. There are also secondary trend drivers like ozone, geomagnetic and solar activity, secular change of Earth's magnetic field, atmospheric waves coming from below, and water vapor. Their unstable behavior makes the investigation of trends more difficult and trends themselves less stable. Among important areas of progress we may include the first satellite observations of carbon dioxide trends in the mesosphere and lower thermosphere, better understanding and simulation of the observed impact of ozone on trends, substantially better agreement of most recent model simulations of trends with observations, significant broadening of our knowledge and understanding of trend sin the ionospheric F2 region parameters and a couple of other results to be presented in the talk.

GUFRAN BEIG : None Tammy Maart : None

Dependency of the equatorial ionospheric current system on solar flux and geomagnetic main field at the Huancayo geomagnetic observatory from 1935 to 1985

Abstract ID : 818

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Juergen Matzka ,jmat@gfz-potsdam.de ,(scientist) ,Germany ,Potsdam ,Presenting[1]

Mr. Tarique Sidiqui ,tarique@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Henning Lilienkamp ,lilienka@uni-potsdam.de ,(None) ,Germany , ,Not Presenting[3]

Prof. Claudia Stolle ,claudia.stolle@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Oscar Veliz ,oscar.veliz@jro.igp.gob.pe ,(None) ,Peru , ,Not Presenting[5]

1 - GFZ 2 - GFZ 3 - University Potsdam 4 - GFZ 5 - IGP

We have analysed 51 years (1935 to 1985) of geomagnetic observatory data from Huancayo, Peru, to determine the sensitivity of the equatorial ionospheric current system (i.e. the solar quiet current system and the equatorial electrojet, EEJ) to solar cycle variations and to the secular variation of the geomagnetic main field. Firstly, we digitised some 19 years of previously unavailable hourly mean values of the horizontal component (H) for the 1960ies, 1970ies and 1980ies, since the period 1935 to 1985 is ideal to analyse the influence of the main field strength on the amplitude of the quiet daily variation. This is because the main field decreases significantly from 1935 to 1985, while the distance of the magnetic equator to the observatory remains stable. The latter is important, because the amplitude of the magnetic field signature of the EEJ decreases significantly with distance to the magnetic equator. Secondly, the sensitivity of the amplitude ?H of the quiet daily variation to solar cycle variations (in terms of sunspot numbers and solar flux F10.7) was determined. Thirdly, the sensitivity of ?H to changes of the geomagnetic main field strength (due to secular variation) was determined. We confirm an increase of ?H for the decreasing main field in this period, as expected from physics based models (Cnossen, 2016). Our measured increase of 4.4% (5.8 % considering one standard error) during this period is slightly smaller than the 6.9 % increase predicted by the physics based model.

Analysis of trends in IWC distributions of PMCs in the northern summer mesosphere for 1871 – 2008

Abstract ID : 931

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Uwe Berger ,berger@iap-kborn.de ,(Scientist) ,Germany ,Kuehlungsborn ,Presenting[1]

Dr. Gerd Baumgarten ,baumgarten@iap-kborn.de ,(None) ,Germany , ,Not Presenting[2]

Prof. Franz-Josef Lübken ,luebken@iap-kborn.de ,(None) ,Germany , ,Not Presenting[3]

1 - IAP 2 - IAP-Kuehlungsborn 3 - Leibniz-Institute of Atmospheric Physics

We have performed trend studies in the mesosphere in the period 1871-2008 with Leibniz-Institute Middle Atmosphere (LIMA) model driven by NCEP reanalysis (20^{th} century data) below approximately 30 km. LIMA adapts temporal variations of CO_2 and O_3 according to observations and observed daily Lyman alpha fluxes. We investigate the role of trends in temperature and mesospheric water vapor that mainly force PMC trends. Generally good agreement is found between the modeled long-term PMC variations and that derived from SBUV observations in the period 1979-2008. The NLC/PMC characteristics deduced from our ice model MIMAS-LIMA are validated with various data sets from different lidar (ALOMAR), and satellite (AIM-SOFIE) observations. As a highlight, we will present first results about the statistical properties of seasonal distribution of ice water content (IWC) which give a deeper insight in IWC trend studies. For the first time, we will introduce a theoretical derivation of the probability distribution (g-function) which has been normally used in the ice community.

Phase-height measurements over Europe during 5 solar cycles – Long-term variability of the mesosphere

Abstract ID : 1124

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Dieter H.W. Peters ,peters@iap-kborn.de ,(Scientist) ,Germany ,Kühlundborn ,Presenting[1]

Mr. Günter Entzian ,entzian@iap-kborn.de ,(None) ,Germany , ,Not Presenting[2]

Mr. Dieter Keuer ,keuer@iap-kborn.de ,(None) ,Germany , ,Not Presenting[2]

Mr. Jorge L. Chau ,chau@iap-kborn.de ,(None) ,Germany , ,Not Presenting[2]

1 - Leibniz-Institute of Atmospheric Physics 2 - Leibniz-IAP at the University of Rostock 3 - Leibniz-IAP at the University of Rostock 4 - Leibniz-IAP at the University of Rostock

Since the end of 1950s, that means over more than 5 solar cycles, ?eld strength measurements of the broadcasting station, Allouis (Central France), have been performed at Kühlungsborn (54° N, 12° E, Mecklenburg, Northern Germany. These so-called indirect phase-height measurements of low frequency radio waves (here with a frequency of 162 kHz) are used to study the long-term variability and trends of the mesosphere over Europe. The advantages of the method are the low costs and the simplicity of operation, with a loss rate of data lower than 3 %. The reanalyzed forth release of standard-phase height (SPH) are presented and discussed.

The SPH-series are anti-correlated to the solar cycle because stronger photo-ionization is linked with higher number of electrons, which reduces the SPH. Furthermore the statistical analysis of the SPH-series shows a signi?cant overall trend in the order of hundred meters per decade induced by a shrinking stratosphere due to global warming but with strong intra-decadal variability in winter. The derived thickness temperature of the mesosphere decreased statistically significant over the period 1959-2008 after pre-whitening with summer means of solar sun spot numbers. The trend value is in the order of about -1.05 K/ decade if the stratopause trend is excluded. The linear regression is stronger, -1.35 K/ decade for the period of 1963-1985 (2 SCs), but weaker, -0.51 K/ decade during 1986-08 (last 2 SCs).

The mean annual cycle of SPH-series shows a negative winter anomaly, known to be due to enhanced downward transport of NO and subsequent photo-ionization. In order to exclude the influence of the winter anomaly in the determination of column-integrated mesospheric temperature trends, our above used procedure is confined to summer months.

Furthermore lower atmospheric in?uences of QBO-like and ENSO-like oscillations on mesospheric SPHs have been found for solar minimum phases.

A13 - Electrodynamics and energetics of the middle atmosphere exploration with ground and space experiments (DIV II)

Short-term variability of the lower ionosphere from VLF narrowband radio observations

Abstract ID : 460

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Colin Price ,cprice@flash.tau.ac.il ,(Head of Porter School of Environment) ,Israel ,Tel Aviv ,Not Presenting[1]

Dr. Israel Silber ,israel0silber@gmail.com ,(None) ,Israel , ,Presenting[1]

1 - Tel Aviv University 2 - Tel Aviv University

Very low frequency (VLF) radio waves propagate over long distances within the Earth-ionosphere waveguide, reflected off the Earth's surface and the ionospheric D-region. The characteristics of these signals depend on several parameters along the path, which apart from the D-region's properties, are fairly constant over short periods of time. This allows probing of perturbations in the lower ionosphere to be made using VLF measurements. In this study, we present an analysis of VLF narrowband signals, transmitted from Sicily, Italy, and detected in Tel-Aviv, Israel. We show observations of the interaction between both pressure waves and electromagnetic perturbations from thunderstorms with the VLF waves aloft. We clearly observe long period acoustic wave signatures (up to ~4 minutes) and short period gravity wave signatures (~5-10 minutes), while also many transient events related to heating and ionization of the D-region. Comparisons with the World Wide Lightning Location Network (WWLLN) data show the possible link between tropospheric thunderstorms and D-region short-term variability. Finally, we conclude that gravity wave signatures are a common and significant feature in VLF measurements.

A Systematic Investigation of Lightning-Generated Extremely Low Frequency Whistlers Observed during Swarm ASM Burst Mode Sessions

Abstract ID : 913

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Pierdavide Coïsson ,coisson@ipgp.fr ,(Associate Physicist) ,France ,Chambon la forêt ,Presenting[1]

Mr. Pierre Deram ,deram@ipgp.fr ,(None) ,France , ,Not Presenting[1]

Dr. Gauthier Hulot ,gh@ipgp.fr ,(Deputy Director in charge of research and space activities) ,France ,Paris ,Not Presenting[1]

Dr. Ciaran Beggan ,ciar@bgs.ac.uk ,(None) ,United Kingdom ,Edinburgh ,Not Presenting[4]

Mr. Pierre Vigneron ,vigneron@ipgp.fr ,(Engineer) ,France ,Paris ,Not Presenting[1]

Dr. Jean-Michel Léger ,jean-michel.leger@cea.fr ,(Program manager) ,France ,Grenoble ,Not Presenting[6]

Mr. Thomas Jager ,thomas.jager@cea.fr ,(None) ,France , ,Not Presenting[6]

1 - Institut de Physique du Globe de Paris 2 - Institut de Physique du Globe de Paris 3 - Institut de Physique du Globe de Paris 4 - British Geological Survey 5 - Institut de Physique du Globe de Paris 6 - CEA, Léti 7 - CEA, Léti

Lightning-released energy covers a wide band of the electromagnetic spectrum. The propagation of the corresponding electromagnetic signal is not limited to the neutral atmosphere, and specific whistler-modes of propagation can enter the ionosphere, thus allowing their detection by LEO satellites. Though most of the whistler energy in the ionosphere propagates between 1 and 10 kHz, part of it also appears to propagate in the 10-125 Hz frequency band and is detectable by the Swarm Absolute Scalar Magnetometers (ASM) when operating in burst mode at 250 Hz. Many whistler events were indeed recorded in this way when a few burst-mode sessions were operated during the commissioning phase of the ESA Swarm mission, at the beginning of 2014. These events have been unambiguously correlated with the occurrence of lightning strikes detected and located on ground by the World Wide Lightning Location Network (WWLLN). A simple ray-tracing software (using the Appleton refraction index through the ionosphere plasma in the Earth magnetic field and solving the Haselgrove equations of propagation) could be used to recover satisfyingly the propagation time and dispersion relation observed in most of the events detected in the Swarm ASM burst mode data. However, not all lightning strikes lead to an observed whistler. In this presentation, we will report on our current efforts to identify exact conditions under which lightning strikes do lead to such whistlers,

with the aim of providing some insight into both the physics of these phenomena and the ability of Swarm ASM burst mode data to provide valuable information about lightning and the way their extremely low frequency signals penetrate the ionosphere.

The TETRA-II Experiment to Observe Terrestrial Gamma Flashes at Ground Level -- Preliminary Results

Abstract ID : 928

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Michael Cherry ,cherry@lsu.edu ,(None) ,United States ,Baton Rouge ,Presenting[1]

1 - Louisiana State University

An upgraded version of the TGF and Energetic Thunderstorm Rooftop Array (TETRA-II) consists of an array of BGO scintillators to detect bursts of gamma rays from thunderstorms at ground level in four separate locations: the campus of Louisiana State University in Baton Rouge, Louisiana; the campus of the University of Puerto Rico at Utuado, Puerto Rico; the Centro Nacional de Metrologia de Panama (CENAMEP) in Panama City, Panama; and the Severe Weather Institute and Radar & Lightning Laboratories in Huntsville, Alabama. The original TETRA-I array of NaI scintillators at Louisiana State University detected 37 millisecond-scale bursts of gamma rays at energies 50 keV-2 MeV associated with nearby (< 8 km) thunderstorms. TETRA-II began operation in May 2016 and now has approximately an order of magnitude greater sensitivity than TETRA-I. The ability to observe ground-level Terrestrial Gamma Flashes from close to the source allows a unique analysis of the storm cells producing these events. A brief description of the TETRA-I observations, a description of TETRA-II, and preliminary results will be presented.

A Statistical Study on Lightning Activities and Global Magnitude M>=7 Earthquakes during 1999–2015

Abstract ID : 1079

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jann-Yenq Liu ,jyliu@jupiter.ss.ncu.edu.tw ,(Professor) ,Taiwan ,TaoYuan ,Presenting[1]

Dr. Yuh-Ing Chen ,ychen5325@gmail.com ,(None) ,Taiwan , ,Not Presenting[2]

Mr. Yi-Wei Chang ,jchang6513@gmail.com ,(None) ,Taiwan , ,Not Presenting[2]

1 - Institute of Space Science, National Central University, Chung-Li 320, Taiwan 2 - National Central University 3 - National Central University

We statistically examine the lightning activities observed by LIS (Lightning Imaging Sensor) onboard TRMM (Tropical Rainfall Measuring Mission) satellite 30 days before and after 195 earthquakes with magnitude M>=7 within 38-degree in geographic latitude during the 18 years period of 1998-2015. The lightning activities versus the magnitude, depth, and epicenter location of the earthquakes are investigated. Results show that lightning activities tend to appear around the epicenter and significantly enhance 8-10 days before the earthquakes, especially the shallow ones with the depth less than 50 km. Moreover, the size of epicenter area with the statistical significance of lightning activity enhancement is proportional to the earthquake magnitude.

Parameters of the global atmospheric electric circuit as measured in the northern and southern polar regions

Abstract ID : 1173

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Renata Lukianova ,r.lukianova@gcras.ru ,(Principal research scientist) ,Russia ,Moscow ,Not Presenting[1]

1 - Geophysical Center, Russian Academy of Science

In the frame of global atmospheric electric circuit (AEC) concept, thunderstorms are responsible for maintaining a slowly time-varying electric potential difference of ~250 kV between the ionosphere and the earth surface. In addition to the meteorological generator, at high latitudes the solar wind-and magnetospheric phenomena imposes relatively rapid electric potential (*U*) variations in the overhead ionosphere. In the polar regions, an electric current flows from the ionosphere to the ground and a vertical electric field (*Ez*) measured near ground-level depends on solar wind conditions and other factors of solar activity, e.g. the events of solar/cosmic rays. Regular measurements of *Ez* variations are performed at several sites in the Antarctic including the station Vostok (mlat 83.6^{o}S) which provides the longest time series. In the northern hemisphere, the measurements of *Ez* are performed at the Hornsund observatory, Svalbard. The relationship is evaluated between the *Ez* values obtained under conditions of "fair weather" and the values of *U* obtained from the SuperDARN radar observations, ionospheric convection models and ground magnetic measurements on the basis of selected days and a larger statistics. It is shown that under certain solar wind/solar zenith angle conditions the *Ez* reflects fairly well the overhead *U* in the near-pole region. At the northern auroral latitudes *Ez* primarily responds to the development of substorm. Quantitative characteristics of the *Ez* and *U* relationship are presented. Contribution of the solar wind, energetic particle precipitation, atmospheric conductivity meteorological conditions, planetary waves and global thunderstorm activity to the observed variations of *Ez* are evaluated and discussed based on the recent studies of the polar branch of AEC.

Collocation of Heights of Key Interest in the Low-Latitude Nighttime Mesosphere

Abstract ID : 1180

Conflict Declaration : None

Content Motivation : Invited talk

Additional Information : This is an invited talk, invited by Irina Mironova and Martin Fullekrug

Dr. Earle Williams ,earlew@ll.mit.edu ,(Research Scientist) ,United States ,Cambridge ,Presenting[1]

Dr. Yen-Jung Wu ,annephyphy@gmail.com ,(None) ,Taiwan , ,Presenting[2]

1 - Massachusetts Institute of Technology 2 - National Cheng Kung University

Collective evidence from ground-based, rocket soundings and satellite observations support the idea that several key heights in the nighttime mesosphere are nearly collocated. This analysis is not based on any simultaneous measurement of all of these heights of interest (no such measurement is available), but rather on a statistical analysis and inter-comparison of many available observations. The heights (and mean altitude estimates) are (1) the OH airglow layer (87 +/-3 km) (Baker and Stair, 1988; Shepherd et al., 1993; von Savigny et al., 2012; Wu, 2016), (2) the location of transient luminous events called elves (87 +/- 3 km) (Wu, 2016; van der Velde et al., 2016), (3) the ledge in electron density and electrical conductivity (86 +/- 3 km; Friedrich and Torkar, 2001; Hale, 1985), (4) the global waveguide boundary at the VLF cutoff frequency (85 km, Toledo-Redondo et al., 2012; Wu,2016), (5) the height for peak ablation debris and meteoric smoke particles from incoming meteors (85 km) (Hunten et al., 1980; Megner et al., 2008; Williams et al., 2015), and (6) the ledge in monatomic oxygen (84 +/-2 km; Gumbel, 1997). The OH airglow and elve collocation has recently been solidified by star calibration of altitudes for simultaneously observed optical phenomena in the limb of the Earth (Huang et al., 2010; Wu, 2016), and comparisons with SCIAMACHY-ENVISAT satellite that was designed for accurate measurements of airglow height, also in limb viewing. Further evidence that these height collocations are not just coincidental is their co-variation in the Semi-Annual Oscillation (Wu, 2016), and their co-variation between land and ocean regions (Wu, 2016). The quantity with some physical/chemical connection with all heights of interest is monatomic oxygen, and on that basis may play the dominant role in explaining the overall collocation. The physical-chemical connections will be discussed.

Particle acceleration due to the electric field of thunderstorm clouds observed by HAWC

Abstract ID : 1403

Conflict Declaration : None

Content Motivation : None

Additional Information : This work has to include the HAWC collaboration as coauthor, but is not possible to do it in the form.

Dr. Alejandro Lara ,alara@igeofisica.unam.mx ,(Researcher) ,Mexico ,Ciudad de México ,Not Presenting[1]

Mr. Pablo Vanegas ,pablovanang@gmail.com ,(None) ,Mexico , ,Not Presenting[2]

1 - None 2 - Instituto de Geofísica, UNAM

The HAWC Gamma Ray observatory consists of 300 water Cherenkov detectors (WCD) instrumented with four photo multipliers tubes (PMT) per WCD. HAWC is located between two of the highest mountains in Mexico. The high altitude (4100 m asl); the relatively short distance to the Gulf of Mexico (~100 km); the large detecting area (22 000 square m) and the high sensitivity, make HAWC a very good instrument to explore the acceleration of particles due to the electric fields existing inside storm clouds. In particular, the scaler system of HAWC records the output of each one of the 1200 PMTs as well as the 2, 3, and 4-fold multiplicities (logic AND in a time window of 30 nsec) of each WCD with a sample rate of 40 Hz. Using the scaler data, we have identified 20 enhancements of the observed rate during periods when storm clouds were over HAWC but without cloud-earth discharges. These enhancements can be produced by electrons with energy of tens of MeV, accelerated by the electric fields of tens of kV/m measured at the site during the storm periods. In this work, we present the recorded data, the method of analysis and our preliminary conclusions on the electron acceleration by the electric fields inside the clouds.

A14 - Energetic Particle Precipitation into the Atmosphere: Sources and Atmospheric Impacts (DIV II – DIV III – VERSIM/ ICMA)

Energetic Particle Precipitation Impacts and Coupling (EPPIC)

Abstract ID : 101

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Daniel Baker ,daniel.baker@lasp.colorado.edu ,(Director and Distinguished Professor, Laboratory for Atmospheric and Space Physics, University of Colorado Boulder) ,United States ,Boulder ,Not Presenting[1]

1 - University of Colorado Boulder

A complete description of Sun-Earth connections requires a deep understanding of the atmospheric processes that amplify in powerful and complex ways the effects of the ever-changing magnetospheric and solar energy inputs. The poorly understood physical effects of these inputs must entail nonlinear feedbacks that act to couple all the layers of the Earth's atmosphere. These ultimately shape the global system in which we live. Central to this problem is determining the atmospheric response to energetic particle precipitation (EPP) both on regional and global scales. This is a last great frontier in solar-terrestrial research that forms the backdrop upon which long-term human-induced atmospheric change is superimposed. Particles plunging into Earth's atmospheric layers lose energy by ionizing constituent molecules. Where and with what strength such ionization occurs is controlled by solar wind forcing and the subsequent levels of geomagnetic activity. Quantifying EPP variations is crucial to understanding the production of key reactive atmospheric chemical constituents, namely reactive odd nitrogen- (NOx = N + NO + NO2) and odd hydrogen (HOx = H + OH + HO2). NOx and HOx participate in ozone (O3) catalytic cycles, with significant consequences for the temperature structure of the atmosphere. Changes in temperature gradients subsequently affect winds and thus atmospheric wave propagation. The altitudes of EPP-induced ionization, and therefore production of NOx/HOx, are inversely proportional to the input particle energy and generally range from the lower thermosphere (100-200 km) down to the stratosphere (10-50 km) where very energetic particles can be directly deposited. NOx produced in the mesosphere or lower thermosphere can descend to the stratosphere in polar winter. To properly quantify these effects, the incoming precipitating particle spectrum must be known with high accuracy in absolute intensity across the electron range from 10 keV to multiple MeV energies. This accuracy will allow requisite determination of ionization rates at altitudes from 100 km down to below 40 km. There have not yet

been, over the six foregoing decades of the Space Age, measurements sufficient to characterize the full energy spectrum of EPP over space and time. This presentation discusses a mission concept that would address with great care the impact and coupling of energetic particles in Earth's atmospheric system.

Drivers of relativistic electron microbursts and their atmospheric impacts

Abstract ID : 290

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Emma Douma ,emmadouma@gmail.com ,(PhD candidate) ,New Zealand ,Dunedin ,Presenting[1]

Dr. Mark Clilverd ,macl@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Lauren Blum ,lwblum@gmail.com ,(None) ,United States , ,Not Presenting[3]

Prof. Craig Rodger ,craig.rodger@otago.ac.nz ,(Head of Department) ,New Zealand ,None ,Not Presenting[1]

1 - University of Otago 2 - British Antarctic Survey 3 - NASA Goddard Space Flight Center 4 - University of Otago

We investigate the distribution of relativistic electron microburst occurrence and flux magnitude in the Earth's outer radiation belts. Using an automated detection algorithm (published in *Blum et al.,* [JGR, 2015]) on low-altitude SAMPEX HILT >1 MeV electron flux observations made by the HILT instrument. From this we have a large database of relativistic microburst events stretching across 1996 - 2007 which we have used to determined relativistic microburst properties. The HILT instrument samples different pitch angle distributions over different parts of the world, such that in different regions HILT is dominated by either trapped, drift loss cone or bounce loss cone fluxes [*Dietrich et al.,* JGR, 2010]. Therefore we limit our relativistic microburst flux magnitude analysis to the North Atlantic region, where HILT only samples the bounce loss cone. We present statistics of the relativistic microburst occurrence properties and the flux intensity properties. It is thought that relativistic microbursts are a result of the pitch angle scattering of trapped outer radiation belt electrons by either whistler mode chorus waves [*Thorne et al.,* JGR, 2005] or EMIC waves [*Omura and Zhao,* JGR, 2013]. Thus, we compare the *L* and MLT distribution of relativistic electrons with the *L* and MLT distributions of whistler mode chorus waves and EMIC waves reported in the literature to ascertain the dominant scattering process. We compare the occurrence of relativistic microbursts to ground based observations of each wave to further clarify the dominant scattering process. We find that whistler mode chorus waves are the dominant scattering process for relativistic microburst generation. We then compare the *L* and MLT distribution of the flux magnitude of the relativistic microbursts in the North Atlantic region to the chorus and EMIC wave activity. We note that the regions of high flux intensity of the relativistic microbursts partially coincides with the regions of high amplitude whistler mode chorus waves. Regions of high flux intensity relativistic microbursts also coincide with regions of frequent EMIC activity and regions of strong EMIC waves.

Electron precipitation from the outer radiation belt during the St Patrick's Day storm

Abstract ID : 320

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Mark Clilverd ,macl@bas.ac.uk ,(None) ,United Kingdom , ,Presenting[1]

Prof. Craig Rodger ,craig.rodger@otago.ac.nz ,(Head of Department) ,New Zealand ,None ,Not Presenting[2]

Dr. Max Van De Kamp ,Max.Van.De.Kamp@fmi.fi ,(None) ,Finland , ,Not Presenting[3]

Prof. Neil Thomson ,neil.thomson@otgao.ac.nz ,(None) ,New Zealand , ,Not Presenting[2]

Dr. Annika Seppala ,Annika.Seppala@fmi.fi ,(None) ,New Zealand , ,Not Presenting[2]

Dr. Pekka Verronen ,pekka.verronen@fmi.fi ,(None) ,Finland , ,Not Presenting[3]

1 - British Antarctic Survey 2 - University of Otago 3 - Finnish Met. Institute 4 - University of Otago 5 - University of Otago 6 - Finnish Met. Institute

Electron precipitation fluxes from the outer radiation belt are determined during the St Patrick's Day storm, which occurred in March 2015. Narrow-band very low frequency (VLF) radio waves from the 22.1 kHz UK transmitter (call sign GVT) are received at Reykjavik, Iceland, with the signal propagation path spanning the magnetic footprint of the outer radiation belt. The received signals are analysed for changes in phase and amplitude caused by precipitating energetic electrons associated with radiation belt acceleration and loss processes enhanced by the St Patrick's Day geomagnetic storm. Phase perturbations of ~95 degrees and amplitude perturbations of ~7.5 dB are observed at the storm peak. Electron precipitation is seen to last for up to 8 days following the onset of the storm. Combining phase and amplitude modelling using the Long Wave Propagation Code (LWPC) we show that the peak fluxes can be modelled by energetic electron precipitation fluxes of 10^5 el. cm^{-2} s^{-1} sr^{-1} for >30 keV with a power law gradient of -5. We compare this finding with observed POES satellite MEPED >30 keV precipitating electron integral fluxes and estimated spectral gradient. We would only anticipate agreement between the two techniques if the electron precipitation was driven by strong diffusion conditions within the radiation belt, and therefore the bounce-loss-cone was isotropically filled. This will be investigated in the talk. Finally we will compare the flux characteristics driven by the St Patrick's Day storm with the equivalent fluxes and D-region ionisation provided in the CMIP6 (Coupled model intercomparison project phase 6) solar forcing dataset [Matthes et al., Geosci. Model Dev. Discuss., doi:10.5194/gmd-2016-91, in review, 2017].

Influence of energetic particle precipitation on Antarctic stratospheric ozone

Abstract ID : 336

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Alessandro Damiani ,alecarlo.damiani@gmail.com ,(None) ,Japan ,Chiba ,Not Presenting[1]

1 - Chiba University

Energetic particle precipitation (EPP) of different energy routinely impact and ionizes the polar atmosphere. The enhanced ionization increases the concentration of odd nitrogen (NO_x) and odd hydrogen (HO_x) species which destroy ozone catalytically. While the most energetic particles can directly affect ozone in the mesosphere, large amounts of NO_x produced by auroral electrons can be transported downwards inside the polar vortex during winter and influence stratospheric ozone levels. On the other hand, the wavelength dependence of the solar irradiance variation can induce stratospheric ozone changes in phase with solar activity mostly at low and middle latitudes. Since ozone is a key factor in explaining the potential influence of the solar activity on the regional climate, we investigated the ozone variability in response to EPP and solar radiation forcing by exploiting satellite observations from Solar Backscatter Ultraviolet Radiometer and Microwave Limb Sounder. Then, we focused on the correlation of the polar ozone variability with EPP in an attempt to quantify the variations on long time scales. The significant stratospheric depletion here highlighted suggests the need of taking the EPP forcing into account in both climate models and trend analysis.

Evaluation of modeled NOx and ozone responses to energetic electron precipitation in the South Hemispheric winter

Abstract ID : 348

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr Pavle Arsenovic ,pavle.arsenovic@env.ethz.ch ,(None) ,Switzerland , ,Not Presenting[1]

Dr. Eugene Rozanov ,eugene.rozanov@pmodwrc.ch ,(Senior Scientist) ,Switzerland ,Davos ,Not Presenting[2]

Prof. Thomas Peter ,thomas.peter@env.ethz.ch ,(None) ,Switzerland , ,Not Presenting[3]

Dr. Alessandro Damiani ,alecarlo.damiani@gmail.com ,(None) ,Japan ,Chiba ,Not Presenting[4]

Dr. Bernd Funke ,bernd@iaa.es ,(Staff Scientist) ,Spain ,Granada ,Not Presenting[5]

1 - IAC ETHZ 2 - PMOD/WRC and IAC ETHZ 3 - ETH 4 - Chiba University 5 - Instituto de Astrofisica de Andalucia CSIC

Precipitating energetic particles have the potential to change the chemistry of the polar atmosphere by producing odd nitrogen and hydrogen (NO_x and HO_x) species, which then catalytically deplete ozone. We investigate the effects of low energy (auroral) electrons and middle energy (radiation belt) electrons on NO_x production during Southern Hemisphere winters from 2002 - 2010 using the SOCOL3-MPIOM chemistry-climate model. Our results show that the majority of NO_x in the polar mesosphere and stratosphere comes from auroral electrons. However, radiation belt electrons should not be neglected as they produce HO_x as well, which is important in ozone depletion. While HO_x depletes ozone in situ, in the polar vortex NO_x subsides and affects ozone at lower altitudes. Comparing a year with high electron precipitation with a quiescent period, we found that the largest ozone depletion occurs in the mesosphere, and as the anomaly propagates downward, 15 % less ozone is found in the stratosphere during active winter months, which is confirmed by satellite observations.

Confirmation of EMIC wave driven relativistic electron precipitation

Abstract ID : 526

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Craig Rodger ,craig.rodger@otago.ac.nz ,(Head of Department) ,New Zealand ,None ,Presenting[1]

Mr. Aaron Hendry ,ahendry@physics.otago.ac.nz ,(None) ,New Zealand , ,Not Presenting[2]

Dr. Mark Clilverd ,macl@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Prof. Mark Engebretson ,engebret@augsburg.edu ,(Professor) ,United States ,Minneapolis ,Not Presenting[4]

Prof. Craig Kletzing ,craig-kletzing@uiowa.edu ,(None) ,United States , ,Not Presenting[5]

Mr. Empty Empty ,marc.lessard@unh.edu ,(None) ,United States , ,Not Presenting[6]

1 - University of Otago 2 - Department of Physics, University of Otago, Dunedin, New Zealand 3 - British Antarctic Survey 4 - Augsburg College, Minneapolis 5 - University of Iowa 6 - Department of Physics, University of New Hampshire, Durham, New Hampshire, USA

It has long been predicted through theory that Electromagnetic Ion Cyclotron Waves (EMIC) should drive significant energetic electron precipitation from the radiation belts into the lower ionosphere. However, until recently there have been surprisingly few experimental observations to confirm this. Recently, we demonstrated a remarkably fortunate conjunction between spacecraft and ground based observations. On 24 Sept 2013 at 16:41 UT EMIC waves were observed by RBSP-A to begin in space. At the same time energetic electron precipitation was seen to start by the NOAA-15 satellite, located <150 km from the base of the RBSP-A magnetic field footprint [Rodger et al., Geophys. Res. Lett., doi:10.1002/2015GL066581, 2015]. Precipitation and EMIC waves were also confirmed by ground based data. We have now confirmed that precipitation triggers found in POES observations of relativistic electron loss correspond to EMIC wave activity. For POES triggers occurring within 15º longitude of the Halley station (Antarctica) search coil magnetometer, ~65% occurred when EMIC waves were seen in the magnetometer data. This should be contrasted with ~20% for random times. For triggers within $\Delta L<0.5$ of Halley, the coincidence rate increases to 90% [Hendry et al., J. Geophys. Res., doi:10.1002/2015JA022224, 2016]. However, this apparently very strong coincidence between precipitation and EMIC wave occurrence does not explain why this linkage has taken so long to demonstrate in the literature. We have attempted to reverse the previous study, and examine how often precipitation occurs when EMIC waves are seen at Halley. Looking only at 2013 data, we manually checked all Halley SCM data and observed 652 EMIC waves representing roughly 82980 minutes of wave activity. Of these 652 wave events, 637 (98%) of the occurred while a POES satellite

was within 15 º longitude of Halley, $2<L<10$, and within +/-1hr of the wave activity. Despite this apparently incredible coverage from the POES satellites, only 13 POES precipitation triggers occurred in 2013 in the region over the Halley magnetometer. Of those 13 triggers, only 1 did not coincide with a wave seen at Halley. While the precipitation may imply waves, the waves do not imply precipitation.

Ultra Low Frequency Waves and Energetic Particle Precipitation

Abstract ID : 630

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Clare Watt ,c.e.watt@reading.ac.uk ,(Lecturer) ,United Kingdom ,Reading ,Not Presenting[1]

Dr. I. Jonathan Rae ,jonathan.rae@ucl.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Kyle R. Murphy ,kyle.r.murphy@nasa.gov ,(None) ,United States , ,Not Presenting[3]

Dr. Alexander W. Degeling ,degeling@ualberta.ca ,(None) ,China , ,Not Presenting[4]

Prof. Ian R. Mann ,mann@ualberta.ca ,(None) ,Canada , ,Not Presenting[5]

Dr. Alexa J. Halford ,alexa.halford@gmail.com ,(None) ,United States , ,Not Presenting[6]

Dr. Louis G. Ozeke ,ozeke@ualberta.ca ,(None) ,Canada , ,Not Presenting[5]

Dr. David Sibeck ,david.g.sibeck@nasa.gov ,(None) ,United States , ,Not Presenting[8]

Dr. Mark Clilverd ,macl@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[9]

Prof. Craig Rodger ,craig.rodger@otago.ac.nz ,(Head of Department) ,New Zealand ,None ,Not Presenting[10]

Dr. Howard J. Singer ,Howard.Singer@noaa.gov ,(None) ,United States , ,Not Presenting[11]

1 - University of Reading 2 - Mullard Space Science Laboratory, UCL 3 - NASA Goddard Space Flight Centre 4 - Shandong University 5 - University of Alberta 6 - Dartmouth College 7 - University of Alberta 8 - NASA GSFC 9 - British Antarctic Survey 10 - University of Otago 11 - NOAA Space Weather Prediction Center

Energetic electron precipitation is often observed to be modulated at ultra low frequency (ULF) wave frequencies. The theoretical framework for such modulation is currently thought to be the modulation of very low frequency whistler-mode waves in the magnetosphere by the slow changes in magnetic field and number density due to the ULF waves. We present a case study of modulated electron precipitation across a range of energies observed during one of the BARREL balloon campaigns, supplemented by space-based and ground-based magnetic field observations. The obseravtions indicate that the ULF wave pulsations are highly localised in local time and we demonstrate, using global ULF wave models, the magnetospheric conditions that could allow this to happen. We discuss the implications of regions of localised ULF wave energy for the precipitation of high-energy electrons

and show that ULF waves can enhance energetic electron precipitation with or without the presence of whistler-mode waves.

Direct and indirect electron precipitation effect on nitric oxide using a full range energy spectrum

Abstract ID : 680

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Hilde Nesse Tyssøy ,hilde.nesse@uib.no ,(Researcher) ,Norway ,N-5020 Bergen ,Not Presenting[1]

Ms. Christine Smith-Johnsen ,christine.smith-johnsen@geo.uio.no ,(None) ,Norway , ,Not Presenting[2]

Mr. Koen Hendrickx ,koen.hendrickx@misu.su.se ,(None) ,Sweden , ,Not Presenting[3]

Dr. Yvan J. Orsolini ,yvan.orsolini@nilu.no ,(None) ,Norway , ,Not Presenting[4]

Dr. Grandhi Kishore Kumar ,kishore.grandhi@uib.no ,(None) ,Norway , ,Not Presenting[1]

Dr. Marit Irene Sandanger ,marit.sandanger@uib.no ,(None) ,Norway , ,Not Presenting[1]

Prof. Frode Stordal ,frode.stordal@geo.uio.no ,(None) ,Norway , ,Not Presenting[2]

Dr. Linda Megner ,linda.megner@misu.su.se ,(None) ,Sweden , ,Not Presenting[8]

1 - Birkeland Centre for Space Science (BCSS) Department of Physics and Technology University of Bergen 2 - Department of Geosciences, University of Oslo 3 - Department of Meteorology, Stockholm University 4 - Birkeland Centre for Space Science (BCSS), Department of Physics and Technology, University of Bergen (UiB) / Norwegian Institute for Air Research 5 - Birkeland Centre for Space Science (BCSS) Department of Physics and Technology University of Bergen 6 - Birkeland Centre for Space Science (BCSS) Department of Physics and Technology University of Bergen 7 - Department of Geosciences, University of Oslo 8 - Department of Meteorology, Stockholm University, Stockholm

A geomagnetic active period in the beginning of April 2010 includes two moderate geomagnetic storms (Dst -81 nT and -67 nT) as well as a few weaker disturbances in their associated recovery periods. The first CME concurred with a high speed solar wind stream reaching 800 km/s, resulting in energetic electron precipitation depositing their energy from the lower thermosphere and throughout the mesosphere. We combine electron fluxes from the Total Energy Detector (TED) and the Medium Energy Proton and Electron Detector (MEPED) on the National Oceanic and Atmospheric Administration (NOAA) Polar Orbiting Environmental *Satellites (POES)*, to obtain a continuous energy spectrum covering 1-750 keV. This corresponds to electrons depositing their energy at atmospheric altitudes 60-150 km. We estimate the accumulated effect on the NO density based on the electron energy deposition and taking into account loss due to photolysis. This is further compared to the NO

measurements from The Solar Occultation for Ice Experiment (SOFIE) instrument on board the Aeronomy of Ice in the Mesosphere (AIM) satellite. We aim to determine how deep into the mesosphere the direct NO production can be detected. We will assess the importance of the direct effect compared to the indirect NO enhancement due the vertical transport at different altitudes.

Energetic Particle Precipitation impact on mesospheric OH – variability of the sources and the background atmosphere

Abstract ID : 694

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Annet Eva Zawedde ,Annet.Zawedde@uib.no ,(Student) ,Norway ,Bergen ,Not Presenting[1]

Dr. Marit Irene Sandanger ,marit.sandanger@uib.no ,(None) ,Norway , ,Not Presenting[2]

Prof. Johan Stadsnes ,Johan.Stadsnes@uib.no ,(Professor Emeritus) ,Norway ,Bergen ,Not Presenting[3]

Prof. Robert Hibbins ,robert.hibbins@ntnu.no ,(None) ,Norway , ,Not Presenting[4]

Prof. Patrick Josep Espy ,patrick.espy@ntnu.no ,(None) ,Norway , ,Not Presenting[4]

Dr. Hilde Nesse Tyssøy ,hilde.nesse@uib.no ,(Researcher) ,Norway ,N-5020 Bergen ,Not Presenting[2]

1 - Birkeland Centre for Space Science, Department of Physics and Technology, University of Bergen 2 - Birkeland Centre for Space Science (BCSS) Department of Physics and Technology University of Bergen 3 - Birkeland Centre for Space Science (BCSS), Department of Physics and Technology, University of Bergen 4 - Birkeland Centre for Space Science, Norwegian University of Science and Technology 5 - Birkeland Centre for Space Science, Norwegian University of Science and Technology 6 - Birkeland Centre for Space Science (BCSS) Department of Physics and Technology University of Bergen

There has been ample evidence that energetic particle precipitation (EPP) can affect the OH density in the polar mesosphere. Whereas the impact of the rare Solar Proton Events has been extensively studied, recent studies show that also smaller, but frequent geomagnetic disturbances involving energetic electron precipitation (EEP) might be equally important (e.g. Andersson et al,. 2014). In a recent work by Zawedde et al. (2016) we found that during solar minimum, EEP-driven OH production commensurate with background dynamical variability. Hence to quantify the EPP effect throughout the solar cycle, the background atmospheric dynamics, along with detailed knowledge of where and when the precipitation occurs, needs to be taken into account. Applying a new analysis technique on the Medium Energy Proton and Electron Detector (MEPED) on the National Oceanic and Atmospheric Administration (NOAA) Polar Orbiting Environmental Satellites (POES) we will estimate the flux of precipitating particles. These fluxes are used to quantify the direct impact of EPP over five years from

2005 till 2009 on middle atmospheric hydroxyl (OH) measured from the Aura satellite. Using multi linear regression analysis of OH with particle energy deposition, temperature, geopotential height and water vapor, we aim to separate the variability of OH due to different sources of EPP as well as the background.

Energetic electron precipitations at auroral and sub-auroral latitudes associated with substorm-induced injection, EMIC wave, and ULF pulsation

Abstract ID : 766

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Fuminonri Tsuchiya ,tsuchiya@pparc.gp.tohoku.ac.jp ,(None) ,Japan ,Sendai ,Presenting[1]

Dr. Takahiro Obara ,obara@pparc.gp.tohoku.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Miss. Asuka Hirai ,hirai.a@pparc.gp.tohoku.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Hiroaki Misawa ,misawa@pparc.gp.tohoku.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Kazuo Shiokawa ,shiokawa@nagoya-u.jp ,(None) ,Japan , ,Not Presenting[5]

Dr. Yoshizumi Miyoshi ,miyoshi@isee.nagoya-u.ac.jp ,(None) ,Japan , ,Not Presenting[5]

Dr. Martin Conners ,martinc@athabascau.ca ,(None) ,Canada , ,Not Presenting[7]

Dr. Takeshi Sakanoi ,tsakanoi@pparc.gp.tohoku.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Donaldo Hampton ,dhampton@alaska.edu ,(None) ,United States , ,Not Presenting[9]

Dr. Yasunobu Ogawa ,yogawa@nipr.ac.jp ,(None) ,Japan , ,Not Presenting[10]

1 - None 2 - Tohoku Univ. 3 - Tohoku Univ. 4 - Tohoku Univ. 5 - ISEE, Nagoya Univ. 6 - ISEE, Nagoya Univ. 7 - Athabasca Univ. 8 - Tohoku Univ. 9 - Univ. Alaska Fairbanks 10 - NIPR

Energetic electron precipitation into the atmosphere is one of central issues of geospace research. Sub-ionospheric propagation of narrowband VLF/LF radio waves is useful probe to observe the electron precipitation with energy of 100keV to MeV. Here, we show observational characteristics of energetic electron precipitations at auroral and sub-auroral latitudes observed by a LF radio receiver network installed at Ny-Alesund(NAL), Athabasca(ATH), and Poker Flat Research Range, Alaska(PKR). The NAL station is located inside the northern polar cap and phase and amplitude of radio signals from mid-latitude transmitters are recorded. Energetic electron precipitation is detected after an onset of storm-time substorm. In the morning and noon sectors, the onset of the precipitation

is delayed by ten to several tens of minutes from the substorm onset. The delay is consistent with the drift of energetic electrons. In the dusk sector the precipitation occurs shortly after the substorm onset and are accompanied by EMIC waves. These results suggest that the energetic electron precipitation is caused by whistler mode and EMIC waves which are excited by energetic electrons and ions, respectively. Substorm induced precipitation was observed at both ATH and PKR simultaneously (the same meridian but different latitude) but each shows a different time profile, suggesting different longitudinal extent of energetic electron population and electron precipitation process. The ATH station is located in the sub-auroral region and observes radio signals propagating from low latitude. Phase changes synchronized with the Pc5 pulsation and EMIC waves were detected. The phase fluctuation in the Pc5 range shows correlation with both magnetic field and SuperDARN data. Spectrum analysis suggests that the Pc5 was toroidal mode and had small m-number, suggesting external origin. The phase changes sometimes show correlation with appearances of EMIC waves. There results show that the energetic electron precipitations are caused by magnetic pulsations and EMIC waves. The radio network described here is one of ground-based observation network supporting a Japanese geospace mission, ARASE. Comparison of the LF radio observations with the in-situ measurements of plasma density, plasma waves, and energetic particles will enable us to determine which processes are responsible for the energetic particle precipitation.

Climate Impact of Polar Mesospheric and Stratospheric Ozone Losses due to Energetic Particle Precipitation

Abstract ID : 852

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Katharina Meraner ,katharina.meraner@mpimet.mpg.de ,(Postdoctoral Researcher) ,Germany ,Hamburg ,Not Presenting[1]

Dr. Hauke Schmidt ,hauke.schmidt@mpimet.mpg.de ,(None) ,Germany , ,Not Presenting[2]

1 - Max Planck Institute for Meteorology 2 - Max Planck Insitute for Meteorology

Energetic particle precipitation (EPP) produces nitrogen oxides and hydrogen oxides in the polar middle atmosphere. Both components deplete ozone in the polar stratosphere and mesosphere. Recently Anderson et al. (2014; Nature Comm.) showed that the direct effect of hydrogen oxides causes significant long-term mesospheric ozone variability. Satellites observe a decrease in mesospheric ozone by up to 34% between EPP maximum and EPP minimum. Those large changes trigger the question of a potential impact of energetic particles on the tropospheric climate.
Here, we analyze the climate impact of polar mesospheric and polar stratospheric ozone losses due to energetic particle precipitation in the Earth System Model MPI-ESM. To rule out potential additional forcings, the boundary conditions are fixed to preindustrial conditions. Using radiative transfer modeling, I will show that the radiative forcing of a mesospheric ozone loss is small. Hence, the climate effects of a mesospheric ozone loss due to energetic particles proposed by Andersson et al. (2014) seem unlikely. A stratospheric ozone loss due to energetic particles cools the winter polar stratosphere and subsequently weakens the polar vortex. However, those changes are small, and few statistically significant changes in surface climate are found.

Precipitating Energetic Electron Observations by the AC6 Cubesat Pair

Abstract ID : 879

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. J Bernard Blake ,jbernard.blake@aero.org ,(Aerospace Fellow) ,United States ,Los Angeles ,Not Presenting[1]

1 - The Aerospace Corporation

It had long been recognized that measurements of energetic electron precipitation by two closely spaced satellites would greatly facilitate the separation of spatial and temporal variations. In particular, microbursts, with their short timescales, make single point observations difficult to interpret. The AC6 mission, launched 19 June 2014, is providing simultaneous, closely-spaced measurements of energetic electron intensities in LEO orbit. First light results are given in Blake and OBrien (2016).

Key features of the two AC6 Cubesats are that they are in polar orbit (98-degree inclination) at an altitude of 620 X 700 km, carry a GPS system that gives location to ~ 10 meters, and use differential drag to control in-track separation.

AC6 observations have revealed that fine latitudinal structure usually is seen in the LEO electron population using a sensor with an integral electron threshold of 35 keV. These fine structures appear as curtains of energetic electrons, confined to a narrow DL range, that are gradient-curvature drifting eastward, and initially scattered to low altitude by chorus waves. Near equatorial electrons are strongly scattered by chorus waves and as a result, a LEO s/c is engulfed in an isotropic burst of energetic electrons. A single microburst lasts less than a second, a timescale of the order of the electron bounce period. Those electrons in the bounce loss cone are quickly lost, leaving electrons in the drift loss cone and/or trapped and the electrons will drift eastwards in longitude on the drift shell where the scattering left them. The drift speed is energy dependent so the burst electrons will spread out in longitude as they drift.

Implicit in this description is the assumption that chorus scatters the electrons such that the DL of a microburst at low altitude can be very small, perhaps only a few tens of km or less in latitude. The narrow latitudinal electron structures seen by AC6 would be difficult to account for without this being the case. AC6 does not give us information of the cross-track or longitudinal width of a microburst. It might be much larger than the latitudinal width. The cross-track separation of the pair is of the order of a few kilometers or less. Examples of these observations will be shown.

A15 - Wave and Particle Dynamics in the Radiation Belts and Ring Current (DIV II – DIV III – VERSIM)

Modeling substorm injections

Abstract ID : 61

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Konstantin Kabin ,konstantin.kabin@rmc.ca ,(Associate Professor) ,Canada ,Kingston ,Not Presenting[1]

Mr German Kalugin ,german.kalugin@gmail.com ,(None) ,Canada , ,Not Presenting[2]

Mr Emma Spanswick ,elspansw@ucalgary,ca ,(None) ,Canada , ,Not Presenting[3]

Mr Eric Donovan ,edonovan@ucalgary.ca ,(None) ,Canada , ,Not Presenting[3]

1 - None 2 - RMC 3 - The University of Calgary 4 - The University of Calgary

We describe a novel model of magnetotail which is easily controlled by several adjustable parameters, such as the thickness of the tail and the location of transition from dipole-like to tail-like magnetic field lines. This model is fully three-dimensional and includes the day-night asymmetry of the terrestrial magnetosphere, however, the field lines are contained in the meridional planes. Our model is well suited to studies of the magnetotail dipolarizations which we consider to be the movements of the transition between dipole-like and tail-like field lines. Induced electric fields generated by this reconfiguration of the magnetotail are capable of energizing electrons and ions. We also study the effects of a dipolarizing electromagnetic pulse propagating towards the Earth. The transient pulse fields are also three-dimensional, thus allowing us to study energization of electrons and ions with different pitch angles. In some cases, the energy of the particles can increase by a factor of 25 or more and approach that of the radiation belt particles. The energized particles are transported towards the Earth where they can be observed by satellites as substorm injections.

A parameter study and superposed epoch analysis of the generation of electromagnetic ion cyclotron (EMIC) waves based on Van Allen Probes observations

Abstract ID : 406

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Mark Engebretson ,engebret@augsburg.edu ,(Professor) ,United States ,Minneapolis ,Not Presenting[1]

Ms. Jennifer Posch ,posch@augsburg.edu ,(None) ,United States , ,Presenting[2]

Dr. Jay Johnson ,jrj@andrews.edu ,(None) ,United States ,Michigan ,Presenting[3]

Mr. Jesse Snelling ,jesses@andrews.edu ,(None) ,United States , ,Presenting[3]

Dr. Eun-Hwa Kim ,ehkim@pppl.gov ,(None) ,United States , ,Presenting[5]

Ms. Sadie Tetrick ,sadie-tetrick@uiowa.edu ,(None) ,United States , ,Presenting[6]

Prof. Craig Kletzing ,craig-kletzing@uiowa.edu ,(None) ,United States , ,Presenting[6]

Mr. Sheng Tian ,tsheng886@gmail.com ,(None) ,United States , ,Presenting[8]

Prof. John Wygant ,wygan001@umn.edu ,(None) ,United States , ,Presenting[8]

Mr Geoffrey Reeves ,geoff@reevesresearch.org ,(None) ,United States , ,Presenting[10]

Dr. Joseph Fennell ,joseph.fennell@aero.org ,(None) ,United States , ,Presenting[11]

1 - Augsburg College, Minneapolis 2 - Augsburg College 3 - Andrews University 4 - Andrews University 5 - Princeton Plasma Physics Laboratory 6 - University of Iowa 7 - University of Iowa 8 - University of Minnesota 9 - University of Minnesota 10 - Los Alamos National Laboratory 11 - Aerospace Corporation

Although it is well accepted that the free energy for growth of electromagnetic ion cyclotron (EMIC) waves in Earth's magnetosphere comes from unstable configurations of hot anisotropic ring current ions, the relative importance of spatial variations in cold plasma density and temporal variations caused by externally imposed magnetospheric compressions and/or substorm injections is still a matter of some uncertainty. In this study we use wave and plasma observations obtained during a set of four successive outbound passes of the two Van Allen Probes spacecraft on November 11, 2013 to perform a parameter study of the conditions under which EMIC waves occur using the WHAMP (waves in homogeneous anisotropic magnetized plasma) code. We also present the results of a

superposed epoch study of the 158 most intense EMIC waves observed during the first full local time pass of the Van Allen Probes, focusing on their temporal dependence on solar wind dynamic pressure and substorm activity as well as their spatial dependence on location relative to the plasmapause.

Cluster observations of EMIC triggered emissions and plasmaspheric plumes

Abstract ID : 527

Conflict Declaration : None

Content Motivation : None

Additional Information : I might not be able to attend the conference on Friday.

Mr. Benjamin Grison ,grison@ufa.cas.cz ,(None) ,Czech Republic ,Prague ,Presenting[1]

Mr. Miroslav Hanzella ,mh@ufa.cas.cz ,(None) ,Czech Republic , ,Not Presenting[2]

Dr. Fabien Darrouzet ,Fabien.Darrouzet@aeronomie.be ,(None) ,Belgium , ,Not Presenting[3]

Prof. Ondrej Santolik ,os@ufa.cas.cz ,(None) ,Czech Republic , ,Not Presenting[4]

Dr. Nicole Cornilleau-Wehrlin ,nicole.cornilleau@lpp.polytechnique.fr ,(None) ,France , ,Not Presenting[5]

1 - Institute of Atmospheric Physics / CAS 2 - IAP CAS 3 - Belgian Institute of Space Aeronomy 4 - Czech Academy of Sciences 5 - LPP/CNRS/Ecole Polytechnique

Density gradients, as observed at the plasmapause, are known for a long time to enhance ElectroMagnetic Ion Cyclotron (EMIC) wave growth. Based on a list of plasmaspheric plume crossings (Darrouzet et al., 2008) by the Cluster spacecraft we focus on occurrence of the EMIC triggered emissions in connection with plasmaspheric plumes. EMIC triggered emissions are considered as ion-scale equivalentsof the whistler-mode chorus emissions. These highly coherent waves are identified by their typical frequency-time dispersion patterns. Their frequency extent spans over frequency ranges where the cold plasma theory predicts multi-ion wave modes with their characteristic cut-off, cross-over and resonance-frequencies. For this study we mainly consider the STAFF-SC (magnetic search coils), FGM (fluxgate magnetometers), WHISPER (relaxation sounder) and CIS (ion detectors) instrument datasets measured onboard the 4 Cluster satellites.
Our study shows that EMIC triggered emissions are observed just outside of plasmaspheric plumes, at the onset of the density gradient. Focusing on the events when EMIC triggered emissions are observed close to a plasmaspheric plume by at least one Cluster spacecraft, we note that EMIC triggered emissions are detected only by those spacecraft of the Cluster fleet which cross the plume. This shows the importance of a dense cold plasma population for destabilization of triggered emissions.
Finally, based on polarization properties of the EMIC triggered emissions (ellipticity, propagation angle), we investigate propagation of these waves by a backward ray tracing technique and we estimate the most probable location of the triggering process.

The origin of the whistler-mode spectral "gap" at half electron gyrofrequency in the magnetosphere

Abstract ID : 650

Conflict Declaration : None

Content Motivation : None

Additional Information : This work was in part funded by the UK STFC grant ST/M000885/1 and EPSRC grants EP/G054950/1, EP/G056803/1, EP/G055165/1 and EP/ M022463/1. This work used the DiRAC Data Analytic system at the University of Cambridge, operated by the University of Cambridge High Performance Computing Service on behalf of the STFC DiRAC HPC Facility (www.dirac.ac.uk). This equipment was funded by BIS National E-infrastructure capital grant (ST/K001590/1), STFC capital grants ST/H008861/1 and ST/H00887X/1, and STFC DiRAC Operations grant ST/K00333X/1. DiRAC is part of the National E-Infrastructure.

Dr. Heather Ratcliffe ,h.ratcliffe@reading.ac.uk ,(Scientist) ,United Kingdom ,Reading ,Not Presenting[1]

Dr. Clare Watt ,c.e.watt@reading.ac.uk ,(Lecturer) ,United Kingdom ,Reading ,Presenting[1]

1 - University of Reading 2 - University of Reading

Decades of in-situ observations of whistler-mode waves in Earth's magnetosphere reveal that there is frequently a gap in the spectral power at around half the local electron gyrofrequency. Recent theoretical and kinetic simulation studies have suggested that the gap arises due to the presence of temperature anisotropy in both a "warm" and a "hot" electron population, leading to two separate (and independent) regions of wave growth in frequency space. We present two-dimensional kinetic plasma simulations using the powerful EPOCH particle-in-cell code (https://goo.gl/phYVqP) that offer an alternative explanation. After an initial linear-growth period, our simulations show self-consistent formation of a gap feature. In most cases this arises where linear theory predicts the maximum growth rate, and is associated with subtle local structuring of the hot electron distributions. This feature persists in multiple simulations with widely varying hot electron parameters. It is important to note that this behaviour only emerges when sufficient particles/cell are used in the simulation, and that it does not appear in similar simulations restricted to one spatial dimension. We discuss these results in the context of in-situ observations of both waves and electron distribution functions and argue that the rapid reorganisation of electron distributions in a small, but key, region of phase-space during the growth of whistler-mode waves naturally results in the spectral gap often observed at half the electron gyrofrequency.

Analysis of proton and electron spectra observed by EPT/PROBA-V in the South Atlantic Anomaly

Abstract ID : 699

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Lopez Rosson Graciela ,graciela.lopez@aeronomie.be ,(Research assistant, PhD student) ,Belgium ,Brussels ,Not Presenting[1]

Prof. Viviane Pierrard ,viviane.pierrard@aeronomie.be ,(None) ,Belgium , ,Not Presenting[1]

1 - Royal Belgian Institute for Space Aeronomy 2 - Royal Belgian Institute for Space Aeronomy

Proton and electron spectra observed by the Energetic Particle Telescope (EPT) on board the ESA satellite PROBA-V have been investigated at different locations in the South Atlantic Anomaly (SAA). The EPT spectrometer provides high-resolution measurements of the charged particle radiation environment in space performing with direct electron, proton and heavy ion discrimination. Dividing the SAA into 5 different bins of 5°x 5° each one for protons, we obtain that the average proton spectra have often similar slopes, but greatly differ from one location to another. The highest fluxes are generally located in the North of the SAA. For some energy ranges and time periods, the South of the SAA shows different shapes, indicating different sources for the North and South populations of the SAA.

One of these populations is very stable, with fluxes that remain constant in time, mainly related with CRAND, while the other one is more variable, on the north part of the SAA, associated with injection of particles during SEP events.

For electrons we selected 5 bins of 15°x 15° each one in similar locations than protons.

The electron spectra show very low fluxes of energetic electrons, often lower than what is provided by the model AE8.

The impressive correlation between substorm activity and the rebuilding of Earth’s radiation belts

Abstract ID : 761

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Allison Jaynes ,Allison.Jaynes@lasp.colorado.edu ,(None) ,United States , ,Presenting[1]

Dr. David Malaspina ,David.Malaspina@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[2]

Ms. Veronica Dike ,chococat@unm.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Daniel Baker ,dan.baker@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Xinlin Li ,xinlin.li@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Hong Zhao ,hong.zhao@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Shri Kanekal ,shrikanth.g.kanekal@nasa.gov ,(None) ,United States , ,Not Presenting[7]

1 - CU-LASP 2 - Laboratory for Atmospheric and Space Physics, University of Colorado Boulder 3 - University of New Mexico 4 - University of Colorado Boulder 5 - University of Colorado Boulder 6 - University of Colorado Boulder 7 - NASA Goddard Space Flight Center

Substorms have long been thought to constitute a crucial mechanism for accelerating medium-energy particles in Earth's outer radiation belt to relativistic and ultra-relativistic energies. This process involves resonant interaction between seed electrons (10s-100s keV) and VLF chorus waves, which can grow to great intensities from repeated substorm injections consisting of source energy electrons (few-10s keV). Historically, strong enhancements of outer Van Allen belt energetic electrons have been shown to have a clear dependence on a southward interplanetary magnetic field, again indicating a direct relationship to substorm activity. Using data from the REPT instrument onboard the twin Van Allen Probes satellites, which measures multi-MeV electrons, we show a clear and repeatable correlation between increases in integrated substorm power (computed from the AE and AL indices) and electron flux enhancements. We also characterize the lag time between AE/AL enhancement and flux increase, which shows an expected dependence on electron energy. With a robust model of predicted AE index, we can improve prediction of the radiation environment in near-Earth space.

Gyroresonant cceleration of energetic electrons by whistler mode waves

Abstract ID : 849

Conflict Declaration : None

Content Motivation : The problem of radiation belt dynamics attracts much attention of the scientific community, and it poses many intresting basic subproblems related to the physics of wave-particle interactions.

Additional Information : None

Dr. Andrei Demekhov ,andrei@appl.sci-nnov.ru ,(Chief Scientist) ,Russia ,Apatity ,Not Presenting[1]

1 - Polar Geophysical Institute

Recently many analytical and numerical results have been obtained about gyroresonant acceleration of radiation-belt electrons by quasimonochromatic whistler-mode waves. We extend these studies by comparing analytical and numerical results for the efficiency of nonlinear trapping of energetic electrons and for the integral contribution of trapped and untrapped particles to the energy balance during the wave-particle interactions. We use test-particle simulations for the interaction with wave packets having idelaized smooth profiles of the amplitude and frequency and realistic wave packets detected by spacecraft. Splitting of wave packets into subpackets, which is typical of VLF chorus emissions, significantly reduces the efficiency of energy exchange between the waves and particles; we study this effect depending on the parameters of the system.

Theory and observations of electromagnetic oxygen cyclotron harmonic waves

Abstract ID : 949

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Maria Usanova ,maria.usanova@lasp.colorado.edu ,(None) ,United States ,Boulder ,Not Presenting[1]

Dr. Konrad Sauer ,ksauer@ualberta.ca ,(None) ,Canada , ,Not Presenting[2]

1 - LASP, CU Boulder 2 - University of Alberta

Waves with frequencies in the vicinity of the oxygen cyclotron frequency and its harmonics have been regularly observed on Van Allen Probes during geomagnetic storms. They are electromagnetic, in the frequency range ~0.5 - several Hz, and amplitude ~0.1- a few nT in magnetic and ~0.1- a few mV/m in electric field, with both the wave velocity and the Poynting vector directed almost parallel to the background magnetic field. These properties are different from previously reported perpendicular propagating harmonic waves (e.g., magnetosonic) and in fact are very similar to those of electromagnetic ion cyclotron (EMIC) waves, which are believed to contribute to loss of ring current ions and radiation belt electrons and therefore can be also important for inner magnetosphere dynamics. We present observations of these waves and associated ion distributions from the Van Allen Probes and results from the linear theory analysis elucidating the nature of this plasma instability and its free energy source.

Chorus Element Properties: Statistics of Sweep Rate

Abstract ID : 989

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Craig Kletzing ,craig-kletzing@uiowa.edu ,(None) ,United States , ,Presenting[1]

Prof. Ananya Sen Gupta ,ananya-sengupta@uiowa.edu ,(None) ,United States , ,Presenting[2]

1 - University of Iowa 2 - The University of Iowa

Using novel signal processing techniques, we have developed autonomous algorithms that can analyse Van Allen Probes waveform observations to determine the characteristics of individual chorus elements. In particular, the methods allow us to determine the frequency/time sweep rate of chorus elements for a large number of events without the need for manual identification of the elements. This enables statistical studies of the properties of the individual chorus elements which has been limited in the past to small numbers of events identified and analysed by hand. We present the basics of the technique and show initial results of the statistics on the range and character of chorus element sweep rate.

Uncerrtainty quantification of radiation belts dynamics

Abstract ID : 1103

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr Enrico Camporeale ,e.camporeale@cwi.nl ,(None) ,Netherlands , ,Not Presenting[1]

Prof. Yuri Shprits ,yshprits@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[2]

Mr. Mandar Chandorkar ,m.chandorkar@cwi.nl ,(None) ,Netherlands , ,Not Presenting[1]

Dr. Alexander Drozdov ,adrozdov@ucla.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Simon Wing ,simon.wing@jhuapl.edu ,(None) ,United States ,Laurel ,Not Presenting[5]

1 - CWI 2 - GFZ Potsdam 3 - CWI 4 - UCLA 5 - Johns Hopkins University

We present the first study of the uncertainties associated with radiation belt simulations, performed in the standard quasi-linear diffusion framework. In particular, we estimate how uncertainties of some input parameters propagate through the nonlinear simulation, producing a distribution of outputs that can be quite broad. Here, we restrict our focus on two-dimensional simulations (in energy and pitch angle space) and to parallel chorus waves only, and we study as stochastic input parameters the geomagnetic index Kp (that characterize the time dependency of an idealized storm), the latitudinal extent of waves, and the average electron density. We employ a collocation method, thus performing an ensemble of simulations. The results of this work point to the necessity of shifting to a probabilistic interpretation of radiation belt simulation results, and suggest as an important research goal a less uncertain estimation of the electron density in the belts.

Relationship between EMIC Waves seen in the Magnetosphere and on the Ground

Abstract ID : 1183

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Brian Fraser ,brian.fraser@newcastle.edu.au ,(Emeritus/Conjoint Professor) ,Australia ,Newcastle ,Presenting[1]

Dr. Sean Ables ,sean.ables@newcastle.edu.au ,(None) ,Australia , ,Presenting[2]

Dr. Murray Sciffer ,murray.sciffer@newcastle.edu.au ,(None) ,Australia , ,Presenting[3]

Prof. Ian Mann ,imann@ualberta.ca ,(None) ,Canada , ,Presenting[4]

1 - University of Newcastle, Australia 2 - Centre for Space Physics, University of Newcastle, 3 - University of Newcastle 4 - University of Alberta

It has long been suggested that electromagnetic ion cyclotron (EMIC) waves are an effective mechanism for scattering relativistic electrons in the outer Van Allen radiation belt due to pitch angle diffusion in the field aligned direction. In order to further understand the relative importance of this mechanism to precipitation it is necessary to establish a spatial and temporal pattern of EMIC wave occurrence. This can be undertaken using in situ magnetosphere observations in conjunction with ground signatures of the waves. However, satellite observations are restricted in coverage, multiple magnetospheric EMIC wave sources exist, and more waves are typically observed on the ground. Consequently it has been suggested that the ground spatial distribution of occurrence may be a more useful indicator of overall EMIC wave activity than the more spasmodic satellite data. To understand the relationship between EMIC wave events seen almost simultaneously at both locations we are studying EMIC waves seen by the GOES 13-15 geosynchronous satellites located over Canada with the same events seen on the ground by the CARISMA network of ground-based induction coil and fluxgate magnetometers. Transmission of waves from the magnetosphere to the ground involves field-aligned ion cyclotron wave packet group propagation in the magnetosphere followed by horizontal propagation in the ionospheric F2 region waveguide, with wave energy finally transmitting through the ionospheric E-region to the ground. Two case study events recorded on 27 June 2016 by GOES 14 and the ground network will be considered in detail. Satellite-ground time delays are 40-60 s and inter-station ground delays 0.5-3 s. Polarisation, phase, time delay and direction of arrival techniques are used to analyse data to establish spatial propagation patterns. The results provide an indication of the extent to which EMIC waves seen in the magnetosphere distribute over the surface of the Earth in longitude and to middle and low latitudes. These observations are supported by MHD model computations.

Relativistic Electron Pitch Angle Distributions from the Van Allen Probe Mission

Abstract ID : 1515

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Reiner Friedel ,rfriedel@lanl.gov ,(None) ,United States ,New Mexico ,Presenting[1]

Dr. Geoffrey Reeves ,reeves@lanl.gov ,(None) ,United States , ,Not Presenting[2]

Mr. Yue Chen ,cheny@lanl.gov ,(None) ,United States , ,Not Presenting[1]

Mr. Mike Henderson ,mhenderson@lanl.gov ,(None) ,United States , ,Not Presenting[1]

Mr. Hong Zhao ,Hong.Zhao@Colorado.edu ,(None) ,United States , ,Not Presenting[5]

Mr. Dan Baker ,Dan.Baker@Colorado.edu ,(None) ,United States , ,Not Presenting[5]

Ms. Allison Jaynes ,Allison.Jaynes@Colorado.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Shri Kanekal ,shrikanth.g.kanekal@nasa.gov ,(None) ,United States , ,Not Presenting[8]

1 - Los Alamos National Laboratory, Los Alamos, New Mexico. United States 2 - LANL 3 - Los Alamos National Laboratory, Los Alamos, New Mexico. United States 4 - Los Alamos National Laboratory, Los Alamos, New Mexico. United States 5 - Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Colorado, United States 6 - Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Colorado, United States 7 - Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Colorado, United States 8 - NASA Goddard Space Flight Center

Relativistic electron pitch angle distributions (PADs) in the trapped inner region of the magnetosphere are a
sensitive measure of many processes that govern the dynamics of these particles. We report here on statistical
observations of relativistic electron PADs from the REPT (Relativistic Electron/Proton Telescope) instrument
aboard the Van Allen Probes mission, which show an unexpected dawn/dusk asymmetry that seems to be a
persistent feature during quiet times of Dst > -20 nT. The observed PADs show a more peaked pancake distribution
at dusk compared to dawn for energies above 1.8 MeV only. Energies from a few 100 KeV to 1 m,eV do NOT

show these asymmetries, ruling out magnetic field model effects. These observations hint at persistent processes
that can act on relativistic electrons on timescales on the order of the outer radiation belt drift period (10 minutes).

A16 - The Earth´s Plasmasphere: Remote Sensing and Modelling (DIV II – DIV III – VERSIM)

Magnetoseismic Study of the Plasmasphere Using ULF Waves Observed by the Van Allen Probes

Abstract ID : 152

Conflict Declaration : None

Content Motivation : None

Additional Information : This is an invited paper

Dr. Kazue Takahashi ,kazue.takahashi@jhuapl.edu ,(Professional Staff) ,United States ,Laurel ,Not Presenting[1]

Dr. Richard E. Denton ,richard.e.denton@dartmouth.edu ,(None) ,United States , ,Not Presenting[2]

1 - The Johns Hopkins University Applied Physics Laboratory 2 - Department of Physics and Astronomy, Dartmouth College

Normal mode magnetoseismology using toroidal mode standing Alfvén waves observed by satellites is a powerful technique in estimating the mass density and the ion composition (when the electron density can be determined by other means) in the magnetosphere. We have extensively used data from the GEOS geostationary spacecraft to estimate the mass density mostly just outside the plasmasphere. With more than four years of data available from the Van Allen Probes for $L < 6$, we can expand the magnetoseismic analysis to the plasmasphere. The spacecraft are each equipped with electric and magnetic field experiments as well as a plasma wave spectrum analyzer that provides information on the electron density. This paper presents examples of Van Allen Probes magnetoseismic analysis and discusses how the mass density controls wave propagation in the inner magnetosphere and is related to particle transport processes in the radiation belt.

Whistler source regions for 16 detector stations around the world

Abstract ID : 180

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. David Koronczay ,david.koronczay@ttk.elte.hu ,(PhD student) ,Hungary ,Budapest ,Not Presenting[1]

Dr. Mark Clilverd ,macl@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Peter Steinbach ,steinb@sas.elte.hu ,(None) ,Hungary , ,Not Presenting[3]

Dr. Fabien Darrouzet ,Fabien.Darrouzet@aeronomie.be ,(None) ,Belgium , ,Not Presenting[4]

Dr. Nina Cherneva ,nina@ikir.ru ,(None) ,Russia , ,Not Presenting[5]

Dr. Csaba Ferencz ,csaba@sas.elte.hu ,(None) ,Hungary , ,Not Presenting[3]

Prof. János Lichtenberger ,lityi@sas.elte.hu ,(Professor) ,Hungary ,Budapest ,Not Presenting[7]

Prof. Craig Rodger ,craig.rodger@otago.ac.nz ,(Head of Department) ,New Zealand ,None ,Not Presenting[8]

Dr. Dmitry Sannikov ,vilgusi@mail.ru ,(None) ,Russia , ,Not Presenting[5]

1 - Dept. of Geophysics, Eotvos University 2 - British Antarctic Survey 3 - Eotvos University 4 - Belgian Institute of Space Aeronomy 5 - Institute of Cosmophysical Research and Radio Wave Propagation 6 - Eotvos University 7 - Eötvös University 8 - University of Otago 9 - Institute of Cosmophysical Research and Radio Wave Propagation

AWDANet is a global, ground-based detection network for the automatic detection and analysis of VLF whistler waves. In this study, we analyzed data from 16 stations located at various geographic locations, identifying the most likely originating lightning stroke of each whistler by using data from the WWLLN global lightning database. This allowed us to create maps of the generating lightning strokes for each station, showing the whistlers' source regions. This revealed the geographic extent of the source regions, previously not studied in detail. Subsequently, we compared these maps of whistler-causing lightning strokes to maps of total lightning activity in the same region and over the same time period, to obtain the geographic distribution of lightning-to-whistler transmission rates. We also looked at the whistler transmission rates as a function of distance from the conjugate point, time of day (day/night), and type of surface over which the lightning stroke in the database occurred (land/ocean). We then analysed and compared theses results obtained for the transmission rates to each other for the 16 stations, which are located at different hemispheres, continents and geographic latitudes. The procedure outlined above, building on and extending previous methods, showed the whistler source

regions to be roughly where they are expected based on the theory of whistler propagation. It is also clearly observable that the whistler transmission rates decrease as a function of increasing distance from the given station's conjugate point. Our results also eliminate previous anomalous results obtained for the sources of whistlers, especially for whistlers at Dunedin, New Zealand.

Analysis and inversion of ducted VLF impulses recorded by satellites

Abstract ID : 181

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. David Koronczay ,david.koronczay@ttk.elte.hu ,(PhD student) ,Hungary ,Budapest ,Presenting[1]

Dr. Lilla Juhasz ,lilla@sas.elte.hu ,(None) ,Hungary , ,Not Presenting[2]

Prof. János Lichtenberger ,lityi@sas.elte.hu ,(Professor) ,Hungary ,Budapest ,Not Presenting[3]

1 - Dept. of Geophysics, Eotvos University 2 - Eotvos University 3 - Eötvös University

VLF recordings by the EMFISIS instrument onboard the Van Allen Probes satellites occasionally show signals from ground-based VLF transmitters. After looking at the typical locations of the two spacecraft when such signals are detected, we carried out a measurement campaign targeting specifically such transmitters/signals. Here we present the results of this campaign. Specifically, we look at quantities that can be deduced from the 6-channel measurements, such as Poynting vectors, that can be indicators of the ducted or oblique propagation of these signals. In cases when the signals undergo ducted propagation, they can be used to calculate plasmaspheric electron densities by an inversion method. The concept is similar to how whistler inversion can be used to obtain plasmaspheric electron densities. When compared to electron densities obtained from independent methods (e.g. local upper hybrid resonances) as a reference, this procedure can validate the model of electron density distribution along the magnetic field line used in the inversion. In addition, it can serve as an alternative way of estimating electron densities in the plasmasphere, especially where other methods such as upper hybrid resonances are out of the range of the instruments.

Improved whistler inversion method for monitoring the electron density in the plasmasphere

Abstract ID : 192

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. János Lichtenberger ,lityi@sas.elte.hu ,(Professor) ,Hungary ,Budapest ,Not Presenting[1]

Dr. Csaba Ferencz ,csaba@sas.elte.hu ,(None) ,Hungary , ,Not Presenting[2]

Dr. Nina Cherneva ,nina@ikir.ru ,(None) ,Russia , ,Not Presenting[3]

Mr. David Koronczay ,david.koronczay@ttk.elte.hu ,(PhD student) ,Hungary ,Budapest ,Not Presenting[4]

Prof. Craig Rodger ,craig.rodger@otago.ac.nz ,(Head of Department) ,New Zealand ,None ,Not Presenting[5]

Dr. Peter Steinbach ,steinb@sas.elte.hu ,(None) ,Hungary , ,Not Presenting[2]

Dr. Mark Clilverd ,macl@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]

Dr. Dmitry Sannikov ,vilgusi@mail.ru ,(None) ,Russia , ,Not Presenting[3]

1 - Eötvös University 2 - Eotvos University 3 - Institute of Cosmophysical Research and Radio Wave Propagation 4 - Dept. of Geophysics, Eotvos University 5 - University of Otago 6 - Eotvos University 7 - British Antarctic Survey 8 - Institute of Cosmophysical Research and Radio Wave Propagation

Improved whistler inversion method for monitoring the electron density in the plasmasphere

János Lichtenberger[1,2]; Dávid Koronczay [1,2]; Csaba Ferencz [1]; Péter Steinbach [3]; Mark Clilverd [4]; Craig Rodger [5]; Dmitry Sannikov [6]; and Nina Cherneva [6]

[1] Department of Geophysics and Space Sciences, Eötvös University, Budapest, Hungary,
[2] Geodetic and Geophysical Institute, RCAES, Sopron, Hungary,
[3] MTA-ELTE Research Group for Geology, Geophysics and Space Sci., Budapest, Hungary,
[4] British Antarctic Survey, Cambridge, United Kingdom,
[5] Department of Physics, University of Otago, Dunedin, New Zealand,
[6] Institute of Cosmophysical Research and Radio Wave Propagation, Paratunka, Russia
In the PLASMON FP7-Space project (http://plasmon.elte.hu, Lichtenberger et al., 2013, SWSC], a new whistler inversion algorithm [Lichtenberger, 2009. JGR] was implemented using Virtual Trace

Transformation [Lichtenberger et al., 2010, JGR]. The accuracy of the parameters inverted by the algorithm - that is basically it works well - depends on their initial values, how close or how far are they from the real values. These initial values are more or less based on - sometimes ad hoc - estimations. Instead of the estimation, a new procedure has been developed based on papers of Dowden and Allcock [1971, JATP] and Park [1972, Stanford Tech. Rep.], as well as on model calculation.
The Virtual Trace Transformation used in the Automatic Whistler Analyzer algorithm is applied to a cleaned reassigned spectrogram and its applicability highly depends on the effectivity of the spectrogram cleaning step. A new approach has been developed for ground based whistlers based on 'de-chirping' [Jacobson et al., 2011, AnnGeo] or 'reduction-to-sferic' method that compensates the signal phase from the time of the recording back to the sferic. The phase calculated for a frequency is based on the whistler inversion algorithm mentioned above. The result of the inversion using phase reduction is more reliable than the one obtained by VTT.
This paper we present the two enhanced algorithm as well as some preliminary results based on the new methods.

Where does the plasma go during a storm?

Abstract ID : 276

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jonathan Krall ,jonathan.krall@nrl.navy.mil ,(None) ,United States ,Washington ,Not Presenting[1]

1 - NRL

The erosion of the plasmasphere during a storm is analyzed using the Naval Research Laboratory (NRL) Sami3 is Also a Model of the Ionosphere (SAMI3) ionosphere/plasmasphere code, coupled to the Rice Convection Model (RCM) of the inner magnetosphere and ring current. We reproduce the commonly-observed post-storm plasmasphere profile, with strong erosion outside of a sharp, post-storm plasmapause and weak erosion inside the plasmapause. We find that the ring current must be included in the simulation to obtain a sharp plasmapause. In the case of a weak storm, erosion inside the post-storm plasmapause might not occur. In all cases, plasma flows are dominated by E x B drifts. For strong storms, we find that erosion, both inside and outside of the post-storm plasmapause, is caused by outward E x B drifts.

Deriving electron density from electric field measurements on the Van Allen Probes spacecraft and building a global dynamic model of plasma density using neural networks

Abstract ID : 373

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Irina Zhelavskaya ,irina.zhelavskaya@gmail.com ,(PhD student) ,Germany ,Potsdam ,Presenting[1]

Dr. Maria Spasojevic ,mariaspasojevic@stanford.edu ,(None) ,United States , ,Not Presenting[2]

Prof. Yuri Shprits ,yuri.shprits@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

Dr. William Kurth ,william-kurth@uiowa.edu ,(None) ,United States , ,Not Presenting[4]

1 - GFZ Potsdam 2 - Stanford University 3 - GFZ Potsdam 4 - University of Iowa

We developed the Neural-network-based Upper hybrid Resonance Determination (NURD) algorithm for automatic inference of the electron number density from plasma wave measurements using 2.5 years of data collected with the Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) instrumentation suite of the Van Allen Probes mission. A feedforward neural network is designed to determine the upper hybrid resonance frequency, f_{uhr}, from electric field measurements, which is then used to calculate the electron number density. In previous missions, the upper hybrid resonance bands were manually identified, and there have been few attempts to do robust, routine automated detections. We describe the design and implementation of the algorithm and perform analysis of the resulting electron number density distribution obtained by applying NURD to more than 4 years of data collected with the EMFISIS instrumentation suite. Densities obtained by NURD are compared to those obtained by another recently developed automated technique and also to an existing empirical plasmasphere and trough density model.
The obtained density dataset has been used then to develop a new global dynamic model of plasma density based just on solar wind data and geomagnetic parameters by employing neural network-based empirical modeling. We validate and test the model by measuring its performance on independent datasets withheld from the training set and by comparing the model predicted global evolution with global images of He^+ distribution in the Earth's plasmasphere from the IMAGE extreme ultraviolet (EUV) instrument. We demonstrate the results of our simulations and discuss the selected inputs to the model and their physical implication.

Assimilation of Ground-Based Observations Into a Plasmasphere Model

Abstract ID : 1497

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Anders Jorgensen ,ajorg.nmt@gmail.com ,(Associate Professor) ,United States ,Socorro, NM, USA ,Not Presenting[1]

Prof. János Lichtenberger ,lityi@sas.elte.hu ,(Professor) ,Hungary ,Budapest ,Presenting[2]

Dr. Balazs Heilig ,heilig.balazs@mfgi.hu ,(None) ,Hungary , ,Not Presenting[3]

Dr. Massimo Vellante ,massimo.vellante@aquila.infn.it ,(None) ,Italy , ,Not Presenting[4]

Dr. Peter Chi ,pchi@igpp.ucla.edu ,(None) ,United States , ,Not Presenting[5]

1 - New Mexico Tech 2 - Eötvös University 3 - Geological and Geophysical Institute of Hungary 4 - University of L'Aquila 5 - University of California Los Angeles

The Earth's plasmasphere is a region of dense plasma, originating in the ionosphere, extending nearly to geostationary orbit. The precise extent of the plasmasphere is dynamic, particularly during geomagnetic active conditions. Knowing the exact distribution of plasma in the plasmasphere is important as an input to coupled magnetospheric models. In particular, density gradients inside the plasmasphere and at the plasmapause, are important in controlling waves which are responsible for the growth and decay of the radiation belts. At the most basic level the plasmasphere can be described in terms of plasma exchange with the ionosphere and convection due to an imposed electric field. At that level plasmasphere modeling is relatively simple. But the drivers are not know sufficiently accurately, particularly the electric field, to model the plasmasphere boundaries to an accuracy which constrain inputs to radiation belt model. A data assimilation approach can help improve this. Data assimilation wraps a feedback loop around the plasmasphere model in which free model parameters are adjusted to maximize the agreement between the model and observations. We use the Ensemble Kalman filter as a data assimilation approach in which a statistical ensemble of models tracks the available observations. We also use a recently improved version of the Dynamic Global Core Plasma Model (DGCPM) for better agreement with observations. We will discuss the observations, the model and the improvements to it, and show some data assimilation results.

A17 - Auroral Processes (DIV II – DIV III)

Kinetic Alfvén Waves and the Acceleration of Auroral Particles

Abstract ID : 213

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Robert Lysak ,lysak001@umn.edu ,(Professor of Physics) ,United States ,Minneapolis, MN ,Not Presenting[1]

Dr. Yan Song ,yan@umn.edu ,(Scientist) ,United States ,Minneapolis, MN ,Not Presenting[1]

1 - University of Minnesota 2 - University of Minnesota

Kinetic Alfvén waves propagate along auroral field lines in the Earth's magnetosphere and play a major role in auroral particle acceleration. Such waves carry energy from the outer magnetosphere to lower altitudes where they accelerate the precipitating electrons and ions that cause the aurora. There are two distinct modes of electron acceleration in the auroral zone: a nearly monoenergetic acceleration of electrons through a static potential drop, and the time-dependent acceleration by kinetic Alfvén waves, known as the Alfvénic aurora. The Alfvénic aurora can be basically understood as resulting from the parallel electric fields that develop in the kinetic Alfvén wave. A linearized two-fluid model has been developed that can describe many important features of auroral dynamics. This model describes the transition from the moderate beta regime, where electron pressure and Landau damping are associated with the development of parallel electric fields to the low-beta regime where electron inertia is more important. Test particle simulations based on the fields determined by this model can determine the expected electron distributions from the kinetic Alfvén waves. These results will be compared with observations of the precipitating electrons that cause the aurora.

Statistical Comparisons of Auroral Electron Acceleration Mechanisms and Meso-Scale Field-Aligned Currents from FAST Observations

Abstract ID : 538

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. John Dombeck ,dombe005@umn.edu ,(Researcher) ,United States ,Minneapolis ,Not Presenting[1]

Dr. Cynthia Cattell ,cattell@umn.edu ,(None) ,United States , ,Not Presenting[1]

Mr. Amin Sakher ,sakhe003@umn.edu ,(None) ,United States , ,Not Presenting[1]

Mr. Nitin Prasad ,prasa043@umn.edu ,(None) ,United States , ,Not Presenting[1]

Dr. William Peria ,peria@fields.space.umn.edu ,(None) ,United States , ,Not Presenting[5]

Ms. Elizabeth Hanson ,lily.hanson@berkeley.edu ,(None) ,United States , ,Not Presenting[6]

Mr. Jim McFadden ,mcfadden@ssl.berkeley.edu ,(None) ,United States , ,Not Presenting[7]

Dr. Robert Strangeway ,strangeway@igpp.ucla.edu ,(None) ,United States , ,Not Presenting[8]

1 - University of Minnesota 2 - University of Minnesota 3 - University of Minnesota 4 - University of Minnesota 5 - Fred Hutchinson Cancer Research Center 6 - Unversity of California at Berkeley 7 - UC Berkeley 8 - University of California at Los Angeles

Field-aligned currents (FACs) provide a fundamental driver and means of Magnetosphere-Ionosphere (M-I) coupling. These currents need to be supported by local physics along the entire field line generally with quasi-static potential structures, but also Alfvén waves with related Alfvénic electron acceleration support the time-evolution of the structures and currents. These processes can result in ion outflow, changes in ionospheric conductivity, and affect the particle distributions on the field line, affecting the M-I coupling processes including auroral precipitation. Using data from the ~13 year mission of the FAST satellite, we identify when the various auroral precipitation mechanisms (quasi-static, Alfvénic and/or substantial particle wave scattering) are occurring separately or in combination, and compare how they are affected by meso-scale (~25km) FACs on the same field lines measured concurrently by the same spacecraft.

Auroral Beads at Substorm Onset and their Acceleration Mechanism

Abstract ID : 634

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Nadine Kalmoni ,nadine.kalmoni@ucl.ac.uk ,(Research Associate) ,United Kingdom ,Dorking ,Presenting[1]

Dr. I. Jonathan Rae ,jonathan.rae@ucl.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Kyle R. Murphy ,kyle.r.murphy@nasa.gov ,(None) ,United States , ,Not Presenting[3]

Dr. Colin Forsyth ,colin.forsyth@ucl.ac.uk ,(NERC Independent Research Fellow) ,United Kingdom ,Dorking ,Not Presenting[4]

Dr. Clare Watt ,c.e.watt@reading.ac.uk ,(Lecturer) ,United Kingdom ,Reading ,Not Presenting[5]

Dr. Marilia Samara ,marilia.samara@nasa.gov ,(None) , , ,Not Presenting[6]

Dr. Robert G. Michell ,robert.g.michell@nasa.gov ,(None) ,United States , ,Not Presenting[7]

Dr. Guy Grubbs ,guy.grubbs@nasa.gov ,(None) ,United States , ,Not Presenting[7]

Dr. Chris J. Owen ,c.owen@ucl.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Andrew Fazakerly ,a.fazakerley@ucl.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University College London 2 - Mullard Space Science Laboratory, UCL 3 - NASA Goddard Space Flight Centre 4 - UCL 5 - University of Reading 6 - NASA Goddard Space Flight Center 7 - NASA GSFC 8 - NASA GSFC 9 - University College London 10 - University College London

An auroral substorm is the manifestation of a rapid, global reconfiguration of the magnetotail that is marked by a sudden brightening and poleward expansion of the most equatorward auroral arc. The onset of an auroral substorm is generally thought to occur on a relatively quiet and homogeneous auroral arc. However, signatures of small-scale azimuthal structures, or "auroral beads" are also sometimes observed along the onset arc in the minutes leading to auroral breakup which, at first glance, presents a dichotomy in substorm research. We show that it is the amplitudes of these "auroral beads" that are the reason behind this dichotomy through statistical analysis, and that clear azimuthal structuring is observed in the overwhelming majority of substorm onset arcs, pointing to a consistent generation mechanism of substorm onset aurora.
Furthermore, we present analysis of state-of-the-art multispectral auroral data to investigate the processes driving auroral beads. We show that auroral beads form along the substorm arc simultaneous to an increase in the characteristic energy of precipitating electrons. We demonstrate

that auroral beads can be resolved in multiple auroral wavelengths in the minutes leading up to auroral breakup, which is consistent with broadband auroral acceleration. We discuss the generation and evolution in terms of a quiescent onset arc initially driven by a quasi-static potential drop, which is subsequently driven unstable by waves.

The Isinglass auroral sounding rocket campaign: combining remote sensing, in situ observations, and modelling

Abstract ID : 763

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Kristina Lynch ,kal@dartmouth.edu ,(Professor, Physics) ,United States ,Hanover ,Not Presenting[1]

1 - Dartmouth College

The NASA auroral sounding rocket mission Isinglass was launched from Poker Flat Alaska in winter 2017. This mission consists of two separate multi-payload sounding rockets, over an array of groundbased observations, including radars and filtered cameras. The science goal is to collect two case studies, in two different auroral events, of the gradient scale sizes of auroral disturbances in the ionosphere. Data from the in situ payloads and the groundbased observations will be assimilated into an ionospheric model, and the results will be studied to learn about the scale sizes of ionospheric structures which have significance for magnetosphere-ionosphere auroral coupling.

The in situ instrumentation includes thermal ion sensors (at 5 points on the second flight), thermal electron sensors (at 2 points), DC magnetic fields (2 point), DC electric fields (one point, plus the 4 thermal ion RPA observations of drift on the second flight), and an auroral precipitation sensor (one point). The groundbased array includes filtered auroral imagers, the PFISR and SuperDarn radars, a coherent scatter radar, and a Fabry-Perot interferometer array. The ionospheric model to be used is a 3d electrostatic model including the effects of ionospheric chemistry.

Modern assimilative tools combined with multipoint but low-resource observations allow a new view of the auroral ionosphere, that should allow us to learn more about the auroral zone as a coupled system. Conjugate case studies such as the Isinglass rocket flights allow for a test of the models' intepretation by comparing to in situ data. We aim to develop and improve ionospheric models to the point where they can be used to interpret remote sensing data with confidence without the checkpoint of in situ comparison.

Shock-Aurora Forms along the Dayside Auroral Oval

Abstract ID : 990

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Xiaoyan Zhou ,xyzhou@igpp.ucla.edu ,(Researcher) ,United States ,Pasadena ,Presenting[1]

Mr ttt ttt ,mail@here.com ,(None) ,Afghanistan , ,Not Presenting[2]

1 - None 2 - 1tt

Generated by interplanetary shocks or solar wind pressure pulses, shock aurora has transient, global, and dynamic significances, and provides a direct manifestation of the solar wind - magnetosphere - ionosphere interaction. UV auroral imaging from space first revealed the global dynamics of the aurora, including the local time of the auroral onset, the auroral expansions in latitudinal and longitudinal directions, and the auroral propagation speed in the ionosphere. The ground-based observations from ASI, MSP, magnetometers and Radars rendered the auroral forms and their variations, In addition to the mechanism of the adiabatic compression, we have learned that magnetic reconnections and Alfvén waves play an important role around local noon, but the magnetic and velocity shears play the dominant role around in dawnside sector along the poleward boundary of the auroral oval. This paper provides a comprehensive description and analysis of the shock-aurora streaks along the dawnside high-latitude oval to where the LLBL maps. The calculated current density is found to be ~8.8×10^{-6} A/m^2, which is distinctly higher than the current density derived for Alfvénic arcs in nightside [Haerendel and Frey, 2014], suggesting that the electrons carrying the current inside the sheared flux tubes are post-accelerated by a field-parallel potential drop. The streaks move antisunward at ~3 km s^{-1} in the ionosphere, which corresponds to ~133 km/s on the dawnside magnetopause and is consistent with in situ observations. A surprise is the spatial scale derived for the Kelvin-Helmholtz wavelengths from upward mapping of the observed auroral streaks. They turn out to be about one order of magnitude smaller than the scale of vortices encountered by the Cluster mission. The streaks are therefore not images of vortex formation in the magnetosphere, but of nonlinear waves generated inside the magnetopause layer. The 400 km width of the shear layer, derived from the wavelength, times the speed of the magnetosheath flow imply an anomalous viscosity of ~10^{14} cm^2/s generally consistent with the theories of Sonnerup [1980] and Miura [1992] but with a somewhat higher magnitude.

Optical observations of inter-hemispheric electron reflections within pulsating aurora

Abstract ID : 1042

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Marilia Samara ,marilia.samara@nasa.gov ,(None) , , ,Presenting[1]

Dr. Robert Michell ,rmichell@umd.edu ,(None) ,United States , ,Not Presenting[2]

Dr. George Khazanov ,george.v.khazanov@nasa.gov ,(None) ,United States , ,Not Presenting[3]

1 - NASA Goddard Space Flight Center 2 - University of Maryland 3 - None

We present evidence that pulsating aurora is caused by electrons bouncing back and forth between the two hemispheres. This means that these electrons are responsible for some of the total light in the aurora, a possibility that has largely been ignored in theoretical models.
Specifically, a case study of a pulsating auroral event imaged optically at high time resolution presents direct observational evidence in agreement with the inter-hemispheric electron bouncing predicted by the SuperThermal Electron Trans-port (STET) model. Immediately following each of the 'pulsation-on' times are equally spaced, and subsequently fainter pulsations, which can be explained by the primary precipitating electrons reflecting upwards from the ionosphere, traveling to the opposite hemisphere, and reflecting upwards again. The high time-resolution of these data, combined with the short duration of the 'pulsation-on' time (~ 1 s) and the relatively long spacing between pulsations (~ 6 to 9 s) made it possible to observe the faint optical pulses caused by the reflected electrons coming from the opposite hemisphere. These results are significant and have broad implications because they highlight that the formation of the auroral electron distributions within regions of diffuse and pulsating aurora contain contributions from reflected primary and secondary electrons. These processes can ultimately lead to larger fluxes than expected when considering only the primary injection of magnetospheric electrons. These reflected primary and secondary electrons constitute the second step in the formation of the precipitating electron distribution. While they have largely been missing from the current theoretical studies of particle precipitation these ground based observations point to the existence of a reflected electron population, thus increasing our confidence in the model predictions, which can have immediate implications for studies of magnetosphere-ionosphere coupling.

Electron signatures associated with kinetic ballooning instability

Abstract ID : 1051

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Eun-Hwa Kim ,ehkim@pppl.gov ,(None) ,United States , ,Not Presenting[1]

Dr. Peter Damiano ,pdamiano@pppl.gov ,(None) ,United States , ,Not Presenting[1]

Dr. Jay Johnson ,jrj@andrews.edu ,(None) ,United States ,Michigan ,Presenting[3]

Dr. Peter Porazik ,pporazik@pppl.gov ,(None) ,United States , ,Not Presenting[1]

1 - Princeton Plasma Physics Laboratory 2 - Princeton Plasma Physics Laboratory 3 - Andrews University 4 - Princeton Plasma Physics Laboratory

Small scale azimuthal structures in optical signatures associated with low frequency wave activity have been observed around the time of substorm onset and the characteristic frequency and kinetic scale structures have been attributed to the onset of a kinetic ballooning instability. In this paper, we present initial results of introducing a ballooning drive term into a hybrid gyrofluid-kinetic electron simulation model with the ultimate aim of understanding the ionospheric electron signatures associated with the instability.

Energeric particle precipitation associated to pulsating aurorae observed by ground-based radio methods (EISCAT radar and KAIRA riometer)

Abstract ID : 1259

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Antti Kero ,antti.kero@sgo.fi ,(Researcher/Project manager) ,Finland ,Sodankylä ,Not Presenting[1]

Dr. Pekka Verronen ,pekka.verronen@fmi.fi ,(None) ,Finland , ,Not Presenting[2]

Dr. Esa Turunen ,esa.turunen@sgo.fi ,(Researcher/Project manager) ,Finland ,Sodankylä ,Not Presenting[1]

Mr. Maxime Grandin ,Maxime.Grandin@oulu.fi ,(None) ,Finland , ,Not Presenting[1]

1 - SGO/University of Oulu 2 - Finnish Met. Institute 3 - SGO/University of Oulu 4 - SGO/University of Oulu

Ionospheric height--dependent density of free electrons, and its time-dependent response to variable ionising radiation from space, yields information on both the ionisation source processes (solar electromagnetic radiation, energetic particle precipitation, cosmic rays) and their consequences on the atmosphere (changes in chemistry, energetics and dynamics). Hence, ground-based radio methods, such as incoherent scatter radars (e.g., EISCAT) and riometers (e.g., KAIRA), can be used for inverting the characteristics of various ionisation events.

Here we introduce a novel inversion technique for determining the precipitation flux density spectrum and ionisation rate profile. In addition, potential chemical consequences of the energetic particle precipitation are assessed. In our approach, a detailed ion chemistry model (SIC) is used as a time-dependent forward model in the MCMC based inversion. We apply this methodology to the pulsating aurora events revealing a remarkable high-energy tail (E>100 keV) of the precipitation spectrum.

A18 - ULF waves in near-Earth space (DIV III)

Propagation of ULF Waves From the Upstream Region to the Midnight Sector of the Inner Magnetosphere

Abstract ID : 138

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Kazue Takahashi ,kazue.takahashi@jhuapl.edu ,(Professional Staff) ,United States ,Laurel ,Presenting[1]

Dr. David Malaspina ,David.Malaspina@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Michael Hartinger ,mdhartin@vt.edu ,(Research Assistant Professor) ,United States ,Hampton ,Not Presenting[3]

Dr. Charles W. Smith ,Charles.Smith@unh.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Dennis Fruhauff ,d.fruehauff@tu-bs.de ,(None) ,Germany , ,Not Presenting[5]

Dr. Dmitry G. G. Baishev ,baishev@ikfia.sbras.ru ,(None) ,Russia , ,Not Presenting[6]

Dr. Alexey V. Moiseev ,moiseev@ikfia.sbras.ru ,(None) ,Russia , ,Not Presenting[6]

Dr. Akimasa Yoshikawa ,yoshi@geo.kyushu-u.ac.jp ,(None) ,Japan ,None ,Not Presenting[8]

Mr. Kiyokazu Koga ,koga.kiyokazu@jaxa.jp ,(None) ,Japan ,None ,Not Presenting[9]

1 - The Johns Hopkins University Applied Physics Laboratory 2 - Laboratory for Atmospheric and Space Physics, University of Colorado Boulder 3 - Virginia Polytechnic Institute and State University 4 - Department of Physics and Institute for the Study of Earth, Oceans and Space, University of New Hampshire 5 - Institute for Geophysics and Extraterrestrial Physics, Technical University of Braunschweig 6 - Yu. G. Shafer Institute of Cosmophysical Research and Aeronomy (IKFIA) Siberian Branch, Russian Academy of Sciences 7 - Yu. G. Shafer Institute of Cosmophysical Research and Aeronomy (IKFIA) Siberian Branch, Russian Academy of Sciences 8 - Department of Earth and Planetary Science, Kyushu University, Japan 9 - Japan Aerospace Exploration Agency

Ultralow frequency (ULF) waves generated in the ion foreshock are a well-known source of Pc3-Pc4 waves (7-100 mHz) observed in the dayside magnetosphere.We use data acquired on 10 April 2013

by multiple spacecraft to demonstrate that ULF waves of upstream origin can propagate to the midnight sector of the inner magnetosphere. At 1130-1730 UT on the selected day, the two Van Allen Probes spacecraft and the geostationary ETS-VIII satellite detected compressional 20 to 40 mHz magnetic field oscillations between L~4 and L~7 in the midnight sector, along with other spacecraft located closer to noon. Upstream origin of the oscillations is concluded from the wave frequency that matches a theoretical model, globally coherent amplitude modulation, and duskward propagation that is consistent with expected entry of the upstream wave energy through the dawnside flank under the observed interplanetary magnetic field. The oscillations are attributed to magnetohydrodynamic fast-mode waves based on their propagation velocity of ~300 km/s and the relationship between the electric and magnetic field perturbations. The magnitude of the azimuthal wave number in the midnight sector is estimated to be ~30. There is no evidence that the oscillations propagated to the ground in the midnight sector.

Modeling of cavity modes and field line resonances in the inner magnetosphere

Abstract ID : 212

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Robert Lysak ,lysak001@umn.edu ,(Professor of Physics) ,United States ,Minneapolis, MN ,Presenting[1]

Prof. Colin Waters ,colin.waters@newcastle.edu.au ,(None) ,Australia ,None ,Not Presenting[2]

Dr. Yan Song ,yan@umn.edu ,(Scientist) ,United States ,Minneapolis, MN ,Not Presenting[1]

Dr. Murray Sciffer ,murray.sciffer@newcastle.edu.au ,(None) ,Australia , ,Not Presenting[2]

Dr. Kazue Takahashi ,kazue.takahashi@jhuapl.edu ,(Professional Staff) ,United States ,Laurel ,Not Presenting[5]

1 - University of Minnesota 2 - University of Newcastle 3 - University of Minnesota 4 - University of Newcastle 5 - The Johns Hopkins University Applied Physics Laboratory

Ultra-low-frequency (ULF) waves are a major means to transport energy through the magnetosphere and play an important role in energization and transport of radiation belt particles. In the inhomogeneous inner magnetosphere, ULF waves frequently are affected by the density structure of the magnetosphere as well as by the ionospheric boundary conditions. We have developed a three-dimensional numerical code in dipole geometry to describe the propagation of ULF waves in the inner magnetosphere. In particular, we model the response of the inner magnetosphere to impulsive compressions that occur on the dayside due to shocks impinging on the magnetosphere and on the nightside due to dipolarization fronts during substorms. These compressions can lead to the development of plasmaspheric cavity modes in the inner magnetosphere that have periods of 1-2 minutes. Furthermore, compressional waves can mode convert to shear Alfvén mode field line resonances that stand on field lines when the compressions contain wave power at the frequency corresponding to harmonics of the fundamental wave period. A special case of field line resonances occurs near the terminator during solstice conditions when one end of the field line is sunlit while the other end is in darkness. Under these circumstances, quarter-wave modes can result in which one end of the field line is a node of the electric field while the other end is an antinode. The model results compare favorably with observations from the Van Allen Probe satellites as well as fields measured by ground magnetometers.

In search of ground image of the magnetopause surface mode: Multi-instrument observations at Svalbard

Abstract ID : 227

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Olga Kozyreva ,kozyreva@ifz.ru ,(Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences) ,Russia ,Moscow ,Not Presenting[1]

Prof. Vyascheslav Pilipenko ,pilipenko_VA@mail.ru ,(None) ,Russia , ,Not Presenting[2]

Dr. Vladimir Belakhovsky ,belakhovsky@mail.ru ,(None) ,Russia , ,Not Presenting[3]

Dr. Dag Lorentzen ,dagl@unis.no ,(None) ,Norway , ,Not Presenting[4]

Dr. Lisa Baddeley ,Lisa.Baddeley@unis.no ,(None) ,Norway , ,Not Presenting[4]

1 - Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences 2 - Institute of Physics of the Earth, Moscow 3 - Polar Geophysical Institute, Apatity 4 - Kjell Henriksen Observatory, Svalbard 5 - Kjell Henriksen Observatory, Svalbard

Long-period pulsations in the nominal Pc5-6 band (periods about 3-20 min) have been known to be a persistent feature of the ULF activity at dayside high-latitudes. A mixture of broadband Irregular Pulsations at Cusp Latitudes (IPCL) and narrowband P?5 waves is observed often, though there is no well-established criterion to separate these phenomena. The mechanism and origin of these pulsations have not been firmly established yet. Magnetopause surface eigenmodes were suggested as a potential source of high-latitude ULF waves with frequencies less than 2 mHz. A ground response to these modes is expected to be beneath the ionospheric projection of the open-closed field line boundary (OCB). To unambiguously resolve the uncertainties regarding the mechanism of the dayside high-latitude ULF activity, a multi-instrument study using data from Svalbard has been undertaken. We examine the local latitudinal structure of high-latitude Pc5-6 pulsations recorded by magnetometers covering near-cusp latitudes. This structure was compared with the instant location of the equatorward boundary of the cusp aurora, assumed to be a proxy of the OCB. The OCB latitude has been identified by an automatic algorithm, using data from the meridian scanning photometer at Longyearbyen. The comparison has shown that a latitudinal maximum of the broadband pulsations maximizes very close to the instant OCB proxy. However, in some events the local latitudinal distribution of band-integrated ULF power is shifted ~1-2o southward from the equatorward cusp boundary. Therefore, it still has to be comprehended why the ULF response to the solar wind driving may be displaced from the magnetosheath/magnetosphere interface. Therefore, the association of dayside broadband (IPCL) pulsations with ground image of the magnetopause surface modes is still an open question.

Characterizing MHD fast mode wave properties and distributions outside the plasmasphere

Abstract ID : 239

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Michael Hartinger ,mdhartin@vt.edu ,(Research Assistant Professor) ,United States ,Hampton ,Not Presenting[1]

Dr. Kazue Takahashi ,kazue.takahashi@jhuapl.edu ,(Professional Staff) ,United States ,Laurel ,Not Presenting[2]

Dr. John Bonnell ,jbonnell@ssl.berkeley.edu ,(None) ,United States , ,Not Presenting[3]

1 - Virginia Polytechnic Institute and State University 2 - The Johns Hopkins University Applied Physics Laboratory 3 - UC Berkeley / Space Sciences Laboratory

Statistical analysis of magnetohydrodynamic (MHD) fast mode wave (FMW) amplitudes, frequencies, and spatial distributions is needed to better understand the role of FMW in wave-particle interactions and field line resonances in the inner magnetosphere. However, observations of FMW outside the plasmasphere are complicated by the presence of other Ultra Low Frequency (ULF) wave modes that have larger amplitudes and generate similar magnetic signatures. We use Time History of Events and Macroscale Interactions during Substorms (THEMIS) satellite measurements of the thermal pressure, magnetic field, and electric field near the magnetic equator to identify FMW events and discriminate them from other ULF wave modes. We present preliminary results for the spatial distribution and typical amplitudes of FMW events with different frequencies.

MESSENGER observations of ultra-low frequency plasma waves during substorm expansion phase at Mercury

Abstract ID : 245

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited presentation

Dr. Wei-Jie Sun ,weijiesun@pku.edu.cn ,(Research Assisstant) ,China ,Beijing ,Not Presenting[1]

Dr. Qiugang Zong ,qgzong@pku.edu.cn ,(None) ,China , ,Not Presenting[2]

Dr. Jim Raines ,jraines@umich.edu ,(None) ,United States , ,Not Presenting[3]

Prof. Weixing Wan ,wanw@mail.iggcas.ac.cn ,(None) ,China , ,Not Presenting[1]

Prof. Yong Wei ,weiy@mail.iggcas.ac.cn ,(None) ,China , ,Not Presenting[1]

Prof. Suiyan Fu ,suiyanfu@pku.edu.cn ,(None) ,China , ,Not Presenting[6]

Mr. Gangkai Poh ,gangkai@umich.edu ,(None) ,United States , ,Not Presenting[3]

Prof. James Slavin ,jaslavin@umich.edu ,(None) ,United States , ,Not Presenting[3]

1 - Key Laboratory of Earth and Planetary Physics, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 2 - Peking University 3 - Department of Climate and Space Sciences and Engineering, University of Michigan, Ann Arbor, MI 4 - Key Laboratory of Earth and Planetary Physics, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 5 - Key Laboratory of Earth and Planetary Physics, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 6 - School of Earth and Space Sciences, Peking University 7 - Department of Climate and Space Sciences and Engineering, University of Michigan, Ann Arbor, MI 8 - Department of Climate and Space Sciences and Engineering, University of Michigan, Ann Arbor, MI

MESSENGER magnetic field and plasma measurements taken in Mercury's magnetotail during substorms have been examined. We have found a number of tail passes containing clear Earth-like growth phase and expansion phase signatures. The thinning of the plasma sheet and the increase of lobe magnetic field intensity during the growth phase and plasma sheet thickening during the expansion phase were observed similar to what is observed at Earth. However, the time scale of Mercury's substorm is only several minutes (~ 2 - 3 mins) comparing with the several hours (~ 2 - 3 hrs) at Earth [*Slavin et al.*, 2010; *Sun et al.,* 2015a]. Detailed analysis of magnetic field fluctuations during the substorm expansion phase have revealed ultra-low frequency plasma waves, e.g. Pi2-like pulsations. The *B*y fluctuations accompanying the dipolarization of the near-Mercury tail magnetic field are found to be consistent with pulses of field-aligned currents near the high latitude edge of the plasma sheet. Further study shows that they are near-circularly polarized electromagnetic waves,

most likely Alfvén waves. Soon afterwards the plasma sheet thickened and MESSENGER detected a series of compressional waves. These Alfvénic and compressional waves have similar durations (10 - 20 s), which were suggested that they may arise from the same source. Drawing on Pi2 pulsation models developed for Earth, we suggest that the Alfvénic and compressional waves reported here at Mercury may be generated by the quasi-periodic sunward flow bursts in Mercury's plasma sheet [*Sun et al.,* 2015b].

Slavin, J. A., et al. (2010). MESSENGER observations of extreme loading and unloading of Mercury's magnetic tail. *Science*, 329, 665-668. doi:10.1126/science.1188067.

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Sun, W.-J., J. A. Slavin, S. Y. Fu, et al. (2015b), MESSENGER observations of Alfvénic and compressional waves during Mercury's substorms. *Geophys. Res. Lett.*, 42, 6189-6198. doi: 10.1002/2015GL065452.

SuperDARN observations of substorm-driven ULF waves

Abstract ID : 360

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited presentation

Dr. Matt James ,mkj13@le.ac.uk ,(PDRA) ,United Kingdom ,Leicester ,Not Presenting[1]

Dr. Suzanne Imber ,si88@le.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Dmitri Klimushkin ,klimush@iszf.irk.ru ,(None) ,Russia , ,Not Presenting[3]

Prof. Tim Yeoman ,yxo@le.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Pavel Mager ,p.mager@iszf.irk.ru ,(None) ,Russia , ,Not Presenting[3]

Prof. Emma Bunce ,ejb10@le.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Leicester 2 - University of Leicester 3 - Institute of Solar-Terrestrial Physics 4 - University of Leicester 5 - Institute of Solar-Terrestrial Physics 6 - University of Leicester

Previous studies have linked the injections of energetic charged particle populations during substorms to the observations of poloidally polarized ULF waves by the Super Dual Auroral Radar Network (SuperDARN). The phase characteristics of such waves have been found to be dependent upon their longitudinal separation from the location of the substorm injection, where the azimuthal wave number, *m*, increases in magnitude with distance. The direction of phase propagation depends on the species of the injected particle population which is providing the wave with energy: protons drift westwards away from the substorm, driving westward propagating waves, and electrons drift eastwards from the substorm, driving eastward propagating waves. Multi-radar observations during individual substorms show that a single substorm injects particles with a large range of energies, which drive multiple waves with very different characteristics. Here we combine the SuperDARN observations of substorm-driven ULF waves with in-situ particle and field data using the Van Allen Probes, with the aim of comparing the particle energies predicted using the wave characteristics to those observed by spacecraft.

ULF Kelvin-Helmholtz Waves Generated at the Day-side Convection Reversal Boundary During Periods of Large IMF By Reconnection

Abstract ID : 397

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Robert Clauer ,rclauer@vt.edu ,(Professor) ,United States ,Newport News ,Not Presenting[1]

Ms. Sana Qamar ,Sana@vt.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Michael Hartinger ,mdhartin@vt.edu ,(Research Assistant Professor) ,United States ,Hampton ,Not Presenting[3]

Dr. Zhonghua Xu ,zxu77@vt.edu ,(None) ,United States , ,Not Presenting[1]

1 - Virginia Polytechnic Institute and State Universit 2 - Virginia Polytechnic Institute and State Universit 3 - Virginia Polytechnic Institute and State University 4 - Virginia Polytechnic Institute and State Universit

During periods of large interplanetary magnetic field (IMF) B_y component (GSM Coordinates), the ionospheric polar electric potential system is distorted so as to produce large east-west convection shears across local noon. Past research has shown examples of ULF waves with periods of approximately 10 - 20 minutes observed at this convection shear by the Greenland west coast chain of magnetometers. Past work has shown examples of these waves and associated them with conditions in the solar wind and IMF. Here we report the results of a search of solar wind data to identify periods when the IMF B_y componet is large and the magnetometer chains along the 40-degree magnetic meridian (Greenland west coast and Antarctic) are within a few hours of local noon. We test here the hypothesis that large IMF B_y reconnection leads to large convection shears across local noon that can generate ULF waves through a shear instability such as Kelvin-Helmholtz.

Electron acceleration by ULF waves associated with dispersionless injections during a substorm event

Abstract ID : 425

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Elena Kronberg ,kronberg@mps.mpg.de ,(scientist) ,Germany ,Göttingen ,Presenting[1]

Dr. Liudmyla Kozak ,gutovska@ukr.net ,(None) ,Ukraine , ,Not Presenting[2]

Dr. Patrick W. Daly ,daly@mps.mpg.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Elena Grigorenko ,elenagrigorenko2003@yandex.ru ,(Leading scientist) ,Russia ,Moscow ,Not Presenting[4]

Dr. Drew L. Turner ,drew.lawson.turner@gmail.com ,(None) ,Germany , ,Not Presenting[5]

Dr. Yuri Khotyaintsev ,yuri@irfu.se ,(None) ,United States , ,Not Presenting[6]

1 - MPS 2 - Kyiv Taras Shevchenko University 3 - MPS 4 - Space Research Institute of Russian Academy of Science, Russia 5 - The Aerospace Corporation, USA 6 - IRFU

Particle injections in the magnetosphere transport electrons and ions from the magnetotail to the radiation belts. We compare electron acceleration during ``dispersionless'' injections, namely those with a simultaneous increase of the particle flux over a wide energy range. We take advantage of multi-satellite observations that simultaneously monitor Earth's magnetosphere from the tail towards the radiation belts during a substorm event. Dispersionless injections are associated with instabilities in the plasma sheet during the growth phase of the observed substorm, with a dipolarization front at the onset and with a magnetic flux pile-up during the expansion phase. During dispersionless electron injections, the electron distributions do not follow a classic power law but instead exhibit a bump-on-tail centered on ~120 keV at geosynchronous distance (6.6 RE). However, the electron distributions of related injections in the magnetotail (13 RE) do not show such a signature. We surmise that an additional resonant acceleration occurs in-between these locations. We relate the acceleration mechanism to electron drift resonance with ultralow frequency (ULF) waves localized in the inner magnetosphere.

Magnetospheric Multiscale observations of the spatial scales and onset conditions of EMIC waves in the outer magnetosphere

Abstract ID : 524

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Mark Engebretson ,engebret@augsburg.edu ,(Professor) ,United States ,Minneapolis ,Presenting[1]

Ms. Jennifer Posch ,posch@augsburg.edu ,(None) ,United States , ,Presenting[2]

Dr. Richard E. Denton ,richard.e.denton@dartmouth.edu ,(None) ,United States , ,Presenting[3]

Dr. Brian Anderson ,brian.anderson@jhuapl.edu ,(None) ,United States , ,Presenting[4]

Dr. Stephen Fuselier ,sfuselier@swri.edu ,(Executive Director, Space Science Directorate) ,United States ,San Antonio ,Presenting[5]

Dr. David Sibeck ,david.sibeck@gsfc.nasa.gov ,(None) ,United States , ,Presenting[6]

Prof. Christopher Russell ,ctrussell@igpp.ucla.edu ,(None) ,United States , ,Presenting[7]

1 - Augsburg College, Minneapolis 2 - Augsburg College 3 - Department of Physics and Astronomy, Dartmouth College 4 - JHU/APL 5 - SWRI 6 - NASA / Goddard Space Flight Center 7 - UCLA

The four Magnetospheric Multiscale (MMS) spacecraft orbit in a closely-spaced (down to ~7 km) highly elliptical, low-inclination (28°) orbit configuration with apogee from 12 to 25 R_E. We have identified numerous EMIC wave events in the outer magnetosphere during the first year of MMS operation. An inter-comparison of the wave signals at the four spacecraft is used to assess the detailed characteristics of the waves and estimate their spatial scales transverse and parallel to the background magnetic field. Initial results indicate that the coherence scale of individual wave packets is larger than ~20 km, but that individual wave packets are often superposed, especially during more intense events. Comparison of the wave polarization determined by several methods indicates that phase jumps produced by superposition of two or more wave packets can significantly impact the validity of some methods. Observations of ion distributions before, during, and after example EMIC wave events confirm patterns observed by Gary et al. [1994] that EMIC waves act promptly to bring the magnetospheric plasma below an "instability threshold."

Solar terminator effects on middle- to low-latitude Pi2 pulsations

Abstract ID : 552

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Shun Imajo ,imajo@kyudai.jp ,(JSPS research fellow) ,Japan ,Kyoto ,Not Presenting[1]

Dr. Akimasa Yoshikawa ,akyoshi@me.com ,(None) ,Japan , ,Not Presenting[2]

Dr. Teiji Uozumi ,uozumi@serc.kyushu-u.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Shinichi Ohtani ,Shin.Ohtani@jhuapl.edu ,(None) ,United States , ,Not Presenting[4]

Mr. Sodnomsambuu Demberel ,demberel@iag.ac.mn ,(None) ,Mongolia , ,Not Presenting[5]

Dr. Boris Mikhailovich Shevtsov ,bshev@ikir.ru ,(None) ,Russia , ,Not Presenting[6]

Dr. Aoi Nakamizo ,aoi.nakamizo@nict.go.jp ,(None) ,Japan , ,Not Presenting[5]

1 - Kyoto University 2 - Kyushu University 3 - Kyushu University 4 - Johns Hopkins University 5 - Mongolian Academy of Sciences 6 - Institute of Cosmophysical Researches and Radio Wave Propagation 7 - Mongolian Academy of Sciences

In order to understand the propagation mechanism of Pi2 toward the dayside and the equatorial enhancement, it is important to study Pi2 pulsations observed in the dawn and dusk regions that mark the transition between nightside and dayside. One of the most notable features of the dawn and dusk regions is a strong longitudinal gradient of the ionospheric conductivity near the solar terminator. To clarify the effect of the dawn and dusk terminators on Pi2 pulsations, we statistically analyzed the longitudinal phase and amplitude structures of Pi2 pulsations at middle- to low-latitude stations (GMLat = 5.30°-46.18°) around both the dawn and dusk terminators. Although the *H* (north-south) component Pi2s were affected by neither the local time (LT) nor the terminator location (at 100 km altitude in the highly conducting *E* region), some features of the *D* (east-west) component Pi2s depended on the location of the terminator rather than the LT. The phase reversal of the *D* component occurred 0.5-1 h after sunrise and 1-2 h before sunset. These phase reversals can be attributed to a change in the contributing currents from field-aligned currents (FACs) on the nightside to the meridional ionospheric currents on the sunlit side of the terminator, and vice versa. The phase reversal of the dawn terminator was more frequent than that of the dusk terminator. The *D*-to-*H* amplitude ratio on the dawn side began to increase at sunrise, reaching a peak approximately 2 h after sunrise, whereas the ratio on the dusk side reached a peak at sunset. The dawn-dusk asymmetric features suggest that the magnetic contribution of the nightside FAC relative to the meridional ionospheric current on the dusk side is stronger than that on the dawn side, indicating that the center of Pi2-associated FACs, which probably corresponds to the Pi2 energy source, tends to be

shifted duskward on average. Different features and weak sunrise/sunset dependences at the middle-latitude station (Paratunka, GMLat = 46.18°) can be attributed to the larger annual variation in the sunrise/sunset time and a stronger magnetic effect because of closeness from FACs. These results are included in published papers by Imajo et al. [2015JGR (doi:10.1002/2013JA019691); 2016EPS (doi:10.1186/s40623-016-0514-1)].

Ionospheric Aflvén resonator observed at low-latitude ground station

Abstract ID : 567

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Masahito Nose ,nose@kugi.kyoto-u.ac.jp ,(None) ,Japan ,Kyoto ,Presenting[1]

Dr. Makoto Uyeshima ,uyeshima@eri.u-tokyo.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Jun Kawai ,j-kawai@neptune.kanazawa-it.ac.jp ,(None) ,Japan , ,Not Presenting[3]

Dr. Hideaki Hase ,hase@gerd.co.jp ,(None) ,Japan , ,Not Presenting[4]

1 - World Data Center for Geomagnetism, Kyoto, Kyoto University 2 - Earthquake Prediction Research Center, The University of Tokyo 3 - Applied Electronics Laboratory, Kanazawa Institute of Technology 4 - Geothermal Energy Research & Development Co., Ltd.

The ionospheric Alfvén resonator (IAR) is found in dynamic power spectrum of the geomagnetic field variations as spectral resonance structures in the frequency range 0.1-10 Hz. The first observations of IAR were reported by Belyaev et al. [1989, 1990] by using induction magnetometers installed at a mid-latitude station, Gorkii (L~2.65). Since then, studies of IAR have been focused on events at mid and high latitudes. To date, observations of IAR at low latitude are only made at Crete by Bösinger et al. [2002, 2004] and not sufficient enough to reveal its general characteristics. We therefore installed an induction magnetometer at Muroto, Japan (24.40° geomagnetic latitude, −155.56° geomagnetic longitude), in December 2013 to investigate low latitude IAR in greater detail. Its dipole L value is 1.206 and smaller than that of Crete (L~1.3). Cadence of observations is 64 Hz. We analyze data from the induction magnetometer for the period from 28 December 2013 to 13 August 2016. From the statistical analysis of IAR observed at Muroto, we find that its occurrence probability is (1) dominant during nighttime with a gradual increase from the dusk sector to midnight and a broad maximum at 00-05 LT followed by a sudden decrease at the dawn sector, (2) slightly higher during May through September (in summer and fall), and (3) independent to the Kp index. We also find that (4) IAR at Muroto has frequency separation between the harmonics (Δf) of 0.1-0.5 Hz with a peak at 0.200-0.275 Hz. It has been considered that IAR is caused by Alfvén waves trapped in the ionospheric cavity bounded by the conductive E layer and a steep gradient of Alfvén velocity above the F2 layer. We calculate the resonant frequency and the Q factor of the ionospheric cavity, using analytical equations proposed by Polyakov and Rapoport [1981] with the IRI-2012 and IGRF-12 models. Results of comparison between the observations and the model calculation will be discussed.

Steepening of waves at the magnetopause

Abstract ID : 663

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited presentation

Dr. Ferdinand Plaschke ,ferdinand.plaschke@oeaw.ac.at ,(Junior Scientist) ,Austria ,Graz ,Presenting[1]

Ms. Nina Kahr ,ntkahr@gmail.com ,(None) ,Austria , ,Not Presenting[2]

Mr. David Fischer ,David.Fischer@oeaw.ac.at ,(None) ,Austria , ,Not Presenting[2]

Dr. Rumi Nakamura ,rumi.nakamura@oeaw.ac.at ,(office) ,Austria ,Graz ,Not Presenting[1]

Dr. Wolfgang Baumjohann ,Wolfgang.Baumjohann@oeaw.ac.at ,(None) ,Austria , ,Not Presenting[2]

Dr. Werner Magnes ,Werner.Magnes@oeaw.ac.at ,(None) ,Austria , ,Not Presenting[2]

Dr. James Burch ,JBurch@swri.edu ,(None) ,United States , ,Not Presenting[7]

Dr. Roy Torbert ,roy.torbert@unh.edu ,(None) ,United States , ,Not Presenting[8]

Dr. Christopher Russell ,ctrussel@igpp.ucla.edu ,(None) ,United States , ,Not Presenting[9]

Dr. Barbara Giles ,barbara.giles@nasa.gov ,(None) ,United States , ,Not Presenting[10]

Prof. Robert Strangeway ,strange@igpp.ucla.edu ,(None) ,United States , ,Not Presenting[9]

Dr. Hannes Leinweber ,hkleinweber@gmail.com ,(None) ,United States , ,Not Presenting[9]

Mr. Kenneth Bromund ,kenneth.r.bromund@nasa.gov ,(None) ,United States , ,Not Presenting[10]

Dr. Brian Anderson ,brian.anderson@jhuapl.edu ,(None) ,United States , ,Not Presenting[14]

Dr. Guan Le ,guan.le-1@nasa.gov ,(None) ,United States , ,Not Presenting[10]

Mr. Mark Chutter ,mark.chutter@unh.edu ,(None) ,United States , ,Not Presenting[8]

Prof. James Slavin ,jaslavin@umich.edu ,(None) ,United States , ,Not Presenting[17]

Mr. Emil Kepko ,larry.kepko@nasa.gov ,(None) ,United States ,None ,Not Presenting[10]

1 - IWF/OEAW 2 - Space Research Institute, Austrian Academy of Sciences, Graz, Austria 3 - Space Research Institute, Austrian Academy of Sciences, Graz, Austria 4 - IWF/OEAW 5 - Space Research

Institute, Austrian Academy of Sciences, Graz, Austria 6 - Space Research Institute, Austrian Academy of Sciences, Graz, Austria 7 - SWRI 8 - UNH 9 - UCLA 10 - NASA/GSFC 11 - UCLA 12 - UCLA 13 - NASA/GSFC 14 - JHU/APL 15 - NASA/GSFC 16 - UNH 17 - Department of Climate and Space Sciences and Engineering, University of Michigan, Ann Arbor, MI 18 - NASA/GSFC

Surface waves propagating along the magnetopause flanks may be amplified by the Kelvin-Helmholtz instability (KHI) as a result of the flow shear across the boundary. When reaching the non-linear stage, the waves' shape is expected to change: the leading (anti-sunward facing) edges become steeper (i.e., more inclined) and thicker than the trailing edges. High time-resolution measurements by the four Magnetospheric MultiScale (MMS) spacecraft flying in close tetrahedral configuration at the flank magnetopause enable us to ascertain the steepening and thickness of surface waves by four-spacecraft timing analysis in a routine manner. We indeed find a majority of waves (77%) to be steepened as expected assuming amplification by the KHI. Also the leading edges are found to be thicker than the trailing edges. A rather large fraction of waves (23%), however, exhibits inverse steepening. Only a few cases of inverse steepening have been previously reported, and all of those were linked to strongly northward interplanetary magnetic field (IMF). We find that inverse steepening also occurs under equatorial IMF conditions that should suppress the KHI along the equatorial magnetopause flanks.

Excitation of ULF waves by a solar wind shock impact in global MHD simulations with plasmasphere

Abstract ID : 1145

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Lars K. S. Daldorff ,Lars.Daldorff@jhuapl.edu ,(None) ,United States ,Laurel ,Not Presenting[1]

Dr. Viacheslav Merkin ,Slava.Merkin@jhuapl.edu ,(None) ,United States , ,Not Presenting[1]

Mr. Kareem A. Sorathia ,kareem.sorathia@jhuapl.edu ,(None) ,United States , ,Not Presenting[1]

Mr. A. Y. Ukhorskiy ,ukhoray1@jhuapl.edu ,(None) ,United States , ,Not Presenting[1]

Dr. John Lyon ,lyon@tinman.dartmouth.edu ,(None) ,United States , ,Not Presenting[5]

1 - JHU/APL 2 - JHU/APL 3 - JHU/APL 4 - JHU/APL 5 - Dartmouth College

Recent advances in high-resolution global modeling of the magnetosphere enable us to take a new look at the mechanisms of excitation and distribution of ultra-low frequency (ULF) waves in the magnetosphere, and their effects on the transport of radiation belt electrons. In this study, we have simulated an idealized version of the Oct 8 2013 sudden storm commencement observed by the Van Allen Probes. To facilitate the analysis, we constructed a strictly perpendicular shock with the jump conditions representative of the event. We then used the multi-fluid high-resolution version of the Lyon-Fedder-Mobarry (LFM) global MHD model that included also an internal plasmasphere module simulated as a separate, cold fluid component. Following the shock impact, the dayside magnetosphere exhibited broadly distributed compressional ultra-low frequency (ULF) oscillations and enhanced Kelvin-Helmholtz instability at the magnetopause. In addition, strongly localized Pc5 and Pc4 range oscillations in both azimuthal and radial components of the electric field were registered at different locations with highly spatially variable spectra. The oscillations appear to be caused by vortical flows developed in the wake of the initial shock We analyze the relative role of field-line resonances and direct driving by flow vorticity in producing shear Alfven waves and commensurate oscillations along the entire affected flux tube. Additionally, to analyze the effects of the shock impact on the radiation belt electrons we quantify the amount of adiabatic heating due to compression versus non-adiabatic energization in the electric field pulse associated with the shock. To this end, we use a test-particle approach. Trajectories of a large number of electrons are traced in the dynamic electromagnetic field extracted from the MHD simulation. The role of non-adiabatic energization is then quantified by computing electron transport in the second and third adiabatic invariants associated with the electron drift and bounce motion.

Energisation of charged particles due to ULF waves

Abstract ID : 1198

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Colin Waters ,colin.waters@newcastle.edu.au ,(None) ,Australia ,None ,Presenting[1]

Mr. Asif Shah ,asif.shah@newcastle.edu.au ,(None) ,Australia , ,Not Presenting[1]

Prof. Fred Menk ,fred.menk@newcastle.edu.au ,(None) ,Australia , ,Not Presenting[1]

Dr. Murray Sciffer ,murray.sciffer@newcastle.edu.au ,(None) ,Australia , ,Not Presenting[1]

Prof. Robert Lysak ,lysak001@umn.edu ,(Professor of Physics) ,United States ,Minneapolis, MN ,Not Presenting[5]

1 - University of Newcastle 2 - University of Newcastle 3 - University of Newcastle 4 - University of Newcastle 5 - University of Minnesota

Ultra low frequency (ULF) plasma waves of a few mHz can accelerate charged particles in the radiation belts. For non-resonant wave-particle interactions, the energy varies according to the first adiabatic invariant. For higher energy particles, resonant wave-particle interactions involving drift and bounce times are possible. The ULF wave fields may be simulated using a cold plasma MHD formulation but few have considered modification of the ULF electric fields due to ionosphere boundaries that include Hall and Pedersen conductances. The energies for both resonant and non-resonant wave-particle interactions using a realistic MHD model are discussed, and compared with spacecraft data. Including the finite conductance ionosphere boundaries enhances the ULF electric fields and alters particle trajectories and energies.

Pulsating proton aurora caused by rising tone Pc1 waves

Abstract ID : 1240

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited presentation

Dr. Reiko Nomura ,nomura@stp.isas.jaxa.jp ,(None) ,Japan ,Kanagawa ,Not Presenting[1]

1 - None

Electromagnetic ion cyclotron (EMIC) wave is one of the key phenomena for the dynamics of high-energy electrons in the radiation belt, since EMIC wave can scatter particles and make them precipitate into the ionosphere from the inner magnetosphere. It is also said that scattering by EMIC waves could be responsible for the slot region formation in the radiation belt. In order to find the impact of EMIC waves to the radiation dynamics, it is important to understand that when and where the significantly strong EMIC waves are excited and interact with particles.
We found rising tone emissions with a dispersion of ~1 Hz per?several tens of seconds in the dynamic spectrum of a Pc1 geomagnetic pulsation (Pc1) observed on the ground. These Pc1 rising tones were successively observed over ~30 min from 0250 UT on 14 October 2006 by an induction magnetometer at Athabasca, Canada (54.7? N, 246.7? E, magnetic latitude ?
61.7?N). Simultaneously, a THEMIS panchromatic all-sky camera detected pulsations of an isolated proton aurora with a period of several tens of seconds, ~10% variations in intensity, and fine structures of 3? in magnetic longitudes. The pulsations of the proton aurora close to the zenith of ATH have one-to-one correspondences with the Pc1 rising tones. ?
These findings are important to understand the nonlinear effects on the wave-particle interactions in the magnetosphere and in our presentation we will discuss it.

A19 - Energy Storage and Release Mechanisms in the Magnetosphere (DIV III)

A Modeling substorm Dynamics of the Magnetosphere Using Self-Organized Criticality Approach

Abstract ID : 199

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Maurício Bolzan ,mauricio.bolzam@gmail.com ,(Professor) ,Brazil ,Jataí ,Not Presenting[1]

Dr. Reinaldo Rosa ,reinaldo@lac.inpe.br ,(None) ,Brazil , ,Not Presenting[2]

1 - Federal University of Jataí 2 - INPE

Responses of Earth magnetic field during substorms exhibits a number of characteristics features such as the power-law spectra of fluctuations on different scales and signatures of low effective dimensions. Due the magnetosphere are constantly out-equilibrium their behavior is similar to real sandpiles during substorms, features of self-organized criticality (SOC) systems. Thus, in this work we presented a simple mathematical model to AE-index based on self-organizing sandpile mentioned by Uritsky and Pudovkin (1998), but we input the dissipation process inside the model. The statistical and multifractal tools to characterization of dynamical processes was used.

Auroral Observations of the Substorm Onset Instability

Abstract ID : 635

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Nadine Kalmoni ,nadine.kalmoni@ucl.ac.uk ,(Research Associate) ,United Kingdom ,Dorking ,Not Presenting[1]

Dr. I. Jonathan Rae ,jonathan.rae@ucl.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Kyle R. Murphy ,kyle.r.murphy@nasa.gov ,(None) ,United States , ,Not Presenting[3]

Dr. Colin Forsyth ,colin.forsyth@ucl.ac.uk ,(NERC Independent Research Fellow) ,United Kingdom ,Dorking ,Not Presenting[4]

Dr. Clare Watt ,c.e.watt@reading.ac.uk ,(Lecturer) ,United Kingdom ,Reading ,Not Presenting[5]

Dr. Chris J. Owen ,c.owen@ucl.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Andrew Fazakerly ,a.fazakerley@ucl.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University College London 2 - Mullard Space Science Laboratory, UCL 3 - NASA Goddard Space Flight Centre 4 - UCL 5 - University of Reading 6 - University College London 7 - University College London

During periods where the interplanetary magnetic field has a southward component, reconnection on the dayside magnetopause leads to a build up of magnetic flux in the magnetotail lobes, and the magnetotail acts as a reservoir of plasma and energy. During a substorm this energy is explosively released, leading to the deposition of large quantities of energy into the polar ionospheres and the bright and dynamic substorm aurora. Auroral substorm onset is observed at the equatorward edge of the auroral oval, suggesting that at least some of the processes which play an important role in energy release occur on closed magnetic field lines. Recent work has highlighted that auroral beads grow exponentially through substorm onset, which indicates the action of a plasma instability in this near-Earth region.

We present a detailed statistical study of auroral beads, which are observed in the minutes leading up to auroral breakup in order to analyse the frequency, growth rates and wavenumbers of the instability and compare them to theoretical predictions. We construct an observational dispersion relation for the instability based upon prevailing magnetotail parameters. We conclude that a magnetospheric plasma instability is a fundamental component to the release of stored energy in the magnetotail during substorms.

Variations in global field-aligned currents before and after substorm onset

Abstract ID : 1331

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Colin Forsyth ,colin.forsyth@ucl.ac.uk ,(NERC Independent Research Fellow) ,United Kingdom ,Dorking ,Not Presenting[1]

Mr. Mark Shortt ,mark.shortt.12@ucl.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. John Coxon ,J.Coxon@soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. I. Jonathan Rae ,jonathan.rae@ucl.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. Mervyn Freeman ,mpf@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[5]

Dr. Nadine Kalmoni ,nadine.kalmoni@ucl.ac.uk ,(Research Associate) ,United Kingdom ,Dorking ,Not Presenting[6]

Dr. Caitriona Jackman ,C.Jackman@soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. Brian Anderson ,brian.anderson@jhuapl.edu ,(None) ,United States , ,Not Presenting[8]

Prof. Steve Milan ,steve.milan@leicester.ac.uk ,(None) ,United Kingdom , ,Not Presenting[9]

Dr. Angeline Burrell ,agb073000@utdallas.edu ,(None) ,United States , ,Not Presenting[10]

1 - UCL 2 - UCL 3 - University of Southampton 4 - Mullard Space Science Laboratory, UCL 5 - British Antarctic Survey 6 - University College London 7 - University of Southampton 8 - JHU/APL 9 - University of Leicester 10 - UT Dallas

Field-aligned currents (FACs) are the principle agents by which energy and momentum are transferred to the ionosphere from the magnetosphere and solar wind. During substorms, the total FAC into and out of the ionosphere increases due to the formation of the substorm current wedge. Using data from the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE) and Substorm Onsets and Phases from Indices of the Electrojet (SOPHIE), we examine the changes in FACs in the northern hemisphere at all local times before and after substorm onset. We find that the total FAC increases by 60 kA before onset. This increase starts in the post-noon sector and propagates to the nightside, with no apparent change in the pre-noon sector. After substorm onset, FACs rapidly increase on the nightside, following the *Weimer* [1994] capacitive-inductive-resistive model of magnetosphere-ionosphere coupling. While the dayside currents vary strongly with season, substorms increase the total FAC by 300-365 kA independent of season. As such, the proportion of the global current from substorm activity is reduced during the summer. We

find that the total upward and downward FAC is well correlated with upstream solar wind driver lagged by 50-75 min, with smaller lags in the summer, although the correlation with FAC in individual MLT sectors is less good. This implies that the nightside activity is strongly influenced by the variations in the upstream conditions, but the exact form of these FACs is not.

A20 - Magnetospheric Boundary Layers (DIV III)

Multiple particle populations in the magnetopause boundary layers

Abstract ID : 194

Conflict Declaration : None

Content Motivation : None

Additional Information : This is an invited presentation.

Dr. Benoit Lavraud ,Benoit.Lavraud@irap.omp.eu ,(Staff researcher) ,France ,Toulouse ,Not Presenting[1]

Dr. Vassilis Angelopoulos ,vassilis@ucla.edu ,(None) ,United States , ,Not Presenting[2]

Mr. Timothée Achilli ,timothee.achilli@orange.fr ,(None) ,France , ,Not Presenting[1]

Mr. Jim McFadden ,mcfadden@ssl.berkeley.edu ,(None) ,United States , ,Not Presenting[4]

Mr. Christian Jacquey ,cjacquey@irap.omp.eu ,(None) ,France , ,Not Presenting[1]

Dr. Elena Grigorenko ,elenagrigorenko2003@yandex.ru ,(Leading scientist) ,Russia ,Moscow ,Not Presenting[6]

Dr. Stephen Fuselier ,sfuselier@swri.edu ,(Executive Director, Space Science Directorate) ,United States ,San Antonio ,Not Presenting[7]

1 - IRAP/CNRS 2 - UCLA 3 - IRAP/CNRS 4 - UC Berkeley 5 - IRAP/CNRS 6 - Space Research Institute of Russian Academy of Science, Russia 7 - SWRI

We review the properties of the dayside boundary layers. We explain, in particular, that while double ion populations, with the cold population originating from the solar wind and the hotter one from the magnetosphere, are frequently observed in Earth's low-latitude boundary layers, similar double electron populations are seldom recorded. We performed a large-scale statistical study on 7 years of THEMIS particle data when these are suitably located close to the magnetopause. Our findings show that combined double populations in both ions and electrons appear much less frequently than double ion populations alone. The analysis of IMF data suggests that such boundary layers form preferentially under northward IMF but with a significant By component. We interpret this trend as a result of reconnection of the same magnetosheath field line in both hemispheres, but with at least one end reconnecting in its hemisphere at a rather low latitude with a closed magnetospheric field line which already contains a hot electron source.

Steven Petrinec : Invited talk

MMS at the Bow Shock (Invited)

Abstract ID : 390

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Steve Schwartz ,s.schwartz@imperial.ac.uk ,(Professor of Space Physics) ,United Kingdom ,London ,Not Presenting[1]

Dr. Frederick Wilder ,Frederick.Wilder@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Stefan Ericksson ,Stefan.Eriksson@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Per-Arne Lindqvist ,lindqvist@plasma.kth.se ,(None) ,United States , ,Not Presenting[4]

Dr. Mihir Desai ,mdesai@swri.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Mitsuo Oka ,moka@ssl.berkeley.edu ,(None) ,United States , ,Not Presenting[6]

Prof. Christopher Russell ,ctrussell@igpp.ucla.edu ,(None) ,United States , ,Not Presenting[7]

Prof. Robert Strangeway ,strange@igpp.ucla.edu ,(None) ,United States , ,Not Presenting[7]

Dr. Andris Vaivads ,andris.vaivads@gmail.com ,(None) ,Sweden , ,Not Presenting[4]

Dr. Imogen Gingell ,i.gingell@imperial.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Levon Avanov ,levon.a.avanov@nasa.gov ,(None) ,United States , ,Not Presenting[11]

Dr. James Burch ,JBurch@swri.edu ,(None) ,United States , ,Not Presenting[12]

Dr. Katherine Goodrich ,Katherine.Goodrich@Colorado.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Stephen Fuselier ,sfuselier@swri.edu ,(Executive Director, Space Science Directorate) ,United States ,San Antonio ,Not Presenting[12]

Dr. Karlheinz Trattner ,Karlheinz.Trattner@lasp.colorado.edu ,(Scientist) ,United States ,BOULDER ,Not Presenting[15]

Mr. Jeffrey Broll ,jbroll@swri.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Hui Zhang ,hzhang14@alaska.edu ,(None) ,United States , ,Not Presenting[17]

Dr. Drew Turner ,drew.l.turner@aero.org ,(None) ,United States , ,Not Presenting[18]

Dr. Hanying Wei ,hwei@igpp.ucla.edu ,(None) ,United States , ,Not Presenting[7]

Dr. Roy Torbert ,roy.torbert@unh.edu ,(None) ,United States , ,Not Presenting[20]

Dr. David Newman ,David.Newman@colorado.edu ,(None) ,United States , ,Not Presenting[21]

Dr. John Dorelli ,john.c.dorelli.1@gsfc.nasa.gov ,(None) ,United States , ,Not Presenting[11]

Prof. Robert Ergun ,Robert.Ergun@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Benoit Lavraud ,Benoit.Lavraud@irap.omp.eu ,(Staff researcher) ,France ,Toulouse ,Not Presenting[24]

Mr. Andreas Johlander ,andreasj@irfu.se ,(None) ,Sweden , ,Not Presenting[25]

Dr. Barbara Giles ,barbara.giles@nasa.gov ,(None) ,United States , ,Not Presenting[26]

Dr. Daniel Gershman ,daniel.j.gershman@nasa.gov ,(Research Scientist) ,United States ,Washington ,Not Presenting[27]

Dr. Yuri Khotyaintsev ,yuri@irfu.se ,(None) ,United States , ,Not Presenting[25]

1 - Imperial College London 2 - LASP 3 - LASP 4 - Uppsala 5 - SwRI 6 - SSL 7 - UCLA 8 - UCLA 9 - Uppsala 10 - Imperial College London 11 - GSFC 12 - SWRI 13 - LASP 14 - SWRI 15 - LASP, University of Colorado 16 - SwRI 17 - Fairbanks 18 - The Aerospace Corporation 19 - UCLA 20 - UNH 21 - Univ Colorado Boulder 22 - GSFC 23 - LASP 24 - IRAP/CNRS 25 - IRFU 26 - NASA/GSFC 27 - University of Maryland, College Park 28 - IRFU

The Magnetospheric Multiscale Mission is comprised of four spacecraft in tight (10's km) tetrahedral formation carrying instruments of unprecedented capability, notably in the resolution of electron and ion particle distributions at 30 ms and 150 ms respectively. The particle and fields instruments are highly calibrated providing a precise microscopic view of space plasma microphysics. Over the first two dayside seasons, focussed on reconnection at the terrestrial magnetopause, solar wind conditions also compressed the magnetosphere enabling MMS to traverse the Earth's bow shock. This invited talk will present an overview of results to date, which include: identification of shock ripples at nearly perpendicular shocks, whistler waves including electron scattering within the shock foot and ramp, detailed investigation of the structure of and ion injection into a Hot Flow Anomaly, a study of parallel electric field observed within an oblique shock, and an exploration of ion composition near the bow shock. As MMS apogee has now been raised to 25 Re, MMS bow shock encounters in the seasons ahead will cover a much wider range of solar wind conditions. Additionally, evolving mission objectives will enable more bow shock data to be downloaded at the highest resolution. The talk will conclude with an open list of key shock science targets.

Boundary layers and diffusion regions at the Earth's magnetopause as observed by MMS

Abstract ID : 407

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited Presentation - Invited by the session organizers Steve Petrinec and Karlheinz Trainer

Dr. Stephen Fuselier ,sfuselier@swri.edu ,(Executive Director, Space Science Directorate) ,United States ,San Antonio ,Not Presenting[1]

1 - SWRI

Representing the MMS Science Team
Magnetic reconnection at the magnetopause creates boundary layers with distinct properties. The thicknesses of the boundary layers on both sides of the magnetopause depend on the distance from the reconnection X-line and the degree of asymmetry in the reconnection process. These layers on the magnetosheath and magnetospheric sides of the magnetopause are bounded by separatrices. Across these separatrices, there is usually a change in field line topology and inside these separatrices, velocity filter effects create separate electron and electron-plus-ion layers. This talk focuses on kinetic aspects of plasma in the boundary layers with emphasis on the new results from the MMS mission. Very high time resolution electron measurements from the MMS spacecraft resolve kinetic features of the electron distribution at the X-line for the first time. Further from the X-line, high time resolution ion composition measurements also show new kinetic features of the magnetospheric and magnetosheath ion distributions. These electron and ion kinetic features are placed in context with the evolving understanding of magnetic reconnection.

Comparative boundary layers of solar system magnetospheres

Abstract ID : 466

Conflict Declaration : None

Content Motivation : None

Additional Information : This abstract is an invited submission.

Dr. Daniel Gershman ,daniel.j.gershman@nasa.gov ,(Research Scientist) ,United States ,Washington ,Not Presenting[1]

1 - University of Maryland, College Park

Boundary layers provide a critical vehicle for the transport of mass and energy between the solar wind and a planetary magnetosphere. While the same types of processes (e.g., viscous mixing, diffusive transport, magnetic reconnection) are present in different magnetospheric systems, their relative importances and manifestations can greatly vary. The different magnetospheric systems spread throughout the solar system span a wide range of parameter space that enables broader study of each of these processes. Not only do these systems have different average upstream solar wind conditions and internal plasma properties, but the dominant boundary layer plasma physics can range from kinetic to fluid scales. Here we present an overview of boundary layers observed at planetary magnetospheres including Mercury, Earth, and Jupiter. For each we will discuss relevant observations of plasma depletion layers, the Kelvin-Helmholtz instability, magnetic reconnection, plasma mantle, and the low-latitude boundary layer, leveraging recent data from MESSENGER, MMS, and Juno.

Magnetic Reconnection at Mercury's Magnetopause

Abstract ID : 726

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Gina DiBraccio ,gina.a.dibraccio@nasa.gov ,(Research Scientist) ,United States ,Greenbelt ,Not Presenting[1]

Dr. Adam Masters ,a.masters@imperial.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Daniel Gershman ,daniel.j.gershman@nasa.gov ,(Research Scientist) ,United States ,Washington ,Not Presenting[3]

1 - NASA/USRA 2 - Imperial College London 3 - University of Maryland, College Park

Mercury's magnetosphere experiences intense solar wind forcing that drives rapid magnetospheric dynamics, including the explosive transfer of magnetic energy into kinetic energy through magnetic reconnection. MESSENGER observations have determined that magnetic reconnection plays a crucial role in transporting magnetic and particle flux through Mercury's magnetosphere. In particular at the magnetopause, reconnection has been observed to occur for low magnetic field shear angles between the planetary field and the Interplanetary Magnetic Field with reconnection rates that are a factor of ~3 larger than Earth as a result of the low-beta plasma present in the inner heliosphere. Here, we present an extension of this magnetopause reconnection work by utilizing an analytical model to predict the location of Mercury's dayside magnetopause reconnection X-line. The use of this model enhances our understanding of magnetic reconnection in low-beta plasmas through data-model comparisons. In order to predict the X-line location over a variety of solar wind conditions, upstream quantities measured by MESSENGER are used as model inputs. By comparing the model results to observed reconnection signatures in the magnetic field and plasma data we elucidate the role of plasma beta on the intensity and occurrence of reconnection - a topic of great debate. Moreover, by comparing the observed reconnection locations to those predicted by the model, we test the theory of whether reconnection occurs sporadically at random locations or continuously along an extended position across Mercury's magnetopause. The results of this study are applicable beyond the scope of Mercury as it helps us to understand the process of magnetic reconnection and how it affects the magnetopause boundary layer at intrinsic planetary magnetospheres throughout the heliosphere.

Observational characteristics of the near-Earth plasma sheet boundary layer

Abstract ID : 730

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Rumi Nakamura ,rumi.nakamura@oeaw.ac.at ,(office) ,Austria ,Graz ,Not Presenting[1]

1 - IWF/OEAW

The plasma sheet boundary layer (PSBL), between the hot plasma sheet and the tenuous lobe, has been known as a dynamic region in the magnetotail, where counter streaming ions are often observed independent of geomagnetic activity. In particular during substorms, a spacecraft located near the PSBL experiences dramatic changes due to thinning and expansion of the plasma sheet reflecting the activation of the reconnection site and associated flux transport and current sheet instabilities. The hot particles streaming Earthward observed in PSBL contains information on the down-tail source mechanism, i.e. temporal/spatial characteristics of acceleration processes, as well as the large-scale magnetosphere dynamics. Recent multi-point observations by MMS (Magnetospheric Multiscale) enable us to study the near-Earth plasma sheet boundary layer, including rapid electron dynamics, which require measurements with high-temporal resolution. In this talk we highlight several PSBL observations obtained by MMS when the spacecraft traversed the near-Earth magnetotail region with its apogee around 12 RE. The topics include field-aligned currents, remote sensing of near-Earth reconnection, and flow braking.

Reconnection through current sheets in dependence on the ambient magnetic field conditions

Abstract ID : 834

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Joerg Buechner ,buechner@mps.mpg.de ,(Research Group leader) ,Germany ,Goettingen ,Not Presenting[1]

1 - Max-Planck-Institute for Solar System Research, Goettingen, Germany

Space plasma current sheets like magnetopauses separate plasma regions which are topologically influenced by different sources of magnetization, e.g. of the solar dynamo and planetary magnetic fields. Magnetic reconnection is the most efficient mechanism of energy release via and plasma transport through such boundaries. The actual reconnection efficiency depends, however, on the plasma parameters and fields on the two sides of the current sheets.
We report new results on the influence of the plasma and field conditions, in particular on the opening angle of the ambient magnetic fields by means of kinetic numerical simulations.

A21 - High-latitude electrodynamics and the polar cap (DIV III)

Global Distribution of Alfvén Waves in the High-Altitude Polar Region

Abstract ID : 162

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Andreas Keiling ,keiling@ssl.berkeley.edu ,(Researcher) ,United States ,Berkeley ,Not Presenting[1]

Prof. John Wygant ,wygan001@umn.edu ,(None) ,United States , ,Not Presenting[2]

Dr. John Dombeck ,johnd@fields.space.umn.edu ,(None) ,United States , ,Not Presenting[2]

1 - UC Berkeley 2 - University of Minnesota 3 - University of Minnesota

With regard to the Alfvén wave paradigm in global M-I coupling, there is a missing part in our understanding that will be explored in this presentation. We know the global distribution of Alfvén wave power above the nominal auroral acceleration region (AAR) in an average sense (i.e., without discriminating between different solar wind/IMF driving conditions and various geomagnetic conditions). Both global auroral luminosity and low-altitude (below the nominal AAR) Alfvénic distributions show physical correspondence, while allowing for dissipation of wave energy due to particle energization. In addition, global simulations have reproduced the observed global distribution of Alfvén wave power coming from the far-tail magnetospheric dynamo. This is indeed a satisfactory picture. What does this picture look like for specific driving and geomagnetic conditions? This question will be (partially) answered during this presentation.

Use of spherical elementary currents to map the polar current systems associated with the geomagnetic sudden commencements on 2013 and 2015 St. Patrick's Day storms

Abstract ID : 365

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Santiago Marsal ,smarsal@obsebre.es ,(Researcher) ,Spain ,Roquetes ,Not Presenting[1]

Prof. Tohru Araki ,tohru.araki.24m@st.kyoto-u.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Antoni Segarra ,asegarra@obsebre.es ,(None) ,Spain , ,Not Presenting[1]

Prof. J. Miquel Torta ,jmtorta@obsebre.es ,(Head of research group) ,Spain ,Roquetes ,Not Presenting[1]

1 - Observatori de l'Ebre 2 - Department of Geophysics, Graduate School of Science, Kyoto University 3 - Observatori de l'Ebre 4 - Observatori de l'Ebre

Araki's model of geomagnetic sudden commencements (SCs) establishes that the ground magnetic signatures globally observed after the onset produced by an increased solar wind dynamic pressure impacting on the Earth's magnetosphere are caused by the development of a system of electric currents in the coupled magnetosphere-ionosphere. This current system consists of a particular evolving set of magnetopause currents closing in the ionosphere through geomagnetic field-aligned currents (FACs) and their induced counterpart. We confirm the starting assumptions of the referred model by use of spherical elementary current systems (SECS), namely, the existence of FACs reversing polarity during the first couple of minutes of the SC. It is the first time that SECS have been applied to the study of SCs. The method has been fed with data from more than 100 stations of the global network of geomagnetic observatories and variometer sites in the northern hemisphere so as to provide a reliable pattern of the equivalent current system flowing at ionospheric heights on the occasion of the SCs associated with the 2013 and 2015 St. Patrick's Day storms. The combined analysis of solar wind data and the synoptic view of the SC current patterns provided by SECS allows it to explain some of the differences observed between both events.

Ion Upflows and Hot Oxygen Atom Production in the Topside Auroral Ionosphere

Abstract ID : 894

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Andrew Yau ,yau@ucalgary.ca ,(Professor) ,Canada ,Calgary ,Presenting[1]

Ms. Victoria Foss ,vfoss@ucalgary.ca ,(None) ,Canada , ,Presenting[1]

Prof. Bernard Shizgal ,shizgal@chem.ubc.ca ,(None) ,Canada , ,Presenting[3]

1 - University of Calgary 2 - University of Calgary 3 - University of British Columbia

Ion up-flows in the topside auroral ionosphere are typically dominated by O^+ oxygen ions, but are at times composed of a non-negligible component of NO^+ and other molecular ions, especially during geomagnetic storms and substorms. In particular, the enhanced flux of NO^+ ions is believed to constitute an appreciable source of hot oxygen atoms due to dissociative ion recombination. We present ion composition observation in the topside auroral ionosphere from the CASSIOPE Enhanced Polar Outflow Probe (e-POP) during storm and substorm times, and the temperature and density distributions of hot oxygen atoms resulting from the collisional relaxation of the dissociative recombination product atoms.

North-south asymmetries in cold plasma density in the magnetotail lobes: Cluster observations

Abstract ID : 902

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Stein Haaland ,Stein.Haaland@uib.no ,(None) ,Germany ,Goettingen ,Presenting[1]

Dr. Lukas Maes ,lukas.maes@aeronomie.be ,(None) ,Belgium , ,Not Presenting[2]

Dr. Karl Laundal ,karl.laundal@uib.no ,(None) ,Norway , ,Not Presenting[3]

Mr. Arne Pedersen ,arne.pedersen@fys.uio.no ,(None) ,Norway , ,Not Presenting[4]

Dr. Bjorn Lybekk ,Bjorn.Lybekk@fys.uio.no ,(None) ,Norway , ,Not Presenting[5]

Prof. Nikolai Ostgaard ,Nikolai.Ostgaard@uib.no ,(Professor) ,Norway ,Bergen ,Not Presenting[6]

Dr. Jone P. Reistad ,Jone.Reistad@ift.uib.no ,(None) ,Norway , ,Not Presenting[7]

Dr. Anders Ohma ,anders.ohma@uib.no ,(None) ,Norway , ,Not Presenting[3]

Dr. Kristian Snekvik ,kristian.snekvik@uib.no ,(None) ,Norway , ,Not Presenting[3]

Dr. Paul Tenfjorde ,paul.tenfjord@uib.no ,(None) ,Norway , ,Not Presenting[3]

1 - MPS/BCSS 2 - Royal Belgian Institute for Space Aeronomy, Brussels, Belgium 3 - BCSS 4 - Univ Oslo 5 - UiB 6 - Birkeland Centre for Space Science 7 - University in Bergen 8 - BCSS 9 - BCSS 10 - BCSS

We present observations of cold (0-70 eV) plasma density in the magnetotail lobes. The observations and results are based on 16 years of Cluster observation of spacecraft potential measurements converted into local plasma densities.

Measurements from all four Cluster spacecraft have been used, and the survey indicate a persistent asymmetry in lobe density, with consistently higher cold plasma densities in the northern lobe. External influences, such as daily and seasonal variations in the Earth's tilt angle, can introduce temporary north-south asymmetries through asymmetric ionization of the two hemispheres. Likewise, external drivers, such as the orientation of the interplanetary magnetic field can set up additional spatial asymmetries in outflow and lobe filling. The persistent asymmetry reported in this paper is also influenced by these external factors, but is mainly caused by differences in magnetic field configuration in the northern and southern hemisphere ionospheres.

Quantitative Assessment of High-Latitude Energy Input

Abstract ID : 935

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Gang Lu ,ganglu@ucar.edu ,(80301) ,United States ,Boulder ,Not Presenting[1]

1 - National Center for Atmospehric Research

The high-latitude ionosphere plays a key role in solar wind-magnetosphere-ionosphere energy transfer processes. Through the solar wind-magnetosphere interaction, a faction of solar wind energy is transmitted into the magnetosphere, and subsequently dissipated into the high-latitude ionosphere to create the aurora and other geophysical phenomena. The high-latitude ionosphere consists of both the polar cap, where the magnetic field lines are open to the solar wind, and the auroral zone, where the two ends of the field lines are connected to the Earth. Many previous studies have shown that magnetospheric energy input mainly resides within the auroral zone. However, more recent studies indicate that the polar cusp is also a region of significant energy input. Some studies even suggest that the polar cap, instead of the auroral zone, is the primary location where the solar wind can directly dissipate its energy to power the ionosphere-thermosphere system. The purpose of this paper is to shed new light on the renewed interest concerning the high-latitude energy input. More specifically, we will quantify the energy partitioning in the polar cap and in the auroral zone during geomagnetic storms by synthesizing various space- and ground-based observations.

How flux transfer events with a low recurrence rate may cause the formation of bending auroral arcs

Abstract ID : 961

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Anita Kullen ,kullen@kth.se ,(Asc. Prof.) ,Sweden ,Stockholm ,Not Presenting[1]

Dr. Tomas Karlsson ,tomas.karlsson@ee.kth.se ,(Associate Professor) ,Sweden ,Stockholm ,Not Presenting[1]

Dr. Robert Fear ,R.C.Fear@soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - KTH Royal Institute of Technology 2 - KTH Royal Institute of Technology 3 - University of Southampton

Bending arcs are faint polar auroral arcs that form on the dawnside (during positive IMF By) or duskside auroral oval (during negative IMF By) with the sunward part of the arc splitting off the dayside oval. The dayside tip subsequently moves into the polar cap in anti-sunward direction, while the arc's nightside end remains attached to the oval, becoming hook-shaped after a while. IMF Bz is predominantly northward the hours before, but drops to near zero values about 10-20 minutes before the arc appears, which is untypical for other polar arcs (Kullen et al., 2015). These observations, and the discovery of strong anti-sunward plasma flows just sunward of bending arcs caused Carter et al. (2015) to suggest, bending arcs form in similar way as poleward moving auroral forms (PMAFs) which are known to be connected to flux transfer events (FTEs).
However, PMAFs and FTEs are quasi-periodic events with a typical recurrence rate of 8-10 minutes, while bending arcs appear to be isolated events. In the present study we investigate the possible role of FTEs in the formation of bending arcs by using the large Cluster database of FTE events by Karimabadi et al. (2009) and comparing it to SuperDARN plasma flow plots overlaid on auroral images. The results show that FTEs appearing during IMF conditions typical for bending arcs have an unusually low recurrence rate, which strengthens the assumption that these may cause the formation of isolated bending arcs.

High Latitude Observations with the CASSIOPE/e-POP Instruments

Abstract ID : 1156

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Andrew Yau ,yau@ucalgary.ca ,(Professor) ,Canada ,Calgary ,Presenting[1]

Dr. Gareth Perry ,perry@phys.ucalgary.ca ,(None) ,Canada , ,Not Presenting[1]

Dr. Gordon James ,james@phys.ucalgary.ca ,(None) ,Canada , ,Presenting[1]

1 - University of Calgary 2 - University of Calgary 3 - University of Calgary

In the 3.5 years of its orbital history since launch in 2013, the CASSIOPE/e-POP payload has been operated for more than 1000 recorded passes. The majority of these were recorded at, or poleward of, sub-auroral latitudes in the northern hemisphere, resulting in about 40 total hours of operation of the Radio Receiver Instrument (RRI) data. In the RRI data set, the most frequently employed RRI mode is at frequencies coordinated with nearby SuperDARN (SD) coherent backscatter radars. Techniques based on the established cold-plasma dispersion relation and geometric optics show the importance of three-dimensional ionospheric density structure for interpretation of the SD-transmitted high-frequency signals at CASSIOPE.

The understanding of auroral-latitude physics is advancing thanks also to movies of auroral luminosity below the spacecraft recorded by the e-POP Fast Auroral Imager (FAI) that provide a setting for processes detected by other e-POP instruments. By producing one image per second of near-infrared (NIR) emissions at heights near 110 km, the FAI contributes to a knowledge of what is happening in the three-dimensional space surrounding the magnetic field line through the spacecraft.

Both radio and NIR emissions are excited by free energy available from nonequilibrium electron distributions. Understanding these processes monitored simultaneously at both wavelengths may help to improve models of energy input to the ionosphere. Very-low-frequency (VLF) hiss recorded in the neighbourhood of pulsating aurora connects with electron precipitation that is sufficiently energetic (10-100 keV) to create whistler-mode propagation with wave-vectors aligned predominantly close to the axis of the terrestrial magnetic field. Such RRI spectrograms contrast with those supplying evidence of oblique quasi-electrostatic whistler-mode propagation of auroral hiss. In e-POP crossings of auroral arcs, simultaneous measurements from FAI and RRI confirm that stable NIR auroral arcs locate the spectrographic vertex of V-shaped VLF hiss emission. We are evaluating concepts proposed for the structure and dynamics of auroral-latitude phenomena by recourse to data from various e-POP and ground instruments.

Dual ExB Flow Responses in the Dayside Ionosphere to a Sudden IMF By Rotation

Abstract ID : 1175

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Stefan Eriksson ,eriksson@lasp.colorado.edu ,(Research Associate) ,United States ,Boulder ,Not Presenting[1]

Dr. Maimaitirebike Maimaiti ,rafiq@vt.edu ,(None) ,United States , ,Not Presenting[2]

Prof. Joseph Baker ,bakerjb@vt.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Karlheinz Trattner ,Karlheinz.Trattner@lasp.colorado.edu ,(Scientist) ,United States ,BOULDER ,Not Presenting[4]

Prof. Delores Knipp ,delores.knipp@colorado.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Frederick Wilder ,Frederick.Wilder@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[6]

1 - CU/LASP 2 - Virginia Tech 3 - Virginia Tech 4 - LASP, University of Colorado 5 - University of Colorado 6 - LASP

We report for the first time a dual transition state in the dayside ionosphere following a sudden (5-s duration) rotation of the interplanetary magnetic field (IMF) in the upstream magnetosheath from IMF By<0 to By>0 during Bz<0. SuperDARN **E**x**B** drifts respond with different time delays in the dayside auroral zone and high-latitude polar cap with an initial 11 min transition state of oppositely directed **E**x**B** drifts coexisting at these locations. This is followed by a 6-8 min rotation of lower latitude **E**x**B** flow from dusk to the expected dawnward direction. We propose that this sequence of events is consistent with two separate X-lines coexisting on the subsolar and lobe magnetopause. Time delays for merged flux of the draped preceding IMF to exit the subsolar region are proposed before the new IMF may be processed along a newly reconfigured component reconnection X-line. A strong direct correlation is also observed with no discernable time delay between magnetosheath plasma density and auroral zone **E**x**B** speeds. Finally, we compare the observations by Cluster and SuperDARN and the predicted orientation of the dayside reconnection X-line with the results of a dedicated MHD model run.

A statistical analysis of the longitudinal location of the southern polar cusp using Pc5 geomagnetic field fluctuations at a pair of Antarctic stations

Abstract ID : 1258

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. DOMENICO DI MAURO ,domenico.dimauro@ingv.it ,(None) , , ,Not Presenting[1]

Mrs. Patrizia Francia ,patrizia.francia@aquila.infn.it ,(None) ,Italy , ,Not Presenting[2]

Mrs. Lili Cafarella ,lili.cafarella@ingv.it ,(None) ,Italy , ,Not Presenting[1]

Mrs. Stefania Lepidi ,stefania.lepidi@ingv.it ,(None) ,Italy , ,Not Presenting[1]

1 - INGV 2 - Univ. degli studi dell'Aquila,L'Aquila 3 - INGV 4 - INGV

Low frequency geomagnetic field measurements (approximately in the Pc5 range, f ~2-7 mHz) at two Antarctic stations are used to statistically investigate the longitudinal location of the polar cusp. The two stations are Mario Zucchelli (geographic coordinates: 74.7°S, 164.1°E; corrected geomagnetic coordinates: 80.0°S, 307.7°E) and Scott Base (geographic coordinates: 77.8°S 166.8°E; corrected geomagnetic coordinates: 80.0°S 326.5° E), located in the polar cap at the same geomagnetic latitude, close to the cusp latitude; they are separated by one hour in magnetic local time.
At each station the Pc5 power maximizes when the station is nearest to the cusp, i.e. around magnetic local noon. The comparison between the Pc5 power at the two stations allows to determine the longitudinal location of the cusp. Our analysis is conducted considering separately the different seasons as well as different values of the solar wind parameters.
The results indicate longitudinal shifts of the polar cusp depending on the interplanetary magnetic field orientation and solar wind dynamic pressure; they are discussed in relation to previous studies based on observations from polar magnetospheric satellite.

A22 - Magnetospheres of Other Planets (DIV III)

Highlights from the Cassini magnetometer instrument at Saturn

Abstract ID : 800

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Michele Dougherty ,m.dougherty@imperial.ac.uk ,(None) , , ,Presenting[1]

1 - Imperial College London

Highlights and lessons learned from the Cassini magnetic field observations made during the orbital tour within the Saturn system will be described. These discoveries encompass topics including the magnetosphere and its aurora, Saturn's internal dynamo magnetic field with its high degree of axial symmetry, the planetary period oscillations which fill the magnetosphere, the icy satellites of Saturn (and Enceladus in particular), as well as the large moon Titan.

Universal Process Involving Wave-Particle Interactions

Abstract ID : 1048

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Richard Thorne ,rmt@atmos.ucla.edu ,(Research Professor) ,United States ,Garden Valley ,Not Presenting[1]

1 - University of California Los Angeles

Energetic particles trapped within the magnetic field of a planet are naturally unstable to the excitation of magnetospheric plasma waves. During wave-particle interactions, the electric and magnetic fields of these waves cause a violation of the particle's first adiabatic invariant leading to scattering in both pitch-angle and energy. An important consequence of such scattering is a lowering of the particle mirror point and ultimate loss of the particle through collisions in the planetary atmosphere. Such scattering places a limit on the stably trapped radiation belt flux and produces a global distribution of diffuse auroral emission on magnetized planets. The waves can also act to transfer energy from the predominant thermal radiation belt population to higher energies during the process of stochastic energy diffusion, leading to the formation of a high-energy tail population, which characterize planetary radiation belts. Recent modeling has been able to quantify the importance of such wave-particle interactions on the dynamic variability and global structure of planetary radiation belts. Similar processes are expected to play an important role in the magnetosphere of other celestial objects such as neutron stars.

A23 - Reporter Review for Division III

Magnetotail Dynamics

Abstract ID : 214

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Mikhail Sitnov ,Mikhail.Sitnov@jhuapl.edu ,(PPS) ,United States ,Laurel ,Not Presenting[1]

1 - JHU/APL

A key process in the interaction of planetary magnetospheres with the solar wind is the explosive release of energy stored in their magnetotails. The energy release is associated with global reconfigurations of the tail that relax strongly stretched magnetic field lines making them more dipolar. The explosive release of energy has long been associated with the onset of magnetic reconnection. However, observed manifestations of magnetotail explosions include both signatures of reconnection and non-reconnection phenomena, such as fast buoyancy-driven motions of localized flux tubes with reduced plasma content. Here we discuss recent progress in theory, simulations and observations of magnetotail dynamics with the special focus on the mechanism of its explosive reconfigurations. This includes case and statistical studies of the tail activity as well as empirical magnetotail models, global MHD and kinetic simulations.

Reporter Review 2015-2017: Ultra Low Frequency Waves

Abstract ID : 240

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited Presentation

Dr. Michael Hartinger ,mdhartin@vt.edu ,(Research Assistant Professor) ,United States ,Hampton ,Not Presenting[1]

1 - Virginia Polytechnic Institute and State University

This review highlights results from Ultra Low Frequency (ULF) wave studies during the period 2015-2017. Multi-satellite constellations and expanded ground-based instrumentation are routinely providing global measurements of ULF wave properties. At the same time, new instrumentation and modeling capabilities are providing new perspectives on wave-particle interactions and energy transfer throughout the magnetosphere-ionosphere system. These topics are reviewed in the context of several recent studies that have advanced our understanding of ULF wave excitation and the role of ULF waves in magnetosphere-ionosphere coupling and inner magnetosphere particle dynamics.

Reporter Review on Auroral Processes

Abstract ID : 436

Conflict Declaration : None

Content Motivation : None

Additional Information : This abstract has been invited in place of the tentative report by Hanna Dahlgren

Dr. Colin Forsyth ,colin.forsyth@ucl.ac.uk ,(NERC Independent Research Fellow) ,United Kingdom ,Dorking ,Not Presenting[1]

1 - UCL

Auroral emissions are a key indicator of plasma-physical processes in interconnected solar wind-magnetosphere-ionosphere systems. Their large-scale morphoology reflects the configuration and reaction of magnetospheres to a variety of internal and external drivers. Their small-scale dynamics can unlock the plasma physics behind particle acceleration and reveal plasma instability processes that are critical to the release of magnetic energy. The relative ease with which auroral observations can be made and the fact that auroral observations can be made covering vast swathes of the sky means that they are a key window into the physics and dynamical processes that govern magnetosphere-ionosphere interactions.

The continued development of new imaging technology and data processing techniques means that we are able to challenge the basic assumptions about the physical processes behind the aurora at the Earth and other planets in the solar system. In this invited review, I will examine the advances in our understanding of the processes behind and within the aurora made since 2015.

Reporter Review 2015-2017: Magnetopause and Boundary Layers

Abstract ID : 548

Conflict Declaration : None

Content Motivation : None

Additional Information : Representing the MMS science team Invited talk

Dr. Steven Petrinec ,steve.petrinec@gmail.com ,(Physicist Senior Staff) ,United States ,Belmont, CA 94002 ,Not Presenting[1]

1 - Lockheed Martin ATC

There has been considerable progress during the past two years in the understanding of the physical processes occurring at the Earth's magnetopause and its surrounding boundary layers. Much of this progress is attributed to the very successful NASA Magnetospheric Multiscale mission (MMS). This set of four identically-instrumented spacecraft (launched in March 2015) was optimized to sample the magnetopause and boundary layers as often as possible, and to target the sites of magnetopause reconnection; especially the ion and electron diffusion regions. The tight formation and unprecedented sampling cadences have provided significant new understanding of this geophysical boundary, and of the interaction between the solar wind and Earth's magnetosphere. A review of the new scientific results during the past two years relating to the magnetopause and boundary layers from MMS, and coordinated studies with other active missions such as THEMIS and Cluster is presented.

Reporter Review: Global Magnetospheric Dynamics

Abstract ID : 743

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Toshi Nishimura ,ynishimura11@gmail.com ,(Researcher) ,United States ,Boston ,Not Presenting[1]

1 - UCLA/Boston University

This talk will review global magnetospheric dynamics research in year 2015-2017. The topics include solar-wind magnetosphere interaction, tail-inner magnetosphere interaction, and magnetosphere-ionosphere coupling. All research means including numerical modeling, multi-satellite/ground-based observations and theory are considered.

Wave-particle interactions in inner magnetosphere

Abstract ID : 948

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Maria Usanova ,maria.usanova@lasp.colorado.edu ,(None) ,United States ,Boulder ,Not Presenting[1]

1 - LASP, CU Boulder

Understanding the mechanisms of build up and decay of radiation belt electron fluxes is one of the fundamental problems of modern space physics having an important application in relation to human technological systems, as energetic particles can pose danger to astronauts working in orbit, and damage space-born instrumentation and satellites. Despite more than a 50-year history of research in this area, the radiation belt physics is yet to be fully understood. Quantification of electron transport, acceleration and loss is crucial for building "space weather" prediction models and understanding the dynamics of the outer radiation belt. As energetic particles undergo cyclotron and bounce motion between magnetic mirror points and azimuthal drift in the Earth's magnetosphere, they encounter several distinct classes of plasma waves. These waves contribute to both particle energization and precipitation into the Earth's atmosphere and ultimate loss. In this talk, I will review recent works advancing our understanding of various plasma wave modes and their role in the energetic particle dynamics in inner magnetosphere.

A24 - The Plasmasheet-Ionosphere, a Coupled System: Sinks, Sources, Transport and the Roles of Field-Aligned Currents and Ion Outflow (DIV III – DIV II)

Plasma Upflow from the Earth's Upper Atmosphere during a Solar Minimum

Abstract ID : 190

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Timothy David ,twd2@le.ac.uk ,(Ph.D. student) ,United Kingdom ,Leicester ,Not Presenting[1]

Prof. Steve Milan ,ets@le.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Darren Wright ,dmw7@le.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Leicester 2 - University of Leicester 3 - University of Leicester

Heavy ion of atmospheric origin plays a crucial role in determining the mass and energy density of the overlying magnetosphere. We have investigated ions from the upper atmosphere at a flux threshold of 10^13/m^2/s using the data during the IPY-ESR 2007 campaign. Upflows above this threshold are further classified into low, medium and high flux. It is discovered that the high flux rarely occur while the low category is a frequent phenomenon. Analysis of the ESR data shows that the occurrence frequency maximizes around local noon for all classes of flux, however, the upflow flux is skewed to the night side for the low class. A further analysis of upflow flux in relation with geomagnetic index, Kp, indicates that upflow occurrence increases as the level of geomagnetic disturbance increases. About 31%, 16% and 2% occurrence peak is observed in the respective low, medium and high upflow during geomagnetically disturbed period. In addition, we have attempted to distinguish between ambipolar and Joule heating effects using the pressure balance equation. Periods of strong ambipolar electric force leading to ion upflow are observed both around the cusp and nightside aurora. Statistical analysis shows that short duration events are most frequent and cover about 40.9% and 45.9% on the dayside and nightside respectively, while about13.6% traverse both sectors. The ambipolar electric force predominantly drives about 59.3% of the total events which is about seven times the total events driven by the Joule heating only.

The dynamics and structure of current systems during dipolarization events

Abstract ID : 678

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Emil Kepko ,larry.kepko@nasa.gov ,(None) ,United States ,None ,Not Presenting[1]

Mr. Joachim Birn ,jbirn@SpaceScience.org ,(None) ,United States , ,Not Presenting[2]

Dr. Brian Anderson ,brian.anderson@jhuapl.edu ,(None) ,United States , ,Not Presenting[3]

1 - NASA/GSFC 2 - Space Science Institute 3 - JHU/APL

During MMS Phase 1x, the MMS tetrahedron passed through the nightside transition region at slightly off-equatorial locations. This orbit was well suited to study the field-aligned currents generated by both the large-scale reconfiguration of the magnetic field during substorms (dipolarization) and the smaller scale, transient reconfigurations directly associated with flow bursts (dipolarization fronts). In this paper, we present the results of a survey of these two types of dipolarization events. While the substorm current wedge (SCW) is able to represent the large scale characteristics of these current systems, it represents an integration of many small scale current systems. The relationship between small-scale, filamented currents observed in the magnetosphere and the larger current system is not well understood. Using the 4-point magnetic field measurements of MMS to calculate the local current densities for dipolarizations and dipolarization fronts, we compare the in situ observations with MHD model results, AMPERE measurements, and ground magnetometer data, to yield new insight into the dynamics and structure of transition region current systems and how they couple to the ionosphere.

Determining current sheet properties using multi-point measurements from the MMS mission

Abstract ID : 693

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Maria Andriopoulou ,maria.andriopoulou@oeaw.ac.at ,(Research associate) ,Austria ,Graz ,Presenting[1]

Dr. Rumi Nakamura ,rumi.nakamura@oeaw.ac.at ,(office) ,Austria ,Graz ,Not Presenting[2]

Dr. Anton Artemyev ,aartemyev@igpp.ucla.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Wolfgang Baumjohann ,Wolfgang.Baumjohann@oeaw.ac.at ,(None) ,Austria , ,Not Presenting[4]

Prof. Christopher Russell ,ctrussell@igpp.ucla.edu ,(None) ,United States , ,Presenting[5]

Dr. John Dorelli ,john.dorelli@nasa.gov ,(None) ,United States , ,Presenting[6]

1 - Space Research Institute, Austrian Academy of Sciences 2 - IWF/OEAW 3 - University of California Los Angeles 4 - Space Research Institute, Austrian Academy of Sciences, Graz, Austria 5 - UCLA 6 - NASA/GSFC

The very small interspacecraft distances achieved in the Magnetospheric Multiscale (MMS) mission and the unprecedented time resolution of the plasma and field measurements of the instruments onboard each spacecraft allow us to study the properties of magnetotail current sheet crossings in great detail in terms of their spatial and temporal evolution and resolve several cases in ion and electron scales. In the present study we focus on the structure of two event studies of thin current sheets during the MMS commissioning phase, which lasted till August 2015, considering multispacecraft magnetic and plasma field observations. The results of this study could be a useful input for current sheet models and simulations.

The time response of the plasmasheet Earth O+ density to the solar wind

Abstract ID : 721

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Romain Maggiolo ,maggiolo@aeronomie.be ,(Research Scientist) ,Belgium ,Brussels ,Presenting[1]

Dr. Maria Hamrin ,maria.hamrin@space.umu.se ,(None) ,Sweden , ,Not Presenting[2]

Dr. Gael Cessateur ,cessateur@aeronomie.be ,(None) ,Belgium , ,Not Presenting[1]

Dr. Johan De Keyser ,johandk@aeronomie.be ,(None) ,Belgium , ,Not Presenting[1]

Dr. Herbert Gunell ,gunell@aeronomie.be ,(None) ,Belgium , ,Not Presenting[1]

Mr. Lukas Maes ,maes@aeronomie.be ,(None) ,Belgium , ,Not Presenting[1]

Mr. Timo Pitkänen ,timo.pitkanen@space.umu.se ,(None) ,Sweden , ,Not Presenting[2]

1 - royal Belgian Institute for Space Aeronomy 2 - Umeå University 3 - royal Belgian Institute for Space Aeronomy 4 - royal Belgian Institute for Space Aeronomy 5 - royal Belgian Institute for Space Aeronomy 6 - royal Belgian Institute for Space Aeronomy 7 - Umeå University

The plasmasheet is the main plasma reservoir of the Earth's outer magnetosphere. It consists of a mixture of ions originating from the solar wind and from the ionosphere. Contrary to the solar wind, ionospheric ions contain a significant amount of O^+ ions which can be used as tracers of the ionospheric material. The ionospheric ion outflow rate, its composition and the transport of ionospheric ions from the ionosphere to the plasmasheet are modulated by the solar wind conditions. This modulation of the ionospheric source impacts the plasmasheet composition, in particular the amount of O^+ ions, with some time delay related to ionospheric ion outflow and transport processes. In order to quantify the ionospheric contribution to the plasmasheet, we use long-term O^+ density measurements from the CODIF ion detector onboard the Cluster spacecraft. CODIF data are mapped along magnetic field lines to produce bi-dimensional maps of the O^+ ions density in the magnetospheric equatorial plane. This has the advantage of improving the statistics as we get rid of the field aligned dimension. We focus on two regions, the inner magnetosphere at geocentric distances between 7 and 8 R_E and the mid-tail region at distances between 15 and 20 R_E. In these two regions, we investigate the correlation between a set of solar wind parameters (density, velocity, dynamic pressure and magnetic field components) and the O^+ density as a function of the time delay between O^+ density and solar wind parameters measurement. We identify the solar wind parameters that have the strongest impact on the plasmasheet O^+ density - and thus on ionospheric ion outflow

and transport processes - as well as the associated response times. We discuss the implication of these results for our understanding of ionospheric ion sources and outflow processes.

Space-ground coordinated observations of subauroral ion drifts

Abstract ID : 744

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Toshi Nishimura ,ynishimura11@gmail.com ,(Researcher) ,United States ,Boston ,Presenting[1]

Dr. Bea Gallardo-Lacourt ,bgallardo@atmos.ucla.edu ,(None) ,United States , ,Not Presenting[2]

Mr Eric Donovan ,edonovan@ucalgary.ca ,(None) ,Canada , ,Not Presenting[3]

1 - UCLA/Boston University 2 - UCLA 3 - The University of Calgary

Duskside plasma convection is often enhanced at narrow latitudes just equatorward of the electron auroral oval (subauroral polarization streams or SAPS). The latitudinal extent of the flows can occasionally become less than a degree with the peak speed exceeding a few km/s. Those are called subauroral ion drifts (SAID), and their formation mechanism and differences from SAPS have been key issues in subauroral magnetosphere-ionosphere coupling.

We aim at understanding occurrence timing and magnetospheric drivers of SAID by using optical imaging, radars, and low-altitude and magnetospheric satellites. Interestingly, although SAID is a subauroral phenomenon where we do not generally expect localized precipitation, all-sky imager data during a subset of SAID events showed a latitudinally narrow (~0.5 deg) auroral arc adjacent to SAID. This unique auroral feature allowed us to optically trace evolution of SAID. We found that SAID was preceded by substorm injections and SAPS, and that subsequent injections without strong proton injection resulted in SAID. This different injection behavior was confirmed by the NOAA and DMSP satellites. DMSP also showed that the bulk of the region-2 field-aligned currents (FACs) are confined to the SAID latitudinal extent. In one of the events, one of the THEMIS satellites crossed the earthward boundary of the electron plasma sheet and detected SAID with much narrower L-shell separation between electron and ion inner boundaries.

These observations indicate that SAID has a similar quasi-steady structure to SAPS both in the ionosphere and magnetosphere except for the latitudinal extent, but the type of particle injection is quite different from SAPS events; namely the injections are dominated by electrons and give much smaller separation with the ion inner boundary.

Storm-time plasma sheet, ionosphere and inner magnetosphere coupling: the Alfvén wave unleashed

Abstract ID : 762

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited Talk

Dr. Christopher Chaston ,ccc@ssl.berkeley.edu ,(None) ,United States ,Berkeley ,Presenting[1]

Rev. Van Allen Probes Team Empty ,vap@coauthors.net ,(None) ,United States , ,Not Presenting[2]

Rev. THEMIS Team ,themis@coauthors.net ,(None) ,United States , ,Presenting[2]

1 - UC Berkeley 2 - NASA 3 - NASA

Recent observations from the Van Allen Probes and the THEMIS spacecraft have demonstrated the persistence and prevalence of intense Alfvénic field variations throughout the nightside magnetosphere during storm times. In this presentation we review the dynamics and some surprising consequences of energy transport and conversion in these waves that have rather dramatic implications for the macro-scale evolution of the magnetosphere and space weather. In particular it is shown how energy transport into the inner magnetosphere during storm time by these waves can extract ions from the topside ionosphere, contribute to pumping up the content and energy density of the ring current and may modulate the radiation belts. The connection between the micro-scale physical interactions in Alfven waves to the macro-scale evolution has become possible due to the simultaneous collection of high temporal and spatial resolution multi-point field and particle measurements which we highlight in this presentation.

Ring current spatio-temporal evolution affected by plasma sheet conditions and magnetosphere-ionosphere coupling

Abstract ID : 1125

Conflict Declaration : None

Content Motivation : None

Additional Information : This is an invited talk.

Dr. Kunihiro Keika ,keika@eps.s.u-tokyo.ac.jp ,(Assistant Professor) ,Japan ,Tokyo ,Not Presenting[1]

1 - University of Tokyo

The ring current in the Earth's inner magnetosphere is determined by the ion pressure and its spatial gradient. The ion pressure is dominated by ions with energies of one to a few 100s keV, which are mostly transported from the near-Earth plasma sheet. The earthward transport is mainly controlled by convection electric field induced from the solar wind (potential) and the electric field associated with magnetic field reconfiguration (inductive). Plasma sheet population is adiabatically accelerated during the transport; the extent of acceleration depends on the depth of transport toward the Earth (i.e., penetration depth), which can be determined by the strength of the electric field. The spatial pattern of the electric field is thus a key to understanding the ring current evolution. The Magnetosphere-Ionosphere (M-I) coupling affects the spatial pattern; for example, it can be distorted near the inner edge of the ring current region due to electric field shielding and/or additional electric field associated with sub-auroral polarization streams (SAPs). Plasma sheet conditions such as density and temperature also play an important role in controlling the ring current buildup, as have been well demonstrated by modeling studies. Ion composition is also an important factor to determine the intensity of the ring current, as the oxygen-to-hydrogen pressure ratio increases with increasing intensity. In this talk, we will introduce plasma sheet conditions and M-I coupling that can affect the spatial-temporal evolution of the ring current, and also present recent results from observational and modeling studies.

Transport of Entropy Structures in the Magnetotail

Abstract ID : 1172

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jay Johnson ,jrj@andrews.edu ,(None) ,United States ,Michigan ,Not Presenting[1]

Prof. Yu Lin ,linyu01@auburn.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Simon Wing ,simon.wing@jhuapl.edu ,(None) ,United States ,Laurel ,Not Presenting[3]

Mr. X Wang ,xywang@physics.auburn.edu ,(None) ,United States , ,Not Presenting[2]

Prof. J Perez ,perez@physics.auburn.edu ,(None) ,United States , ,Not Presenting[2]

1 - Andrews University 2 - Auburn University 3 - Johns Hopkins University 4 - Auburn University 5 - Auburn University

Plasma sheet flows are a fundamental mode of magnetospheric energy transport. Entropy conservation is a key organizing principle that is thought to describe the general characteristics of these flows. We discuss the development and evolution of entropy-depleted structures in 3-D global hybrid simulations and their implications for global transport in the magnetotail. The formation of the bubbles primarily results from changes in the magnetic field line configuration associated with tail reconnection. The bubbles are associated with earthward fast flows when they develop on the earthward side of an X-line. The entropy-depleted structures are injected deep into the magnetosphere through an interchange of flux tubes. As the flux tubes propagate earthward the flux tube entropy increases due to nonadiabatic processes. Wave compressions lead to periodic enhancements in temperature at the equatorial region of the flux tube, and these enhancements propagate toward the ionosphere, while the overall flux tube entropy increases. We discuss implications for magnetotail transport and the role of waves in dissipating the flow energy.

Field Line Mapping with Electron Beams

Abstract ID : 1181

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jay Johnson ,jrj@andrews.edu ,(None) ,United States ,Michigan ,Not Presenting[1]

Mr. Tasman Powis ,apowis@princeton.edu ,(None) ,United States , ,Not Presenting[2]

Mr. Jake Willard ,jakewillard55@gmail.com ,(None) ,United States , ,Not Presenting[1]

Mr. Igor Kaganovich ,ikaganovich@pppl.gov ,(None) ,United States , ,Not Presenting[2]

Dr. Peter Porazik ,pporazik@pppl.gov ,(None) ,United States , ,Not Presenting[5]

Dr. Ennio Sanchez ,ennio.sanchez@sri.com ,(None) ,United States , ,Not Presenting[6]

1 - Andrews University 2 - Princeton University 3 - Andrews University 4 - Princeton University 5 - Princeton Plasma Physics Laboratory 6 - SRI

New accelerator technologies have made it possible to produce a light-weight compact electron beam accelerator that can be installed on a small-to-medium satellite. We discuss how relativistic electron beams launched from a satellite propagate in the magnetospheric environment. In particular, we examine whether electron beams can carry adequate energy flux into the ionosphere, where they can be detected and provide a map between the satellite location and the ionospheric footpoint. We discuss stability of the beam and how the magnetic field configuration (curvature), background plasma profile, and beam properties control the electron flux at the ionosphere. Such beams could provide valuable information about field line mapping that could be useful for understanding dynamics in the near-earth plasma sheet and radiation belts.

Challenges in Understanding and Modeling Subauroral Polarization Streams (SAPS)

Abstract ID : 1511

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Phillip Anderson ,phillip.anderson1@utdallas.edu ,(Professor) ,United States ,Richardson, TX ,Not Presenting[1]

Mr. Russell G. Landry ,rxl123930@utdallas.edu ,(None) ,United States , ,Not Presenting[2]

1 - University of Texas at Dallas 2 - W. B. Hanson Center for Space Sciences University of Texas at Dallas

SAPS are a profound example of Ionosphere/Thermosphere/Magnetosphere coupling. They lie on subauroral field lines that map to the inner magnetosphere and modify magnetospheric convection. Indeed, the potential drop across them has been shown to sometimes exceed 70 kV, constituting more than half of the total cross-polar-cap-potential drop at times. They modify the plasmasphere and thus impact the energization and loss processes in the radiation belts. They reduce the ionospheric conductivity providing a feedback mechanism that further modifies the subauroral fields and thus the convection in the inner magnetosphere. They also impact the thermosphere producing significant thermospheric winds that impact the thermospheric structure. Thus it is critical that we develop a complete understanding of the phenomenon and the ability to accurately model it. Even after decades of study, there are many things that we still don't fully understand about SAPS. For instance, what is the importance of ionospheric preconditioning and the mid-latitude trough on SAPS formation and development? How does the ionosphere/thermosphere system respond and how does that response impact SAPS evolution? What is the role of field-aligned currents and how does their evolution impact SAPS evolution? How does the distribution of precipitating auroral particles at the equatorward edge of the auroral oval impact SAPS development? How are SAPS observed during storms different from SAPS observed during isolated substorms and what is the importance of storm/substorm phase on SAPS structure? I will give a review of what we know about SAPS and discuss these outstanding questions and the implications on our attempts to model the SAPS phenomenon.

A25 - Magnetic reconnection (DIV III – DIV IV)

MMS Observations of Energetic Particle Escape Associated with Magnetic Reconnection

Abstract ID : 120

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ian Cohen ,ian.cohen@jhuapl.edu ,(Senior Professional Staff) ,United States ,Laurel ,Presenting[1]

Dr. Brian Anderson ,brian.anderson@jhuapl.edu ,(None) ,United States , ,Not Presenting[1]

Dr. David Sibeck ,david.g.sibeck@nasa.gov ,(None) ,United States , ,Not Presenting[3]

Dr. Drew Turner ,drew.l.turner@aero.org ,(None) ,United States , ,Not Presenting[4]

Dr. Daniel Baker ,daniel.baker@lasp.colorado.edu ,(Director and Distinguished Professor, Laboratory for Atmospheric and Space Physics, University of Colorado Boulder) ,United States ,Boulder ,Not Presenting[5]

Dr. J Bernard Blake ,jbernard.blake@aero.org ,(Aerospace Fellow) ,United States ,Los Angeles ,Not Presenting[4]

Dr. Barry Mauk ,barry.mauk@jhuapl.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Joseph Westlake ,joseph.westlake@jhuapl.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Joseph Fennell ,Joseph.F.Fennell@aero.org ,(None) ,United States , ,Not Presenting[4]

Dr. Trevor Leonard ,Trevor.Leonard@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Geoffrey Reeves ,reeves@lanl.gov ,(None) ,United States , ,Not Presenting[11]

Dr. Harlan Spence ,harlan.spence@unh.edu ,(None) ,United States , ,Not Presenting[12]

Dr. Allison Jaynes ,Allison.Jaynes@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[13]

1 - JHU/APL 2 - JHU/APL 3 - NASA GSFC 4 - The Aerospace Corporation 5 - University of Colorado Boulder 6 - The Aerospace Corporation 7 - JHU/APL 8 - JHU/APL 9 - The Aerospace Corporation 10 - University of Colorado Boulder 11 - LANL 12 - University of New Hampshire 13 - CU-LASP

Observations from the Energetic Particle Detector (EPD) instrument suite on the Magnetospheric Multiscale (MMS) spacecraft show that energetic (greater than tens of keV) magnetospheric particle escape into the magnetosheath occurs commonly, generally irrespective of conditions that engender reconnection and boundary-normal magnetic fields. Of great interest is the unexpectedly common simultaneous monohemispheric streaming of multiple species (electrons, H, He) in the dayside, dusk quadrant of the magnetosheath even though that region is thought to be drift-shadowed from energetic electrons. This signature is sometimes part of a pitch angle distribution evolving from symmetric in the magnetosphere, to asymmetric approaching the magnetopause, to monohemispheric streaming in the magnetosheath. While monohemispheric streaming in the magnetosheath may be possible without a boundary-normal magnetic field, the additional pitch angle depletion, particularly of electrons, on the magnetospheric side requires one. Statistical analysis of observations from MMS's first dayside magnetopause season show that generally energetic electron escape, in particular, occurs much more frequently during southward IMF. We also find that while energetic electron escape occurs across nearly all magnetic local times (MLT) on the dayside, a peak exists at approximately 15:00 MLT. We hypothesize that this may be correlated with the location where the draped interplanetary magnetic field lines nominally intersect with the dayside magnetosphere. In general, the apparent ubiquity of energetic electron escape at the dayside magnetopause implies that the dynamics of energetic particles in the outer magnetosphere are more complex than suggested by the static picture of magnetospheric drift-shadowing.

Electron particle dynamics in collisionless magnetic reconnection

Abstract ID : 121

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Seiji Zenitani ,seiji.zenitani@nao.ac.jp ,(Research Assistant Professor) ,Japan ,Mitaka/Tokyo ,Not Presenting[1]

Dr. Hiroshi Hasegawa ,hase@stp.isas.jaxa.jp ,(None) ,Japan , ,Not Presenting[2]

Prof. Tsugunobu Nagai ,nagai@geo.titech.ac.jp ,(None) ,Japan , ,Not Presenting[3]

1 - 2 - JAXA/ISAS 3 - Tokyo Tech

In order to study the inner workings of magnetic reconnection, NASA has recently launched Magnetospheric Multiscale (MMS) spacecraft. MMS observes electron-physics signatures such as velocity distribution functions (VDFs) at ultrahigh resolution in space. Since VDFs and other signatures are outcomes of electron kinetic motion, it is important to understand the electron orbits in the reconnection system. In this work, we study electron orbits and dynamics near the X-line, by using two-dimensional particle-in-cell (PIC) simulations.

First, we study electron dynamics in magnetotail-type symmetric reconnection. By analyzing millions of electron orbits, we discovered many new orbits in the electron-physics layer near the X-line: (1) Figure-eight-shaped regular orbits inside the electron jet, (2) noncrossing Speiser orbits that do not cross the midplane, (3) noncrossing regular orbits on the jet flanks, and (4) nonadiabatic orbits in the downstream of the jet termination region. Among them, the noncrossing orbits are mediated by the polarization electric field (Hall electric field E_z) near the midplane. Properties of these orbits are organized by an electrostatic extension of the particle-orbit theory (Buchner & Zelenyi 1989 JGR). Surprisingly, the new noncrossing electrons appear to be the majority in the system. This raises a serious question to our present understanding of physics of collisionless magnetic reconnection, which only assumes crossing populations. We will also discuss spatial distribution of energetic electrons and observational signatures of noncrossing electrons.

Second, we study electron dynamics in magnetopause-type asymmetric reconnection. In this case the polarization electric field enhances the meandering motions of sheath-origin electrons. They are evident in a crescent-shaped VDF, as highlighted in recent studies (Hesse+ 2014 GRL, Burch+ 2016 Science). The chaotic electron orbits are found in conjunction with the violation of the electron idealness in the sheath-side vicinity of the X-line and inside the outflow exhaust.

Finally, we will organize our understanding of electron physics in collisionless magnetic reconnection, based on the two investigations.

References:

1 Zenitani and Nagai, *Phys. Plasmas*, 23, 102102 (2016)
2 Zenitani, Hasegawa, and Nagai, submitted to *J. Geophys. Res.*, Space Physics

Distinctive features of internally driven magnetotail reconnection

Abstract ID : 143

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Mikhail Sitnov ,Mikhail.Sitnov@jhuapl.edu ,(PPS) ,United States ,Laurel ,Not Presenting[1]

Dr. Viacheslav Merkin ,Slava.Merkin@jhuapl.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Philip Pritchett ,pritchett@physics.ucla.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Marc Swisdak ,swisdak@umd.edu ,(None) ,United States , ,Not Presenting[4]

1 - JHU/APL 2 - JHU/APL 3 - UCLA 4 - University of Maryland, College Park

Onset of reconnection in a tail-like equilibrium with a finite Bz magnetic field component is studied using 3-D explicit particle-in-cell simulations. Due to a region of a tailward Bz gradient the onset develops spontaneously as the magnetic flux release instability with dominant earthward ion flows. The instability drives the change of magnetic field topology internally, without any external forcing. The distinctive features of this regime are: previously unreported Hall magnetic field patterns; energy conversion near the dipolarization front prior to the X-line formation; and asymmetry of the energy conversion, plasma heating and anisotropy relative to the X-line, with regions of ion and electron heating out of phase both along and across the tail. These features distinguish the internally driven reconnection regime from similar processes in anti-parallel magnetic field configurations as well as interchange- and externally-driven magnetotail reconnection regimes, and can be used to identify the different regimes in upcoming MMS tail season observations.

Magnetotail Reconnection Ejecta: Building Blocks of Magnetospheric Activity

Abstract ID : 171

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Andrei Runov ,arunov@igpp.ucla.edu ,(None) ,United States ,Los Angeles ,Not Presenting[1]

1 - UCLA

Near-Earth magnetotail reconnection is considered as a trigger for dynamic processes in the night-side magnetosphere such as substorms, bursty bulk flows, and dipolarizations in the plasma sheet. Transient localized dipolarizations and associated electric field pulses , known as dipolarizing flux bundles (DFBs) and rapid flux transfers (RFTs) are remote signatures of near-tail reconnection. Statistical studies of DFBs/RFTs observed in the plasma sheet at geocentric distances 7 to 25 Earth's radii (RE) and at lunar orbit (~60 RE) in the tail revealed that they are localized in the sun-earth (X) and cross-tail (Y) directions and their equatorial cross-section dimensions are of 1 to 5 RE (tens of ion inertial lengths). These localized area of the enhanced north-south magnetic field component and cross-tail electric field field (reconnection ejecta) are dominantly observed in the pre-midnight magnetotail. This paper reports on results of statistical and event-based studies of reconnection ejecta properties, such as magnetic and electric fields, particle distributions and their moments, observed in near-Earth tail and at lunar orbit by THEMIS and ARTEMIS probes. The obtained results suggest that near-Earth reconnection is spatially and temporally localized. The characteristic spatial scales or reconnection ejecta and temporal scales of reconnection pulses are 10 to 100 ion inertial lengths and 5 to 10 proton gyroperiods, respectively. What determines these spatial and temporal scales remains an open question.

Characteristics of high latitude precursor flows ahead of dipolarization fronts

Abstract ID : 179

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Xuzhi Zhou ,xuzhi.zhou@gmail.com ,(Assistant Professor) ,China ,Beijing ,Not Presenting[1]

Dr. Qiugang Zong ,qgzong@pku.edu.cn ,(None) ,China , ,Not Presenting[1]

Dr. Vassilis Angelopoulos ,vassilis@ucla.edu ,(None) ,United States , ,Not Presenting[3]

Ms. Dongxiao Pan ,pdxsun122@gmail.com ,(None) ,China , ,Not Presenting[1]

Dr. Andrei Runov ,arunov@igpp.ucla.edu ,(None) ,United States ,Los Angeles ,Not Presenting[3]

Mr. Jiazheng Li ,lijiazheng2013@pku.edu.cn ,(None) ,China , ,Not Presenting[1]

Dr. Jiang Liu ,jliu@igpp.ucla.edu ,(None) ,United States , ,Not Presenting[3]

1 - Peking University 2 - Peking University 3 - UCLA 4 - Peking University 5 - UCLA 6 - Peking University 7 - UCLA

Dipolarization fronts (DFs), earthward-propagating structures in the magnetotail current sheet characterized by sharp enhancements of northward magnetic field, are capable of converting electromagnetic energy into particle kinetic energy. The ions previously accelerated and reflected at the DFs can contribute to plasma flows ahead of the fronts, which have been identified as DF precursor flows in both the near-equatorial plasma sheet and far from it, near the plasma sheet boundary. Using THEMIS (Time History of Events and Macroscale Interactions during Substorms) observations, we show that the earthward particle and energy flux enhancements ahead of DFs are statistically larger further away from the neutral sheet (at high latitudes) than in the near-equatorial region. High-latitude particle and energy fluxes on the DF dawnside are found to be significantly greater than those on the duskside, which is opposite to the dawn-dusk asymmetries previously found near the equatorial region. Using forward- and backward- tracing test-particle simulations, we then explain and reproduce the observed latitude-dependent characteristics of DF precursor flows, providing a better understanding of ion dynamics associated with dipolarization fronts.

MMS Observations of Electron Heating near the Magnetic Reconnection X-line

Abstract ID : 327

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Tai Phan ,phan@ssl.berkeley.edu ,(None) ,United States ,Berkeley ,Presenting[1]

Dr. James Burch ,JBurch@swri.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Colby Haggerty ,colbych@udel.edu ,(None) ,United States , ,Not Presenting[3]

Dr. John Dorelli ,john.dorelli@nasa.gov ,(None) ,United States , ,Not Presenting[4]

Dr. Thomas Moore ,thomas.e.moore@nasa.gov ,(None) ,United States , ,Not Presenting[4]

Dr. Michael Shay ,shay@udel.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Daniel Gershman ,daniel.j.gershman@nasa.gov ,(Research Scientist) ,United States ,Washington ,Not Presenting[7]

Dr. Barbara Giles ,barbara.giles@nasa.gov ,(None) ,United States , ,Not Presenting[4]

Dr. Masaki Fujimoto ,fujimoto.masaki@jaxa.jp ,(None) ,United States , ,Not Presenting[9]

1 - UC Berkeley 2 - SWRI 3 - U of Delaware 4 - NASA/GSFC 5 - NASA/GSFC 6 - U of Delaware 7 - University of Maryland, College Park 8 - NASA/GSFC 9 - ISAS/JAXA Japan

Most of the reconnecting magnetopause crossings by the MMS spacecraft occurred in the exhaust downstream of the X-line, but a number of them occurred in the vicinity of the X-line. We have compared the plasma properties of the current sheet near the X-line versus in the exhaust far downstream of the X-line. One of the clearest differences is the amount of electron heating, with the heating within the current sheet being substantially higher close to the X-line than downstream. The observed electron distributions near the X-line suggest that the heating is partially due to mixing of pre-energized electrons in the two inflow regions, in addition to electron acceleration by the reconnection electric field. These experimental findings should shed lights on the mechanisms that heat electrons in reconnection.

Magnetic reconnection and its manifestations in the Plasma Sheet Boundary Layer of the Earth's magnetotail

Abstract ID : 608

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Elena Grigorenko ,elenagrigorenko2003@yandex.ru ,(Leading scientist) ,Russia ,Moscow ,Not Presenting[1]

Dr. L. Zelenyi ,lzelenyi@iki.rssi.ru ,(None) ,Russia , ,Not Presenting[2]

Dr. J.-A. Sauvaud ,jsauvaud@irap.omp.eu ,(None) ,France , ,Not Presenting[3]

Prof. M. Hoshino ,hoshino@eps.s.u-tokyo.ac.jp ,(None) ,Japan , ,Not Presenting[4]

Dr. Elena Kronberg ,kronberg@mps.mpg.de ,(scientist) ,Germany ,Göttingen ,Not Presenting[5]

Dr. Andrei Runov ,arunov@igpp.ucla.edu ,(None) ,United States ,Los Angeles ,Not Presenting[6]

Dr. Benoit Lavraud ,Benoit.Lavraud@irap.omp.eu ,(Staff researcher) ,France ,Toulouse ,Not Presenting[3]

Dr. Patrick W. Daly ,daly@mps.mpg.de ,(None) ,Germany , ,Not Presenting[5]

1 - Space Research Institute of Russian Academy of Science, Russia 2 - Space Research Institute of Russian Academy of Science 3 - IRAP/CNRS 4 - University of Tokyo 5 - MPS 6 - UCLA 7 - IRAP/CNRS 8 - MPS

Magnetic reconnection is a powerful plasma accelerator which generates ion and electron beams and high-speed plasma flows streaming to large distances from the acceleration source. The energetic characteristics of these structures and features of their velocity distribution functions reflect the peculiarities of energy release in the reconnection region. In this sense the Plasma Sheet Boundary Layer (PSBL) of the Earth's magnetotail represents a particular interest since its magnetic field lines can be mapped directly to the reconnection site. Multipoint observations provided by Cluster, THEMIS/ARTEMIS, Geotail spacecraft showed various spatial and temporal characteristics of the accelerated plasma structures in the near-Earth, mid- and distant tail. In this talk we discuss different regimes of plasma acceleration associated with magnetic reconnection in the magnetotail current sheet and their PSBL and plasma sheet manifestations including spatial-temporal and energetic characteristics of the accelerated plasma structures observed at different distances from the Earth.
This work is supported by the Volkswagen Foundation (grant AZ 90 312)

MMS high time resolution observations of a Flux Transfer Event

Abstract ID : 801

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Lorenzo Trenchi ,Lorenzo.Trenchi@serco.com ,(None) ,Italy ,Roma ,Not Presenting[1]

Dr. Robert Fear ,R.C.Fear@soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - ESA - ESRIN 2 - University of Southampton

Time-varying reconnection at the Earth magnetopause generates magnetic structures called Flux Transfer Events (FTE) characterized by the typical bipolar variation in the magnetic field component normal to the magnetopause. Different generation mechanisms have been proposed: the original Russell and Elphic FTE model (1978) predicts a pair of elbow shaped flux tubes of reconnected field lines generated by intermittent and localized reconnection. Alternatively, Lee and Fu (1985) propose that FTEs are caused by reconnection along multiple extended X-lines while a third FTE model is based on bursty reconnection along a single X-line (Scholer et al. 1988; Southwood et al., 1988).
In this presentation, we present an FTE observed at the dayside magnetopause by MMS. This FTE is associated with a reconnection jet propagating at his trailing edge.
Moreover, the study of the high time resolution ions and electrons velocities measured by the Fast Plasma Instrument onboard MMS allowed to identify the Hall currents propagating along the magnetic separatrices located at the borders of the FTE.
These observations, which demonstrate that magnetic reconnection is active at the moment when the FTE is observed, have been discussed in the framework of the main FTE models cited above.

Particle energization turbulence-structured reconnection-electric-fields near current sheets of collisionless space plasmas

Abstract ID : 835

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Joerg Buechner ,buechner@mps.mpg.de ,(Research Group leader) ,Germany ,Goettingen ,Not Presenting[1]

1 - Max-Planck-Institute for Solar System Research, Goettingen, Germany

Magnetic reconnection is a powerful mechanism of transforming magnetic energy into plasma bulk flows, heat and the acceleration of particles to high energies. Reconnection takes place in solar and other astrophysical plasmas where its consequences can be remotely observed. But it also takes place in planetary magnetospheres and in the interplanetary space, the solar wind, where it can be investigated in situ as otherwise only in a limited range of parameters laboratory plasma chambers. Despite of all these research opportunities we still cannot predict the efficiency of the energy conversion by reconnection in dependence on ambient plasma parameters and configurations in collisionless astrophysical plasmas.
Currently the MMS mission has begun to carry out high resolution in situ observations of space plasma currents sheets and their micro-physics for different ambient plasma and magnetic field conditions. In particular, different intensities of turbulence and small scale electric fields parallel to the magnetic field were observed which seem to depend on the actual opening angle of the ambient reconnecting magnetic fields. It looks like these small scale phenomena determine also the overall efficiency of collisionless reconnection. In order to understand the relation between small scale processes and the observed reconnection processes kinetic numerical simulations were carried out which revealed the turbulence generated in current sheets in dependence on the opening angle of the ambient magnetic fields. It was shown that the turbulence supports the formation of parallel electric fields in a well-structured form of a propagating reconnection wave. The corresponding heating and acceleration rates of reconnection are theoretically derived and compared with MMS observations. Applications to astrophysical reconnection processes are discussed.

Reconnection signatures observed by MMS in the near-Earth magnetotail

Abstract ID : 1062

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Rumi Nakamura ,rumi.nakamura@oeaw.ac.at ,(office) ,Austria ,Graz ,Not Presenting[1]

Dr. Wolfgang Baumjohann ,Wolfgang.Baumjohann@oeaw.ac.at ,(None) ,Austria , ,Not Presenting[2]

Dr. James Burch ,JBurch@swri.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Bob Ergun ,Bob.Ergun@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Stephen A. Fuselier ,stephen.fuselier@swri.org ,(None) ,United States , ,Not Presenting[3]

Dr. Barbara Giles ,barbara.giles@nasa.gov ,(None) ,United States , ,Not Presenting[6]

Mr. Olivier Le Contel ,olivier.lecontel@lpp.polytechnique.fr ,(None) ,France , ,Not Presenting[7]

Dr. Per-Arne Lindqvist ,lindqvist@plasma.kth.se ,(None) ,United States , ,Not Presenting[8]

Dr. Barry Mauk ,barry.mauk@jhuapl.edu ,(None) ,United States , ,Not Presenting[9]

Dr. Christopher Russell ,ctrussel@igpp.ucla.edu ,(None) ,United States , ,Not Presenting[10]

Dr. Roy Torbert ,roy.torbert@unh.edu ,(None) ,United States , ,Not Presenting[11]

1 - IWF/OEAW 2 - Space Research Institute, Austrian Academy of Sciences, Graz, Austria 3 - SWRI 4 - LASP/UColorado 5 - SWRI 6 - NASA/GSFC 7 - LPP 8 - Uppsala 9 - JHU/APL 10 - UCLA 11 - UNH

Formation of the near-Earth magnetotail reconnection has been considered as a major energy conversion process leading to large-scale reconfiguration of the magnetotail. An important consequence of the magnetotail reconnection is the narrow fast plasma jet (known as bursty bulk flow), which contribute energy transport toward inner magnetosphere. Interaction with the reconnection jets and the Earth's dipole field lead to acceleration of particles, formation of field-aligned currents and associated auroral precipitation. In this way magnetotail reconnection and instabilities in the near-Earth current sheet have large-scale consequences as manifested during substorms. The Magnetosheric Multiscale (MMS) mission launched in March 2014, which traverse the near-Earth magnetotail with apogee 12 RE during the first two years and 20 RE afterwards, provides a unique opportunity to study detailed structures of the thin reconnection current sheets as well as the dynamic thin boundaries of the reconnection jets down to the electron scale for the first time. In this presentation, we show several examples of remote and in-situ observations of the near-Earth magnetic reconnection and associated boundary events based on multi-point analysis of the high-time resolution plasma and electric and magnetic field measurements from MMS.

The Onset of Magnetic Reconnection: Tearing Instability in Current Sheets with a Guide Field

Abstract ID : 1146

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Lars K. S. Daldorff ,Lars.Daldorff@jhuapl.edu ,(None) ,United States ,Laurel ,Presenting[1]

Mr. James A. Klimchuk ,james.a.klimchuk@nasa.gov ,(None) ,United States , ,Not Presenting[2]

Dr. James e. Leake ,james.e.leake@nasa.gov ,(None) ,United States , ,Not Presenting[2]

Mr. Kalman \Knizhnik ,kalman.knizhnik.ctr@nrl.navy.mil ,(None) ,United States , ,Not Presenting[4]

1 - JHU/APL 2 - NASA Goddard Space Flight Center 3 - NASA Goddard Space Flight Center 4 - NRL

Magnetic reconnection is fundamental to many solar phenomena, ranging from coronal heating, to jets, to flares and CMEs. A poorly understood yet crucial aspect of reconnection is that it does not occur until magnetic stresses have built to sufficiently high levels for significant energy release. If reconnection were to happen too soon, coronal heating would be weak and flares would be small. As part of our program to study the onset conditions for magnetic reconnection, we have investigated the instability of current sheets to tearing. Surprisingly little work has been done on this problem for sheets that include a guide field, i.e., for which the field rotates by less than 180 degrees. This is the most common situation on the Sun. We present numerical 3D resistive MHD simulations of several sheets and show how the behavior depends on the shear angle (rotation). We compare our results to the predictions of linear theory and discuss the nonlinear evolution in terms of plasmoid formation and the interaction of different oblique tearing modes. The relevance to the Sun is explained.

The effects of guide field on crescent electron distribution functions in asymmetric magnetic reconnection

Abstract ID : 1169

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Naoki Bessho ,naoki.bessho@nasa.gov ,(Visiting Assistant Research Scientist) ,United States ,Greenbelt ,Presenting[1]

Dr. Li-Jen Chen ,lijen@mailaps.org ,(None) ,United States , ,Not Presenting[1]

Dr. Michael Hesse ,michael.hesse@uib.no ,(None) ,Norway , ,Not Presenting[3]

1 - University of Maryland College Park/NASA Goddard Space Flight Center 2 - University of Maryland College Park/NASA Goddard Space Flight Center 3 - University of Bergen

NASA's Magnetospheric Multiscale (MMS) Mission have detected crescent-shaped electron distributions in electron diffusion regions (EDRs) during the Earth's magnetopause reconnection with/without a guide field. Crescent distributions are formed in the velocity plane perpendicular to the magnetic field, mainly due to the effect of the Hall electric field in the magnetospheric side of the EDR, and the meandering motion of electrons in the EDR. When there is a guide field, the meandering motion is modified, and particle orbits show a combination of meandering motion in the reconnecting magnetic field and gyro-motion in the guide field. We have derived formulas to explain the shape of electron distribution functions in the EDR of asymmetric reconnection with a guide field, and compared them with electron distributions in 2-D particle-in-cell (PIC) simulations. The electron motion is affected by the guide field, and electrons can access only a limited range in the velocity space. As a result, crescent electron distribution functions are modified. In the magnetospheric side of the EDR, mainly the positive V_x (outflow direction) side of the crescent shows up in distribution functions, while in the magnetosheath side of the EDR, mainly the negative V_x side of the crescent appears. In this presentation, we will show several particle trajectories obtained in a PIC simulation to explain the above features of crescent distributions in guide field reconnection, and we will compare theory and observation data obtained by MMS.

MMS Observations of Large Guide Field Magnetic Reconnection

Abstract ID : 1171

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Stefan Eriksson ,eriksson@lasp.colorado.edu ,(Research Associate) ,United States ,Boulder ,Presenting[1]

Dr. Frederick Wilder ,Frederick.Wilder@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Narges Ahmadi ,narges.ahmadi@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Bob Ergun ,Bob.Ergun@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[4]

Prof. Steve Schwartz ,s.schwartz@imperial.ac.uk ,(Professor of Space Physics) ,United Kingdom ,London ,Not Presenting[5]

Dr. Daniel Gershman ,daniel.j.gershman@nasa.gov ,(Research Scientist) ,United States ,Washington ,Not Presenting[6]

Prof. Robert Strangeway ,strange@igpp.ucla.edu ,(None) ,United States , ,Not Presenting[7]

Dr. James Burch ,JBurch@swri.edu ,(None) ,United States , ,Not Presenting[8]

1 - CU/LASP 2 - LASP 3 - CU/LASP 4 - LASP/UColorado 5 - Imperial College London 6 - University of Maryland, College Park 7 - UCLA 8 - SWRI

The MMS spacecraft recorded a spectacular Kelvin-Helmholtz (KH) event on 8 Sept 2015 across the post-noon magnetopause at a time when the spacecraft were separated by 160 km or roughly 2-4 ion skin depths. The KH surface wave resulted in a large number of periodically compressed magnetopause current sheets. Approximately half of these current sheets support various reconnection signatures such as ion and electron exhausts in the equatorial plane. The exploration of magnetic reconnection signatures across KH-related current sheets is now possible for the first time because of the fast plasma investigation instrument with 150-ms ion and 30-ms electron cadence measurements. New evidence of asymmetric Hall magnetic and electric fields has also been confirmed across these current sheets which is due to the large out-of-plane (guide) magnetic field. This guide field was 2-4 times larger than the reconnecting field and allows for a detailed examination of reconnection diffusion regions in this large guide field regime, which is known to be very common in the solar wind. This presentation will discuss parallel electron heating, parallel electric fields, and dissipation in a large guide field as recorded by MMS at one recently published, very short duration, electron diffusion region (EDR) encounter. We compare these EDR observations with a new EDR-like event during this KH period that displays very similar characteristics, which will further our understanding of large guide field reconnection.

Electron dynamics and current dissipation during magnetic reconnection in the solar corona

Abstract ID : 1485

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Philippe-A. Bourdin ,Philippe.Bourdin@oeaw.ac.at ,(Post-Doc) ,Austria ,Graz ,Not Presenting[1]

1 -

Magnetic features, such as flux tubes, are observed to emerge from the photosphere and rise through the solar atmosphere. This causes global reconfiguration of the magnetic connectivity and hence induces currents that are eventually dissipated. How fast the reconnection may happen and if it leads to intermittent or continuous heating (nanoflares versus magnetic diffusion) is a question still under debate. Our 3D-MHD model resembles well an observed active region, featuring loops raising with a speed of about 2 km/s, which already gives hints to the real reconnection rate. The model implements magnetic-field braiding by photospheric driving of the field lines together with a realistic energy balance. While in MHD the dissipation mechanism is assumed by a simple diffusion equation, kinetic PIC simulation allow to test for this assumption well below the spatial scales resolved by MHD-processes. We try to bridge this gap with two-fold simulations: a realistic MHD corona together with a realistic electron diffusion region in a simple reconnection setup. Our MHD model supports the slow Ohmic dissipation of currents that are induced by the slow reconfiguration of the magnetic field, while our PIC model gives hints on the correctness of the assumptions we made for the MHD model.

Energetic particle enhancements and VLF waves in the vicinity of dayside reconnection

Abstract ID : 1493

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Allison Jaynes ,Allison.Jaynes@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Frederick Wilder ,Frederick.Wilder@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Drew Turner ,drew.l.turner@aero.org ,(None) ,United States , ,Not Presenting[3]

Dr. Trevor Leonard ,Trevor.Leonard@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Barry Mauk ,barry.mauk@jhuapl.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Joseph Fennell ,Joseph.F.Fennell@aero.org ,(None) ,United States , ,Not Presenting[3]

Dr. Hong Zhao ,hong.zhao@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Ian Cohen ,ian.cohen@jhuapl.edu ,(Senior Professional Staff) ,United States ,Laurel ,Not Presenting[5]

Dr. Daniel Baker ,dan.baker@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Bob Ergun ,Bob.Ergun@lasp.colorado.edu ,(None) ,United States , ,Not Presenting[10]

1 - CU-LASP 2 - LASP 3 - The Aerospace Corporation 4 - University of Colorado Boulder 5 - JHU/APL 6 - The Aerospace Corporation 7 - University of Colorado Boulder 8 - JHU/APL 9 - University of Colorado Boulder 10 - LASP/UColorado

Energetic electrons (>30 keV) have not often been observed in Earth's low latitude boundary layer (LLBL) in the dayside magnetopause region. Many theories have been proposed to account for their occasional existence and association with magnetic reconnection events. NASA's Magnetospheric Multiscale (MMS) mission was developed to investigate just such a problem. The FEEPS instrument on board MMS is capable of measuring the near-all-sky energetic electron distribution from 30 to >500 keV every 0.3 seconds in burst mode. Here we show that the existence of energetic electrons in the LLBL is not so rare, and that these events nearly always occur with simultaneous measurements of narrow-band VLF wave power and strong parallel electric fields. The data often shows signatures of reconnection occurring nearby to the local observations. We present several case studies from our observation set showing the scope of energization possible, as well as the range of values in the parallel electric fields. We discuss the theoretical linear and nonlinear wave-particle interactions that may provide such energetic electron acceleration in the LLBL.

A26 - Understanding the electromagnetic impact of space weather on infrastructure: progress in theory, observations, evaluation and mitigation (DIV III – DIV IV – DIV V – DIV VI – ICSW)

Continental scale geomagnetic induction hazards using a 3-D electrical conductivity model of Australia

Abstract ID : 164

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Liejun Wang ,liejun.wang@ga.gov.au ,(Geophysicist) ,Australia ,Canberra ,Not Presenting[1]

Mr. Andrew Lewis ,andrew.lewis@ga.gov.au ,(Geomagnetism Team Leader) ,Australia ,Canberra ,Not Presenting[1]

1 - Geoscience Australia 2 - Geoscience Australia

Geomagnetically induced currents (GICs) in the Earth surface and interior are caused by geomagnetic storms and other natural field variations. GICs in the Australian region are distorted by conductivity contrasts caused by oceans, geology and enhanced crustal conductivity structures.
This study provides a regional indicator of geomagnetic induction hazards across Australia by modelling the distribution of induced surface electric field using a continental-scale 3-D electrical conductivity model of Australia. The model includes broad electrical structures of the oceans, resistive cratons, sedimentary basins and enhanced conductivity anomalies beneath the continent. The amplitude and orientation of the induced electric field at periods of 360 s and 1800 s are presented and compared to those derived from a simplified ocean-continent electrical conductivity model. Australia is surrounded by deep oceans and shallow seas resulting in large electrical conductivity contrast across the coastlines which influence induced electric fields up to 500 km inland. The continent can be broadly grouped into resistive western, northern and southern cratons (of the order of 1000 ? m) separated by more conductive orogenic belts or Phanerozoic sedimentary basins (around 10 ? m). This heterogeneous crustal structure significantly affects the spatial distribution of induced electrical fields. There are enhanced conductivity anomalies in Archaean cratonic areas in Western Australia and Phanerozoic terranes to the east of the continent and an enhanced conductivity structure at middle-lithosphere depths across much of central Australia. These structures increase the electrical conductivity contrast in the inland regions and enhance the induced electric field. On the northern coastlines, the induced electric field is decreased relative to the simple ocean-

continent model due to a reduced conductivity contrast between the shallow seas and the enhanced conductivity structures inland. In central Australia, the induced electric field is less distorted with respect to the ocean-continent model but inland crustal high-conductivity anomalies cause distortion. In the west, the increased conductivity contrast between the deeper oceans and lower conductivity of the Western Australia cratons enhances the induced electric field. Generally, the induced electric field in southern Australia is higher compared to northern Australia.

Transformer level modelling of GIC in New Zealand's electrical transmission network

Abstract ID : 183

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Tim Divett ,tim.divett@otago.ac.nz ,(Postdoctoral Research Fellow) ,New Zealand ,Dunedin ,Presenting[1]

Mr. Michael Dalzell ,Michael.Dalzell@transpower.co.nz ,(None) ,New Zealand , ,Not Presenting[2]

Prof. Craig Rodger ,craig.rodger@otago.ac.nz ,(Head of Department) ,New Zealand ,None ,Not Presenting[1]

Dr. Gemma Richardson ,gemk@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. Ciaran Beggan ,ciar@bgs.ac.uk ,(None) ,United Kingdom ,Edinburgh ,Not Presenting[5]

Dr. Malcolm Ingham ,Malcolm.Ingham@vuw.ac.nz ,(None) ,New Zealand , ,Not Presenting[6]

Dr. Alan Thomson ,awpt@bgs.ac.uk ,(Head of Geomagnetism) ,United Kingdom ,Edinburgh ,Not Presenting[5]

1 - University of Otago 2 - Transpower New Zealand Limited, Wellington 3 - University of Otago 4 - British Geological Survey, Edinburgh 5 - British Geological Survey 6 - School of Chemical and Physical Sciences, Victoria University of Wellington 7 - British Geological Survey

During storms geomagnetically induced currents (GIC) have caused alerts and damage to transformers in Transpower New Zealand Limited's electrical transmission network across the South Island of New Zealand. We wish to advance our understanding of these impacts and the potential severity of GIC on this network during extreme events. To achieve this we have developed a GIC network model of the South Island's electrical transmission network driven by modeled geoelectric fields. We calculate the geoelectric field in New Zealand as a function of ground level magnetic field variations and our recently developed surface conductance and layered resistivity model for New Zealand. New Zealand's geomagnetic latitude and island nature are similar to the United Kingdom and Ireland, allowing us to build on previous modeling approaches developed there. However, these and other previous GIC models assume that each substation can be represented by a single resistor in series with an earth-ground resistor. By contrast, in the present study we have developed a more detailed transformer level network model using the same nodal network structure as previous studies. In this model we have individually represented every high and low voltage winding of every

transformer in every substation as a unique resistor. This more detailed network model allows the calculation of GIC flowing through each individual transformer and hence a comparison to be made with Transpower's GIC observations, collected since 2001 at up to 61 individual transformers. These comparisons show that including individual transformers in the network model is crucial to understanding the impact of space weather on electrical networks. Eventually this model will be used to evaluate mitigation strategies at the transformer level, where the risk lies, rather than at the substation level as has commonly been done previously. Although initially applied to the South Island of New Zealand, this network modeling technique is applicable to any electrical transmission network. Thus once we have validated this model against Transpower's observations our study will provide a demonstration of a more detailed network modeling technique, as well as confirming the GIC modeling approaches used by many in the wider international community.

Observations of the Geomagnetic Effects on Ground Infrastructure: historical perspective

Abstract ID : 255

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. David Boteler ,david.boteler@canada.ca ,(Research Scientist) ,Canada ,Ottawa ,Not Presenting[1]

Dr. Risto Pirjola ,Risto.Pirjola@fmi.fi ,(None) ,Finland , ,Not Presenting[2]

Dr. Heikki Nevanlinna ,Heikki.Nevanlinna@gmail.com ,(None) ,Finland , ,Not Presenting[3]

1 - Natural Resources Canada 2 - Finnish Meteorolgical Institute 3 - Finnish Meteorological Institute

Geomagnetic disturbances affect a variety of ground infrastructure: power systems, pipelines, communication cables and railway signalling. Geomagnetically induced currents in power systems produce partial saturation of transformers resulting in heating that can damage the transformers, generation of harmonics that can cause mis-operation of protective relays and increased reactive power consumption that can cause voltage stability problems. On pipelines the telluric voltage fluctuations interfere with the cathodic protection systems, preventing pipeline surveys and creating conditions where corrosion can occur. On both land-based and submarine cables induced voltages can add or oppose the driving voltage, interfering with the amplification of signals sent along the cables. Voltages induced in railway lines can cancel track circuit voltages leading to mis-operation of railway signals. The first reported effects date back to 1841 and each introduction of new technologies since then has uncovered new vulnerabilities to geomagnetic disturbances. This talk will illustrate the effects on different systems and review the published reports of problems that have been experienced. Our previous review of the effects of geomagnetic disturbances on electrical systems at the Earth's surface included effects reported up to 1996. In the twenty years since then more effects have occurred, such as the Malmö power system blackout in 2003. Also, information has been uncovered about the effects produced during other geomagnetic disturbances that were not reported in our original review, while new information has been found about the known events. Particular attention will be paid to the additional material that has been found. This talk is part of a project to produce a comprehensive list of observed geomagnetic effects on ground infrastructure and we will be soliciting information on any events not included in the published list.

Recent developments and knowledge gaps in geomagnetically induced current research

Abstract ID : 271

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Alan Thomson ,awpt@bgs.ac.uk ,(Head of Geomagnetism) ,United Kingdom ,Edinburgh ,Not Presenting[1]

1 - British Geological Survey

Geomagnetically induced currents (GIC) in conducting networks such as power grids and pipelines are a space weather hazard caused by induction in the Earth by rapidly varying geomagnetic fields. Assessment of the risk to conducting ground-based infrastructures usually relies on models of the surface geo-electric (telluric) field, which acts as the source term for the flow of GIC. In turn, modeled electric fields are based on models of the conductivity of the Earth, which is known only to a variable degree, as well as on measured or modelled magnetic variations, for example measurements made at magnetic observatories. In this presentation, we review recent progress in modelling magnetic variations, Earth conductivity and surface electric fields, that are relevant to the threat posed by GIC to ground-based conducting networks. We also consider what gaps remain in our understanding of GIC and its causation and we discuss recent policy and other developments at national and international levels and how this may impact future research.

Improving the modeling of geomagnetically induced currents in Spain

Abstract ID : 273

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. J. Miquel Torta ,jmtorta@obsebre.es ,(Head of research group) ,Spain ,Roquetes ,Not Presenting[1]

Dr. Joan Campanyà ,joancampillov@gmail.com ,(None) ,Spain , ,Not Presenting[2]

Dr. Alex Marcuello ,alex.marcuello@ub.edu ,(None) ,Spain , ,Not Presenting[3]

Dr. Pilar Queralt ,pilar.queralt@ub.edu ,(None) ,Spain , ,Not Presenting[3]

Dr. Juanjo Ledo ,jledo@ub.edu ,(None) ,Spain , ,Not Presenting[3]

Dr. Santiago Marsal ,smarsal@obsebre.es ,(Researcher) ,Spain ,Roquetes ,Not Presenting[1]

1 - Observatori de l'Ebre 2 - Trinity College Dublin 3 - Institut Geomodels 4 - Institut Geomodels 5 - Institut Geomodels 6 - Observatori de l'Ebre

Vulnerability assessments of the risk posed by geomagnetically induced currents (GICs) to power transmission grids are benefited from the accurate knowledge of the geomagnetic field variations at each node of the grid, the Earth's geoelectrical structures beneath them, and the topology and relative resistances of the grid elements in the precise instant of a geomagnetic storm. The results of previous analyses on the threat posed by GICs to the Spanish 400 kV grid are improved in this study by resorting to different strategies to progress in the three aspects identified above. Firstly, although at mid-latitude regions the source fields are rather uniform, we have investigated the effect of their spatial changes by interpolating the field from the records of several closest geomagnetic observatories with different techniques such as the spherical elementary current systems (SECS). Secondly, we have performed a magnetotelluric (MT) sounding in the vicinity of one of the transformers where GICs are measured to determine the geoelectrical structure of the earth, and we have identified the importance of estimating the MT impedance tensor when predicting GIC, specially where the effect of lateral heterogeneities is important. Finally, a sensitivity analysis to network changes has allowed assessing the reliability of both the information about the network topology and resistances, and the assumptions made when all the details or the network status are not available. In our case, the most essential issue to improve the coincidence between model predictions and actual observations came from the use of realistic geoelectric information involving local MT measurements.

New Zealand Long term Geomagnetically Induced Current Observations: Peak Current Estimates and Mitigation Approaches for Extreme Geomagnetic Storms

Abstract ID : 288

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Craig Rodger ,craig.rodger@otago.ac.nz ,(Head of Department) ,New Zealand ,None ,Presenting[1]

Dr. Alan Thomson ,awpt@bgs.ac.uk ,(Head of Geomagnetism) ,United Kingdom ,Edinburgh ,Not Presenting[2]

Dr. Tim Divett ,tim.divett@otago.ac.nz ,(Postdoctoral Research Fellow) ,New Zealand ,Dunedin ,Not Presenting[1]

Dr. Tanja Petersen ,T.Petersen@gns.cri.nz ,(None) ,New Zealand , ,Not Presenting[4]

Ms. Ellen Clarke ,ecla@bgs.ac.uk ,(Geomagnetism Scientist) ,United Kingdom ,Edinburgh ,Not Presenting[5]

Dr. Mark Clilverd ,macl@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[6]

Mr. Michael Dalzell ,Michael.Dalzell@transpower.co.nz ,(None) ,New Zealand , ,Not Presenting[7]

Mr. Daniel H. Mac Manus ,macda381@student.otago.ac.nz ,(None) ,New Zealand , ,Not Presenting[8]

1 - University of Otago 2 - British Geological Survey 3 - University of Otago 4 - GNS Science, Lower Hutt, New Zealand 5 - British Geological Survey, Edinburgh, United Kingdom 6 - British Antarctic Survey 7 - Transpower New Zealand Limited, Wellington 8 - Department of Physics, University of Otago, Dunedin, New Zealand

Transpower New Zealand Limited has measured DC currents in transformers in the New Zealand electrical network at multiple South Island locations. The measurements provide an unusually long and spatially detailed set of Geomagnetically Induced Current (GIC) measurements. GIC are a clear hazard to the New Zealand electrical network, with the loss of a $2 million transformer in November 2001 during a severe magnetic storm. Near continuous archived DC current data exist since 2001, starting with 12 different substations, and expanding from 2009 to include 17 substations. From 2001-2015 a total of 61 individual transformers were monitored. Primarily the measurements were intended to monitor the impact of the High Voltage DC system linking the North and South Islands when it is operating in "Earth return" mode. However, after correcting for Earth return operation, only GIC remain in the measurements. We have recently started a research project to analyse the New

Zealand GIC dataset in order to better understand the occurrence and impact of GIC to the New Zealand electrical network. Of particular focus is the peak GIC values expected during extreme geomagnetic storms. We are working with Transpower New Zealand Limited to examine existing, and recommend options to, their GIC mitigation plans. Initial results from that effort will be discussed. In addition, we have worked on looking at the detailed GIC observations from the multiple measuring locations. As expected, we find that in most locations and for most times the observed GIC is best correlated with the rate of change of the horizontal component of the geomagnetic field. Using the ~14 year dataset and results from previous extreme studies (Kelly *et al*, 2014), we have estimated the likely extreme GIC magnitude expected at the transformer which was lost in November 2001. This is ~640-2300 A, depending on the storm case used, which should be compared with our estimate of 100 A during the failure event.

Modelling geomagnetically induced currents in Austria

Abstract ID : 426

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Rachel Bailey ,r.bailey@zamg.ac.at ,(None) ,Austria ,Vienna ,Not Presenting[1]

Mr. Roman Leonhardt ,r.leonhardt@zamg.ac.at ,(None) ,Austria , ,Not Presenting[1]

Dr. Ciaran Beggan ,ciar@bgs.ac.uk ,(None) ,United Kingdom ,Edinburgh ,Not Presenting[3]

Mr. Alexander Römer ,Alexander.Roemer@geologie.ac.at ,(None) ,Austria , ,Not Presenting[4]

Mr. Ramon Egli ,r.egli@zamg.ac.at ,(None) ,Austria ,None ,Not Presenting[1]

Mr. Thomas Halbedl ,halbedl@tugraz.at ,(None) ,Austria , ,Not Presenting[6]

Ms. Ingrid Schattauer ,Ingrid.Schattauer@geologie.ac.at ,(None) ,Austria , ,Not Presenting[4]

Mr. Georg Achleitner ,Georg.Achleitner@apg.at ,(None) ,Austria , ,Not Presenting[8]

1 - Zentralanstalt für Meteorologie und Geodynamik 2 - Zentralanstalt für Meteorologie und Geodynamik 3 - British Geological Survey 4 - Geologische Bundesanstalt 5 - Zentralanstalt für Meteorologie und Geodynamik 6 - TU Graz 7 - Geologische Bundesanstalt 8 - Austrian Power Grid

Geomagnetically induced currents (GIC) in power systems, which can lead to transformer damage over the short and the long term, are a result of space weather events and geomagnetic variations. For a long time, only high latitude areas were considered to be at risk from these currents, but recent studies show that considerable GIC also appear in mid-latitude and equatorial countries. Here we present results from a GIC model using a thin-sheet approach with detailed surface and subsurface conductivity models to compute the induced geoelectric field and the resultant GIC. The results are compared to measurements of direct currents in a transformer neutral and show very good agreement, especially for short period variations such as geomagnetic storms. Furthermore, the model is improved iteratively through a detailed parameter study to find the best fit between model and measurements.

Modelling geomagnetically induced currents using data from a remote geomagnetic observatory

Abstract ID : 484

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ciaran Beggan ,ciar@bgs.ac.uk ,(None) ,United Kingdom ,Edinburgh ,Not Presenting[1]

Ms. Ellen Clarke ,ecla@bgs.ac.uk ,(Geomagnetism Scientist) ,United Kingdom ,Edinburgh ,Not Presenting[2]

Dr. Laurence Billingham ,laurence@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Gemma Richardson ,gemk@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

1 - British Geological Survey 2 - British Geological Survey, Edinburgh, United Kingdom 3 - British Geological Survey 4 - British Geological Survey, Edinburgh

Space weather effects on grounded infrastructure such as high-voltage power networks have been well documented over the past three decades. Current research on Geomagnetically Induced Currents (GIC) seeks to understand both the detailed effects of extreme geomagnetic storms on transformers as well as methods for nowcasting or forecasting the magnitude of such events in real-time, particularly where only sparse measurements may be available.
We examine the use of remote observatories (up to 1000 km away) to model the GIC flowing in two hypothetical power grids. The first grid is the benchmark test grid of Horton et al (2012) with 15 'transformers' and the second is a simplified version of the UK power network with around 250 nodes. We place the grids at high geomagnetic latitudes in the auroral to sub-auroral zone around Hudson Bay in Canada and use data from three local magnetic observatories (Baker Lake: BLC; Fort Churchill: FCC and Poste de-la-Baleine: PBQ). We use magnetic data from three large storms of March 1989, June 1991 and October 2003 and a simple land/sea conductance model to calculate the geo-electric field using the thin-sheet modelling method. The GIC flowing with each grid is computed, both separately and jointly, from the magnetic field recorded at the observatories.
We find that although the correlation between the GIC flows computed from the different observatories varies with distance to the instrument, the magnitude of the GIC are similar to within around 20%. This suggests that remote observatories can provide useful information for nowcasting GIC flow in a power grid.

Extreme value analysis of geomagnetically induced electric field in South Africa

Abstract ID : 535

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Stefan Lotz ,slotz@sansa.org.za ,(None) ,South Africa ,Hermanus ,Presenting[1]

Dr. Donald Danskin ,donald.danskin@canada.ca ,(None) ,Canada , ,Not Presenting[2]

1 - SANSA 2 - NRCAN

Extreme geomagnetic disturbances occur rarely, but can have great impact on technological systems such as power distribution networks. Long-term planning for extreme events require the projection of event magnitude to occurrence periods greater than the length of observed data. With this in mind an analysis of extreme geomagnetic events observed in South Africa (middle geomagnetic latitude) is performed over four solar cycles (1974-2015).
Active periods are identified in terms of SYM-H magnitude, incorporating storm onset and recovery periods. An index is defined to characterise the severity of each event in terms of total electric field induced during the event. It is found that the severity index shares a highly linear relationship with accumulated SYM-H over each event. Event severity is log-normal distributed, with tail deviating greater than log-normal, confirming fat-tailed occurrence. A general Pareto distribution is fitted to the tail of the distribution and extrapolated to calculate the return levels of extreme events.
Return levels of once in 100 and once in 200 year events are estimated and the 23 July 2012 CME is analysed in this context.

Regional rigorous 3-D modelling of ground geoelectric and geomagnetic field due to realistic geomagnetic disturbances

Abstract ID : 757

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Elena Ivannikova ,elena.ivannikova@erdw.ethz.ch ,(PhD candidate) ,Switzerland ,Zürich ,Presenting[1]

Dr. Mikhail Kruglyakov ,mikhail.kruglyakov@erdw.ethz.ch ,(None) ,Switzerland , ,Not Presenting[1]

Prof. Alexey Kuvshinov ,kuvshinov@erdw.ethz.ch ,(None) ,Switzerland , ,Not Presenting[3]

Dr. Lutz Rastätter ,lutz.rastaetter-1@nasa.gov ,(None) ,United States , ,Not Presenting[4]

Prof. Antti Pulkkinen ,antti.a.pulkkinen@nasa.gov ,(None) ,United States , ,Not Presenting[4]

1 - Institute of Geophysics, ETH Zürich 2 - Institute of Geophysics, ETH Zürich 3 - ETH Zürich 4 - NASA Goddard Space Flight Center 5 - NASA Goddard Space Flight Center

We present the results of ground geoelectric and geomagnetic field modelling which is performed with the use of our novel numerical tool based on integral equation approach. The tool exploits realistic regional and global three-dimensional (3-D) models of the Earth's electrical conductivity and realistic global models of the spatio-temporal evolution of magnetospheric and ionospheric current systems responsible for geomagnetic disturbances. The 3-D modelling is performed for various regions of the Earth: the British Isles, Scandinavia, North America, Japan and Australia. The fields are computed for real geomagnetic disturbances and compared to observations. We also explore in detail the manifestation of the coastal effect - anomalous intensification of geoelectric field near the coasts - in these regions.

It’s not about the GICs

Abstract ID : 941

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited paper

Prof. Charles Gaunt ,ct.gaunt@uct.ac.za ,(Em. Prof,, Senior Scholar) ,South Africa ,Cape Town ,Not Presenting[1]

1 - UCT

The modelling and prediction of GICs is not yet an exact science. Trouble is, it's not about the GICs, nor the GMDs producing them. The real concern is about the effects they have on infrastructure, and the modelling of those effects is still imprecise. Indeed, part of the challenge is that GMDs and GICs expose infrastructure weaknesses caused by more than space weather, adding complexity to the existing problems.
Understanding the real nature of the concerns about the effects of space weather on infrastructure can guide researchers of GMDs and GICs towards expressing the outputs of their scientific insight as information useful for applications.
Governments do not want to incur avoidable costs but don't want to be caught out by an extreme event. They often leave to regulators and industry associations the decisions about how to prepare society for extreme events. Of course, diverse groups from insurers to manufacturers lobby for their desired outcomes. The effects of GICs on infrastructure differ according to the sector. Pipeline networks and electrical power, rail transport and communications systems are affected in different ways. Big pictures are composed of many small details, such as the electrical response of transformers, the degradation initiated by GICs, and their eventual failure. In all this complexity, infrastructure engineers want to know how space weather in future will affect the reliability and cost in the long term - for planning - and short term - for operations, so they can take good decisions.
This paper draws from these several perspectives, locally and worldwide, to identify what has already been done, what is happening at present and what is still needed in space weather science, infrastructure engineering and public policy. Although focusing mostly on power systems, the similarities and dependencies between different infrastructure sectors cannot be ignored. The analysis should help all participants to appreciate each other's needs and constraints.
[Infrastructure sectors include power, rail transport, pipelines and communications. Participants include regulators, industry associations, insurers, electricity utilities, manufacturers, research councils and institutes, academia. Status includes done, doing, needed. Areas of research and application include networks, transformers, failure, decision making, etc.]

Power System Response to Geomagnetically Induced Currents

Abstract ID : 1480

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. David Oyedokun ,davoyedokun@ieee.org ,(Lecturer) ,South Africa ,Cape Town ,Not Presenting[1]

1 - University of Cape Town

During a solar storm leading to a geomagnetic disturbance (GMD), the interaction of the Earth's magnetic field and Coronal Mass Ejections gives rise to Geomagnetically Induced currents (GICs). These currents flow through the grounded neutrals of wye connected transformers. The flow of GICs through transformers lead to increased harmonics and reactive power consumption in transformers. High levels of harmonics may prelude voltage instability in a power network. A review of the events leading to the blackout in Canada during the severe GMD in March 1989 revealed that high levels of harmonics precipitated tripping of compensators, voltage instabilities, tripping of transmission lines, loss of generating units and the eventual collapse of the power system. The progression from grid instabilities to collapse informs the need to understand the response of the power system over and above the effect of GICs on power transformers.

This study aims to conduct a stability analysis of the power system subjected to varying levels of geomagnetic disturbances. The fluctuation of the reactive power consumption in transformers during the storm can be modelled after the profile of the GIC. While reactive power fluctuation persists, multiple swings in the reactive power generated or absorbed by generators, synchronous condensers and other VAR compensators within the network are expected. In the case of a GMD severe enough to cause high GICs to flow in the network, the increase in harmonics leading to possible tripping and voltage instability may be modelled as a voltage stability problem. If the magnitude and variation of the GIC is very low and not considered to have adverse effect to power systems, then the scenario is likened to that of slight changes in load and generation. This can be analysed as such using relevant power system stability tools.

The results from network analysis carried out using this combined approach presents power system operators with an understanding of the dynamic ability of the network to withstand sever GMDs which may not lead to instant transformer damage, yet severe enough to cause instabilities which can lead to eventual power system collapse.

Interpolation of surface impedance for GIC modelling

Abstract ID : 1505

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Pierre Cilliers ,pjcilliers@sansa.org.za ,(Senior Researcher) ,South Africa ,Hermanus ,Not Presenting[1]

Mr. Michael Heyns ,mheyns@sansa.org.za ,(Student) ,South Africa ,Hermanus ,Not Presenting[2]

Mrs. Electdom Matandirotya ,electdom@gmail.com ,(Student) ,South Africa ,Hermanus ,Not Presenting[3]

1 - SANSA 2 - SANSA/UCT 3 - UZ and SANSA Space Science

The geophysical link in modelling geomagnetically induced currents (GICs) has been shown to be a significant source of error in the modelling chain. This stems from the assumption that GICs in networks are related to an induced plane-wave geoelectric field, which is usually derived using limited knowledge of the Earth's conductivity profile. The surface impedance can be derived from an estimated conductivity profile, or from magnetotelluric (MT) measurements. By using both an interpolated magnetic field and an interpolated surface impedance in the estimation of GICs, the accuracy can be significantly improved compared to using data from a magnetometer station and magnetotelluric (MT) station nearest to the power line of interest. This paper presents a new algorithm for the interpolation of the surface impedance to estimate the E-field at locations distant from MT observation stations. The plane wave assumption is quantified using a SECS interpolation of the magnetic field over South Africa and by deriving a regional geoelectric field using the improved interpolated surface impedance. The results are compared to the measured E-field at MT stations.

A27 - Quiet Sun and Active Regions (DIV IV)

Probing coronal magnetic field at the TR level using microwave gyroresonant techniques

Abstract ID : 305

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sergey Anfinogentov ,Sergey.Anfinogentov@warwick.ac.uk ,(Research Fellow) ,United Kingdom ,Coventry ,Not Presenting[1]

1 - University of Warwick

Solar magnetic field is the main factor of solar activity; therefore, information about its spatial distribution is necessary for understanding physical nature of solar activity and its forecasting. Nowadays, the most valuable information about the magnetic field in the Corona is obtained by its reconstruction from photospheric magnetograms in potential or force-free approximation. However, this approach has a number of difficulties. For instance, it involves the assumption that an investigated active region is stable or only slowly evolves. The other problem is caused by the incomplete and non-force-free boundary conditions observed only at the bottom boundary (photosphere). Therefor the reconstruction methods are a subject of improvement. Here the radio observations can help. Allowing us to measure the magnetic field in the corona directly, they can test the extrapolations results and provide additional constraints for its improving.
In this review, I will discuss magnetic field measurements using microwave gyroresonant techniques. Microwave gyroresonant emission of solar active regions is formed in the layers of plasma where the absolute value of the magnetic field corresponds to one of the gyro-frequency harmonics (typically third or second). The detection of a gyroresonant emission at a certain frequency means that the line of sight crosses the layer with the corresponding magnetic field, giving us the lowest possible absolute value of the field in the transition region. Currently, 2D solar-dedicated microwave imaging observations are available on the regular basis only for two frequencies: 5.7 GHz (SSRT), and 17 GHz (NoRH). The other frequency of NoRH (34 GHz) is too high for gyroresonant magnetography. These observational facilities allow for making magnetograms for two values of the magnetic field, defining the areas where the field is greater than ~ 680 G and ~2020G, which I will show and discuss for a few ARs. Upcoming radioheliographs such as EOVSA, MUSER and Siberian Radio Heliograph will provide simultaneous observations at multiple frequencies allowing for mapping the absolute value of the magnetic field at the base of the corona with significantly higher accuracy.

Measurements of electric current density in the solar photosphere

Abstract ID : 474

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Veronique Bommier ,V.Bommier@obspm.fr ,(Directeur de recherche) ,France ,Meudon ,Not Presenting[1]

1 - Observatoire de Paris

The measurement of the electric current density results from the measurement of the magnetic field vector, via Ampère's circuital law. A short review of the magnetic field vector measurement will then be done. Emphasis will be put on the solution of the measurement ambiguities, which are necessary for the current density purpose. If the magnetic field vector is measured at a single depth, only the vertical component of the current density can be retrieved. The retrieval of the full current density vector requires the measurement of the magnetic field vector at two different depths. Results will be shown in term of electric current density maps, for some active regions observed by SDO/HMI (one depth) and HINODE/SOT/SP (two depths).

A new web resource for solar physics: reconstruction of 3D reality in solar flares and active regions.

Abstract ID : 530

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Anastasia Tsvetkova ,tsvetkova@mail.ioffe.ru ,(Junior Research Scientist) ,Russia ,St. Petersburg ,Not Presenting[1]

Dr. Alexander Altyntsev ,altyntsev@iszf.irk.ru ,(None) ,Russia , ,Not Presenting[2]

Dr. Sergey Anfinogentov ,Sergey.Anfinogentov@warwick.ac.uk ,(Research Fellow) ,United Kingdom ,Coventry ,Not Presenting[3]

Dr. Rafail Aptekar ,aptekar@mail.ioffe.ru ,(None) ,Russia , ,Not Presenting[1]

Dr. Dmitry Frederiks ,fred@mail.ioffe.ru ,(None) ,Russia , ,Not Presenting[1]

Dr. Alexey Kuznetsov ,a_kuzn@iszf.irk.ru ,(None) ,Russia , ,Not Presenting[6]

Dr. Maria Loukitcheva ,m.lukicheva@spbu.ru ,(None) ,Russia , ,Not Presenting[7]

Mrs. Alexandra Lysenko ,alexandra.lysenko@mail.ioffe.ru ,(Associate Researcher) ,Russia ,Saint-Petersburg ,Not Presenting[8]

Dr. Galina Motorina ,g.motorina@gao.spb.ru ,(None) ,Russia , ,Not Presenting[9]

Dr. Ivan Myshyakov ,ivan_m@iszf.irk.ru ,(Researcher) ,Russia ,Irkutsk ,Not Presenting[6]

Dr. Alexey Stupishin ,agstup@yandex.ru ,(None) ,Russia , ,Not Presenting[11]

Mr. Mikhail Ulanov ,ulanov@mail.ioffe.ru ,(None) ,Russia , ,Not Presenting[1]

Dr. Gregory Fleishman ,gfleishm@njit.edu ,(Distinguished Research Professor) ,United States ,Newark ,Not Presenting[13]

1 - Ioffe Institute 2 - Institute of Solar-Terrestrial Physics 3 - University of Warwick 4 - Ioffe Institute 5 - Ioffe Institute 6 - Institute of Solar-Terrestrial Physics 7 - Astronomical Institute, Saint-Petersburg University 8 - Ioffe institute 9 - Pulkovo Observatory 10 - Institute of Solar-Terrestrial Physics 11 - St. Petersburg State University 12 - Ioffe Institute 13 - NJIT

Over the recent years the availability of solar observational data in the public domain has become a common practice. Complementary, our effort attempts to create a publicly available database of data-

driven three-dimensional (3D) models. The science goal of our project "Solar Flares and Active Regions: Reconstructing the 3D Reality" is obtaining new fundamental knowledge about the magneto-thermal structure and gradual or impulsive release of the free magnetic energy in Active Regions (ARs) at the Sun. It is achieved via creation of realistic 3D magneto-plasma models of the corona and chromosphere above ARs consistent with observations in a broad spectral domain from the radio waves to X-rays and gamma-rays. The user can quantitatively use these models and simulation tools for a detailed analysis of the specific ARs and solar flares. The database of these realistic models is made freely available via the website http://www.ioffe.ru/LEA/SF_AR/, an open web resource which is a part of this project. In this presentation I navigate through the web page to show how the models can be retrieved and utilized by the user. In addition, the website offers a number of useful links, software resources, modeling tools, and provides access to the hard X-ray and gamma-ray solar data (light curves, FITS and SAV files) obtained in the joint US-Russian Konus-WIND experiment. We have developed and are maintaining the website as an open resource for the solar data sharing, so we encourage other researchers or research groups to share their 3D models using this web resource, created specifically for the storage and exchange of magneto-plasma models of ARs and solar flares.

Coronal Magnetic Field Reconstruction with Magnetic Field Constraints above the Photosphere

Abstract ID : 770

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ivan Myshyakov ,ivan_m@iszf.irk.ru ,(Researcher) ,Russia ,Irkutsk ,Presenting[1]

Dr. Gregory Fleishman ,gfleishm@njit.edu ,(Distinguished Research Professor) ,United States ,Newark ,Not Presenting[2]

Dr. Sergey Anfinogentov ,Sergey.Anfinogentov@warwick.ac.uk ,(Research Fellow) ,United Kingdom ,Coventry ,Not Presenting[3]

Dr. Maria Loukitcheva ,m.lukicheva@spbu.ru ,(None) ,Russia , ,Not Presenting[4]

Dr. George Rudenko ,rud@iszf.irk.ru ,(None) ,Russia , ,Not Presenting[5]

Dr. Alexey Stupishin ,agstup@yandex.ru ,(None) ,Russia , ,Not Presenting[6]

1 - Institute of Solar-Terrestrial Physics 2 - NJIT 3 - University of Warwick 4 - Astronomical Institute, Saint-Petersburg University 5 - Institute of Solar-Terrestrial Physics 6 - St. Petersburg State University

Coronal magnetic field is a key ingredient that controls the solar activity, yet direct measurements of the coronal magnetic field are limited. To fill this gap in observational diagnostics, various methods of magnetic field reconstruction have been proposed and implemented. Low plasma beta in the coronal volume justifies the use of force-free approach, to approximate the slowly evolving coronal magnetic field in active regions. Such reconstructions typically extrapolate the magnetic field up starting from the photospheric boundary, where the magnetic field vector can be measured reasonably easy. However, the magnetic field at the photospheric level deviates from being force-free. This fact may negatively affect the reconstruction. Here we propose to take into account information about the magnetic field above the photosphere; specifically, chromospheric line-of-sight magnetograms (from either optical or radio free-free probing) and diagnostics of the field magnitude derived from gyroresonance radio observations as additional constraints in conjunction with the photospheric magnetograms. Using a realistic MHD (Bifrost) model of the solar atmosphere as a proxy of the real corona, we demonstrate that this approach does improve reliability of the coronal magnetic field reconstruction even with incomplete data on the magnetic field vector at the chromosphere.

Coronal Magnetic Field Reconstruction

Abstract ID : 841

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Michael Wheatland ,michael.wheatland@sydney.edu.au ,(Associate Professor) ,Australia ,The University of Sydney ,Not Presenting[1]

1 - The University of Sydney

We review the status of nonlinear force-free field (NLFFF) modeling of coronal magnetic fields in solar active regions from photospheric vector magnetogram data (magnetic field reconstruction). Ready access to data, in particular from the space-based missions Hinode and the Solar Dynamics Observatory, and the availability of NLFFF codes, has seen NLFFF modeling become commonplace. Dozens of papers presenting NLFFF reconstructions are published each year. However, the reliability of the results is rarely discussed. In general the boundary data are inconsistent with the model, and this problem, together with various assumptions made in the modeling, mean that the results may not be accurate. We discuss possible ways to improve NLFFF reconstruction.

Measuring quiet-Sun magnetic fields in the photosphere: recent advances and future perspectives

Abstract ID : 927

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Andreas Lagg ,lagg@mps.mpg.de ,(Senior staff member) ,Germany ,Goettingen ,Not Presenting[1]

1 - Max Planck Institute for Solar System Research

At all times during the solar activity cycle, the so-called quiet Sun covers more than 90% of the solar photosphere. High-resolution magnetic field measurements reveal that even the most quiet regions harbor ubiquitous, small-scale magnetic elements of both magnetic polarities. The question about the production, the transport and the cancellation of these elements is therefore intimately related to the understanding of not only the dynamo process acting in the solar convection zone, but also of the heating mechanisms to produce the million-degree hot corona.
The small scales, the weak fields and the signal cancellation by the presence of opposite polarities pose a challenge even for the most sensitive instrumentation currently available for solar magnetometry. In this review I will present some of the recent advances in characterizing the quiet-Sun magnetism. Additionally, I discuss the potential of future observatories and promising advances in instrumentation to enhance our knowledge on quiet-Sun magnetic fields in the photosphere.

Overview of modern chromospheric magnetic field measurements.

Abstract ID : 962

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Alexei Pevtsov ,apevtsov@nso.edu ,(Astronomer) ,United States ,Sunspot ,Not Presenting[1]

1 - None

Our current understanding of topology and evolution of magnetic fields in solar upper atmosphere (corona) relies heavily on extrapolations from lower, photospheric heights. Such extrapolations are done under the assumption that either these fields contain no electric currents (potential field) or that there are only field-aligned currents (e.g., linear or non-linear force-free field). Historically, due to lack of observations of magnetic field from the atmospheric heights satisfying the force-free field condition, such extrapolations disregarded a well-accepted fact that the photosphere is not a force-free environment. The force-free conditions are satisfied in the chromosphere, but the routine observations of the chromospheric magnetic field were not available until very recently. This talk will discuss a current status of observational studies of the chromospheric magnetic fields including their measurements based on Zeeman effect and the derivation of the magnetic field properties (or inversion) from the observed spectro-polarimetric information. It will summarize the recent results of these observations in respect to the topology of magnetic fields in various solar structures (quiet Sun, active regions, and prominences/filaments), and compare properties of magnetic fields in the photosphere and chromosphere.

Casting the Coronal Magnetic Field Reconstruction Tools in 3D Using MHD Bifrost Model

Abstract ID : 1064

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Gregory Fleishman ,gfleishm@njit.edu ,(Distinguished Research Professor) ,United States ,Newark ,Presenting[1]

Dr. Sergey Anfinogentov ,Sergey.Anfinogentov@warwick.ac.uk ,(Research Fellow) ,United Kingdom ,Coventry ,Not Presenting[2]

Dr. Maria Loukitcheva ,maria.a.lukicheva@njit.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Ivan Myshyakov ,ivan_m@iszf.irk.ru ,(Researcher) ,Russia ,Irkutsk ,Not Presenting[4]

Dr. Alexey Stupishin ,agstup@yandex.ru ,(None) ,Russia , ,Not Presenting[5]

1 - NJIT 2 - University of Warwick 3 - NJIT 4 - Institute of Solar-Terrestrial Physics 5 - St. Petersburg State University

Measuring and modeling coronal magnetic field, especially above active regions (ARs), remains one of the central problems of solar physics given that the solar coronal magnetism is the key driver of all solar activity. Nowadays the coronal magnetic field is often modelled using methods of nonlinear force-free field reconstruction, whose accuracy has not yet been comprehensively assessed. Given that the coronal magnetic probing is routinely unavailable, only morphological tests have been applied to evaluate performance of the reconstruction methods and a few direct tests using available semi-analytical force-free field solution. Here we report a detailed casting of various tools used for the nonlinear force-free field reconstruction, such as disambiguation methods, photospheric field preprocessing methods, and volume reconstruction methods in a 3D domain using a 3D snapshot of the publicly available full-fledged radiative MHD model. We take advantage of the fact that from the realistic MHD model we know the magnetic field vector distribution in the entire 3D domain, which enables us to perform "voxel-by-voxel" comparison of the restored magnetic field and the true magnetic field in the 3D model volume. Our tests show that the available disambiguation methods often fail at the quiet sun areas, where the magnetic structure is dominated by small-scale magnetic elements, while they work really well at the AR photosphere and (even better) chromosphere. The preprocessing of the photospheric magnetic field, although does produce a more force-free boundary condition, also results in some effective `elevation' of the magnetic field components. The effective `elevation' height turns out to be different for the longitudinal and transverse components of the magnetic field, which results in a systematic error in absolute heights in the reconstructed magnetic data cube. The extrapolation performed starting from actual AR photospheric magnetogram (i.e.,

without preprocessing) are free from this systematic error, while have other metrics either comparable or only marginally worse than those estimated for extrapolations from the preprocessed magnetograms. This finding favors the use of extrapolations from the original photospheric magnetogram without preprocessing. Our tests further suggest that extrapolations from a force-free chromospheric boundary produce measurably better results, than those from the photospheric boundary.

ALMA Observations of the Sun

Abstract ID : 1513

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Timothy Bastian ,tbastian@nrao.edu ,(None) ,United States ,Charlottesville, VA ,Presenting[1]

1 - National Radio Astronomy Observatory

The Atacama Large Millimeter/Submillimeter Array (ALMA) is a joint North American, European, and East Asian interferometric array that opens the mm-submm wavelength part of the electromagne?tic spectrum for general astrophysical explora?tion, providing high-resolu?tion imaging in frequency bands ranging from 86 GHz to 950 GHz . Despite being a general purpose instrument provisions have been made to enable solar observa?tions with ALMA. Radia?tion emitted at ALMA wavelengths originates mostly from the chromosphere, which plays an important role in the transport of energy and matter and the heati?ng of the outer layers of the solar atmosphere. This talk will briefly review the diagnostic potential of observations at millimeter and submillimeter wavelengths for addressing outstanding problems in contemporary solar physics, discuss the current use and capabilities of ALMA for solar observations, and present some examples of recent observations.

A28 - Multi-Spectral Studies of Solar Flares (DIV IV)

Recent Progress in Observing Solar Flares at Radio Wavelengths

Abstract ID : 287

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Timothy Bastian ,tbastian@nrao.edu ,(None) ,United States ,Charlottesville, VA ,Presenting[1]

1 - National Radio Astronomy Observatory

With the advent of a new generation of radio instrumentation - including the Jansky Very Large Array, the Expanded Owens Valley Solar Array, the Murchison Widefield Array, the Low Frequency Array, and the Mingantu Ultrawide Spectral Radioheliograph - a number of new capabilities and diagnostics have become available at radio wavelengths to probe solar flares. In particular, dynamic radio imaging spectroscopy, a fundamentally new capability, can now be exploited to gain new insights into such problems as coronal magnetic fields, explosive magnetic energy release, particle acceleration, and particle transport. I will review these capabilities and present some recent work that illustrates the potential of these observations.

Multi-Instrument analysis of coronal X-ray and temperature signatures in solar limb flares

Abstract ID : 405

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Frederic Effenberger ,frederic.effenberger@me.com ,(Postdoc) ,United States ,Palo Alto ,Not Presenting[1]

1 - ISSI Bern, Stanford University

The bright footpoint emission from solar flare loops often prevents a detailed analysis of the weaker coronal loop-top source in X-rays due to limitations in dynamical range. These coronal regions, however, are of particular interest to studies of particle acceleration, since it is believied that reconnection processes near the loop top are a major source for energy that goes into non-thermal particles. Thus, flares close to the solar limb, where the footpoints are occulted, are interesting events to study because they can reveal the coronal loop-top emission and thus the electron properties at their acceleration site. We present results of a survey study of partially occulted flares observed with the Reuven Ramaty High-Energy Solar Spectroscopic Imager (RHESSI). We found that most of the flare spectra allow a fit to a thermal plus non-thermal component, either with a broken power-law or a kappa function. The spatial separation between the thermal and non-thermal component, as derived from imaging, is usually small. The study is extended further to analyze the thermal structure in the flaring loops with detailed differential emission measure inversions from AIA data. We discuss implications for particle acceleration models informed by our findings.

KW-Sun: Konus-Wind Hard X-ray and Soft Gamma-ray Solar Flare Database

Abstract ID : 457

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Alexandra Lysenko ,alexandra.lysenko@mail.ioffe.ru ,(Associate Researcher) ,Russia ,Saint-Petersburg ,Presenting[1]

Mr. Philipp Oleynik ,oleynik.phil@mail.ioffe.ru ,(None) ,Russia , ,Not Presenting[2]

Mr. Alexey Kokomov ,loylick@mail.ioffe.ru ,(None) ,Russia , ,Not Presenting[2]

Dr. Alexey Kuznetsov ,a_kuzn@iszf.irk.ru ,(None) ,Russia , ,Not Presenting[4]

Dr. Larisa Kashapova ,lkk@iszf.irk.ru ,(None) ,Russia , ,Not Presenting[4]

Dr. Gregory Fleishman ,gfleishm@njit.edu ,(Distinguished Research Professor) ,United States ,Newark ,Not Presenting[6]

Dr. Rafail Aptekar ,aptekar@mail.ioffe.ru ,(None) ,Russia , ,Not Presenting[2]

Dr. Dmitry Svinkin ,svinkin@mail.ioffe.ru ,(None) ,Russia , ,Not Presenting[2]

Mr. Mikhail Ulanov ,ulanov@mail.ioffe.ru ,(None) ,Russia , ,Not Presenting[2]

Dr. Rafail Aptekar ,aptekar@mail.ioffe.ru ,(None) ,Russia , ,Not Presenting[2]

Dr. Dmitry Frederiks ,fred@mail.ioffe.ru ,(None) ,Russia , ,Not Presenting[2]

Ms. Anastasia Tsvetkova ,tsvetkova@mail.ioffe.ru ,(Junior Research Scientist) ,Russia ,St. Petersburg ,Not Presenting[2]

1 - Ioffe institute 2 - Ioffe Institute 3 - Ioffe Institute 4 - Institute of Solar-Terrestrial Physics 5 - Institute of Solar-Terrestrial Physics 6 - NJIT 7 - Ioffe Institute 8 - Ioffe Institute 9 - Ioffe Institute 10 - Ioffe Institute 11 - Ioffe Institute 12 - Ioffe Institute

Konus is a Russian instrument onboard the US *Wind* spacecraft launched on November 1, 1994 for gamma-ray burst and solar flare studies. The spacecraft is located in the interplanetary space (since July of 2004 - near Lagrange point L1), so the instrument sees the Sun 24 hours a day. During its more than 22 year-long history Konus-*Wind* has accumulated a unique volume of solar flare observations in hard X-ray and soft gamma-ray range. Data registered by Konus-*Wind* in the triggered mode constitute the presented database, named KW-Sun. The data can be accessed via http://www.ioffe.ru/LEA/kwsun/ (at the time of writing the data for years 2005-2017 are available, the

remaining data will be added soon). KW-Sun provides light curves with high temporal resolution (down to 16 ms) and energy spectra in wide energy range (now ~20 keV - 15 MeV) which covers the region of non-thermal emission from electrons and ions accelerated in solar flares. New solar observations will be added to the database as soon as they arrive. We present a quick statistical analysis of solar flares based on Konus-Wind observations and compare solar flare properties between 23 and 24 solar cycles.

Determining the Frequency of Coronal Heating with the Marshall Grazing Incidence X-ray Spectrometer

Abstract ID : 735

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sabrina Savage ,sabrina.savage@nasa.gov ,(35801) ,United States ,Huntsville ,Not Presenting[1]

Dr. Amy Winebarger ,amy.r.winebarger@nasa.gov ,(None) ,United States , ,Not Presenting[2]

Dr. Ken Kobayashi ,ken.kobayashi-1@nasa.gov ,(None) ,United States , ,Not Presenting[2]

Mr. Patrick Champey ,patrick.r.champey@nasa.gov ,(None) ,United States , ,Not Presenting[4]

Dr. Peter Cheimets ,pcheimets@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Leon Golub ,lgolub@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Harry Warren ,harry.warren@nrl.navy.mil ,(None) ,United States , ,Not Presenting[7]

Dr. Edward DeLuca ,edeluca@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[8]

Mr. Katharine K. Reeves ,kreeves@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[9]

Dr. Paola Testa ,ptesta@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Stephen Bradshaw ,stephen.bradshaw@rice.edu ,(None) ,United States , ,Not Presenting[11]

Dr. David McKenzie ,david.e.mckenzie@nasa.gov ,(None) ,United States , ,Not Presenting[2]

Dr. Giulio Del Zanna ,g.del-zanna@damtp.cam.ac.uk ,(None) ,United Kingdom , ,Not Presenting[13]

Dr. Helen Mason ,hm11@damtp.cam.ac.uk ,(None) ,United States , ,Not Presenting[13]

Dr. Robert Walsh ,RWWalsh@uclan.ac.uk ,(None) ,United Kingdom , ,Not Presenting[15]

1 - NASA Marshall Space Flght Ctr 2 - NASA MSFC 3 - NASA MSFC 4 - University of Alabama Huntsville 5 - Smithsonian Astrophysical Observatory 6 - Smithsonian Astrophysical Observatory 7 - Naval Research Laboratory 8 - Center for Astrophysics/Harvard University 9 - Harvard-Smithsonian Center for Astrophysics 10 - Smithsonian Astrophysical Observatory 11 - Rice University 12 - NASA MSFC 13 - University of Cambridge 14 - University of Cambridge 15 - University of Central Lancashire

The discovery of the million-degree corona by Edlen and Grotrian in the 1930s sparked an extensive ongoing debate over the mechanisms responsible for transfering heat and energy into the solar atmosphere. The frequency with which energy is released into the corona is a critical measurement needed for distinguishing between the physical processes contributing to coronal heating. Soft X-ray spectroscopy of the corona is a direct way for obtaining these key measurements, but such observations are technically challenging due to low signal throughput associated with traditional grazing incidence X-ray designs. Using a novel implementation of corrective optics, the Marshall Grazing Incidence X-ray Spectrometer (MaGIXS), a sounding rocket instrument scheduled to fly in 2018-2019, will measure, for the first time, the solar spectrum from 6 - 24 Angstroms with a ~6" resolution (2.8"/pixel) over an 8' slit. This innovative set of observations can definitively determine the frequency of heating in an active region core through line-based diagnostics and the exploration of non-thermal electron distributions.

Solar flare observations from ground-based and space-borne observatories

Abstract ID : 1055

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Lucia Kleint ,lucia.kleint@fhnw.ch ,(None) ,Switzerland ,Windisch ,Not Presenting[1]

1 - FHNW

Solar flares show signatures in most wavelength ranges, from accelerated electrons in X-rays to continuum emission in the visible range and infrared. To sample the different heights of the solar atmosphere, in order to obtain a more complete flare picture, it is therefore advantageous to combine observations from multiple instruments with different wavelength bands. I will review current multi-instrument studies of solar flares.

A Large-scale Plume in an X-Class Solar Flare

Abstract ID : 1065

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Gregory Fleishman ,gfleishm@njit.edu ,(Distinguished Research Professor) ,United States ,Newark ,Presenting[1]

Dr. Gelu Nita ,gelu.m.nita@njit.edu ,(None) ,United States , ,Not Presenting[1]

Prof. Dale Gary ,gary@njit.edu ,(None) ,United States , ,Not Presenting[3]

1 - NJIT 2 - NJIT 3 - None

Ever increasing spatial resolution of solar observations suggests that solar flares often involve more than one magnetic flux tube. Some of the flaring flux tubes are entirely closed, while others contain open field. The question of the nonthermal electron partitions between those distinct loops is highly important for understanding the free energy release, particle acceleration, and transport. The nonthermal electron partition on the open field is further important as the open field facilitates the solar energetic particle (SEP) escape from the flaring site, and thus controls the SEP fluxes elsewhere in the solar system. The large-scale flux tubes including the flux tubes open to the interplanetary space are often filled with a relatively tenuous plasma, and, thus, difficult to detect in either EUV or X-ray range; however, they can dominate at low radio frequencies, where a relatively modest component of nonthermal electrons can render the source optically thick and, thus, bright enough to be observed. Here we report detection of a large-scale `plume' of a powerful X-class solar flare (25-Aug-2001) using multi-frequency radio data from Owens Valley Solar Array. To quantify both main flare site and its large-scale plume we employ a 3D modeling utilizing force-free field extrapolations from the line-of-sight SOHO/MDI magnetograms with our modeling tool GX Simulator. We found that a significant fraction of the nonthermal electrons accelerated at the flare site low in the corona, escapes to the plume that contains both closed and open field. We propose that the proportion between the closed and open field at the plume may have implications for the SEP population escaping to the interplanetary space.

Observations and modelling of escaping solar energetic particles

Abstract ID : 1382

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Olga Malandraki ,omaland@noa.gr ,(Senior Researcher) ,Greece ,Athens ,Not Presenting[1]

1 - National Observatory of Athens

Solar Energetic Particles (SEPs) from suprathermal (few keV) up to relativistic (~few GeV) energies are generally divided in two broad classes: impulsive events with characteristic timescales of the observed fluxes of several hours, enrichment by electrons, ^{3}He and heavy ions, relatively high charge states of ions, and gradual events which exhibit fluxes lasting for several days, are rather proton-rich, and associated with interplanetary shocks. The two classes are frequently assessed to have different acceleration mechanisms: the impulsive events are attributed to acceleration during magnetic reconnection in solar flares, while the gradual events are a result of diffusive acceleration at Coronal Mass Ejection-driven coronal and interplanetary shocks. In this work, an overview of the recent developments from the observational and modeling perspective on the origin, acceleration and transport of the escaping SEPs from solar flares will be presented. Furthermore, lessons learned from multi-spacecraft SEP observations will be reviewed. The recently developed inversion software for Neutron Monitor observations in the framework of the HORIZON 2020 project 'HESPERIA: High Energy Solar Particle Events Forecasting and Analysis' that infers the release timescales of relativistic SEPs at or near the Sun and the characteristics of their transport in the interplanetary space will also be highlighted.

A29 - Boundary Layers in the Heliosphere (DIV IV)

Formation of the Earth magnetopause

Abstract ID : 234

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Zdenek Nemecek ,zdenek.nemecek@mff.cuni.cz ,(professor) ,Czech Republic ,Prague ,Not Presenting[1]

Prof. Jana Safrankova ,jana.safrankova@mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

Dr. Jiri Simunek ,sim@ufa.cs.cz ,(None) ,Czech Republic , ,Not Presenting[3]

Dr. Andrey Samsonov ,andre.samsonov@gmail.com ,(None) ,Russia , ,Not Presenting[4]

1 - Charles University 2 - Charles University 3 - Institute of Atmospheric Physics 4 - St. Petersburg University

An example of a boundary layer in the magnetized plasma is the Earth magnetopause that divides the solar wind carrying frozen-in magnetic field and the space where basic processes are controlled by the Earth magnetic field. This boundary is a subject of the intensive research for many years and processes leading to its formation are believed to be rather well understood and included into numerous models. A success/failure of the magnetopause location prediction under different upstream conditions can serve as a test of our knowledge.
First magnetopause observations revealed a power-law dependence of its location on the solar wind pressure but the fact that the power index varies from -1/4.8 to -1/6.6 in different (about equally successful) empirical models suggests that the problem would be treated in a more complex way. An incorporation of the interplanetary magnetic field vertical component (IMF Bz) as a second upstream parameter improved a prediction of magnetopause locations significantly but the uncertainty is still large. Moreover, there are studies showing that the magnetopause can be strongly expanded during intervals when IMF is aligned with the solar wind velocity, during high-speed solar wind streams or when a solar activity is very low.
The present contribution concentrates on an analysis of these observations with an attempt to put all of them into a unified view on the solar wind-magnetosphere interaction. This approach includes not only an evaluation of possible upstream drivers but a response of magnetospheric current systems as well. We show that and discuss why the solar wind dynamic pressure should be separated into its components and both should be treated individually and why the solar UV flux exhibits the effect similar to that of IMF Bz.

How are isolated magnetic field structures in Mercury's magnetosheath related to the bow shock?

Abstract ID : 321

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Tomas Karlsson ,tomas.karlsson@ee.kth.se ,(Associate Professor) ,Sweden ,Stockholm ,Not Presenting[1]

Dr. Jim Raines ,jraines@umich.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Torbjörn Sundberg ,t.sundberg@qmul.ac.uk ,(None) ,Sweden , ,Not Presenting[3]

Mr. Elisabet Liljeblad ,elilil@kth.se ,(None) ,Sweden , ,Not Presenting[4]

Dr. Anita Kullen ,kullen@kth.se ,(Asc. Prof.) ,Sweden ,Stockholm ,Not Presenting[1]

Prof. James Slavin ,jaslavin@umich.edu ,(None) ,United States , ,Not Presenting[2]

1 - KTH Royal Institute of Technology 2 - Department of Climate and Space Sciences and Engineering, University of Michigan, Ann Arbor, MI 3 - - 4 - KTH 5 - KTH Royal Institute of Technology 6 - Department of Climate and Space Sciences and Engineering, University of Michigan, Ann Arbor, MI

Recently there has been an increased interest in transient, localized increases in plasma density and flow velocity in Earth's magnetosheath. Such enhancements have been studied under several different designations, e.g. magnetosheath jets or plasmoids. The latter designation specifically refers to the presence of clear magnetic signatures associated with localized density increases. These transients have been suggested to be universally present in planetary magnetospheres. As a first check of that hypothesis, we present results from the Mercury magnetosheath and near solar wind, using MESSENGER magnetic field data from the MAG instrument (and ion data from the Fast Imaging Plasma Spectrometer (FIPS) instrument for contextual information). We identify clear, isolated changes in the field magnitude, and study their properties in order to determine if they may be considered as analogues to plasmoids and jets in the terrestrial magnetosheath. Both isolated decreases of the magnetic field absolute value ('negative structures') and increases ('positive structures') are found in the magnetosheath, whereas only negative structures are found in the solar wind. The similar properties of the solar wind and magnetosheath negative magnetic field structures suggests that they are analogous to diamagnetic plasmoids found in Earth's magnetosheath and near solar wind. Positive magnetic field structures are only found in the magnetosheath, relatively close to the magnetopause. Their proximity to the magnetopause, their scale sizes, and the association of a majority of the structures with bipolar magnetic field signatures identify them as flux transfer events (which are associated with a decrease of plasma density in the magnetosheath). The positive magnetic field structures are therefore not likely to be analogous to terrestrial paramagnetic plasmoids but possibly to a sub-population of magnetosheath jets. We discuss some consequences of the findings of the present investigation pertaining to the different nature of the quasi-parallel bow shock at Mercury and Earth.

Numerical Simulation of Cosmic Rays Effects on the Structure of the Outer Heliosphere

Abstract ID : 338

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Xiaocheng Guo ,xcguo@spaceweather.ac.cn ,(Professor) ,China ,Beijing ,Not Presenting[1]

Dr. Vladimir Florinski ,vaf0001@uah.edu ,(None) ,United States ,Huntsville ,Not Presenting[2]

Dr. Chi Wang ,cw@spaceweather.ac.cn ,(None) ,China , ,Not Presenting[3]

1 - NSSC 2 - University of Alabama in Huntsville 3 - National Space Science Center, Chinese Academy of Sciences

The heliopause is a pressure balanced structure that separates the inner and outer heliosheaths. The total pressure of the solar wind particles, including pickup ions and anomalous cosmic rays (ACRs), is approximately equal to the pressure of the interstellar gas and its magnetic field on the outer side. If one component of the pressure changes, the
heliosphere will shrink or expand in response in order to compensate for the imbalance and reach a new equilibrium state. Based on Voyager 1 observations, some ACRs may have crossed the heliopause and escaped into the interstellar medium, providing a mechanism of energy transfer between the inner and outer heliosheaths that is not included in conventional MHD models. Here we evaluate the effect of ACR escape on the size and shape of the heliosphere using a
simple model that is integrated with the transport equation of cosmic rays. We will show the effect of the cosmic rays on the structure of the outer heliosphere and make the corresponding discussions.

Voyager data from the heliosheath and interstellar medium: An overview

Abstract ID : 380

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. john richardson ,jdr@space.mit.edu ,(PRS) ,United States ,Cambridge ,Not Presenting[1]

1 - M.I.T.

Voyager 1 is in the interstellar medium and Voyager 2 in the heliosheath. This talk will give a brief overview of recent Voyager data. Highlights are the plasma wave events in the interstellar medium which are asoociated with decreases in galactic cosmic ray intensities, unmodulated cosmic ray intensities from the interstellar medium, very different flow patterms and energetic particle intensities at the two spacecraft, and solar cycle changes in the heliosheath.

The Plasma Depletion Layer Beyond the Heliopause: Spatiotemporal Variations and Radio Emissions

Abstract ID : 419

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited talk (John Richardson)

Prof. Iver Cairns ,iver.cairns@sydney.edu.au ,(Professor in Space Physics) ,Australia ,Sydney ,Not Presenting[1]

Dr. Stephen Fuselier ,sfuselier@swri.edu ,(Executive Director, Space Science Directorate) ,United States ,San Antonio ,Not Presenting[2]

1 - University of Sydney 2 - SWRI

Voyager 1 plasma wave and magnetometer observations show evidence for the plasma depletion layer (PDL) predicted beyond the heliopause. The physics is that draping of interstellar (ISM) magnetic field lines over the heliopause increases the magnetic field strength (and so the perpendicular ion temperature) and causes density depletions by allowing plasma ions (and electrons) with large parallel temperatures to escape along the field. The strong region of the global PDL is thus predicted to occur where draping is strong and to be aligned with the ISM direction.

Accordingly, using the ISM direction given by the IBEX Ribbon, Voyager 2 should observe a much stronger PDL than Voyager 1. Importantly, the global PDL cannot be in (time-stationary) equilibrium and the PDL properties observed at Voyager 1 are likely not self-consistent with those predicted for the strong PDL region and Voyager 2. The reason is that the transit time of plasma from the PDL's frontside to regions downstream of the Sun is much longer than the timescales for changes in heliopause location and the solar cycle. Additionally, a largescale region with slowly varying, increased, density is expected beyond the PDL, corresponding to the pile-up region expected from MHD due to deflection of the ISM flow around the heliopause. Radio emissions produced at multiples of the electron plasma frequency upstream of shocks moving away from the heliopause should thus drift rapidly upwards in the PDL and then drift more slowly to towards a maximum frequency at the densest part of the pileup region. Any further radiation produced is unable to propagate backwards across the high density region and is lost into the ISM. These predictions will be compared with available Voyager radio and in situ data.

The transport of energetic particles across tangential discontinuities

Abstract ID : 471

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Du Toit Strauss ,dutoit.strauss@nwu.ac.za ,(Senior Lecturer) ,South Africa ,Potchefstroom ,Not Presenting[1]

1 - Center for Space Research

We investigate the transport of charged particles across magnetic discontinuities, focusing specifically on stream interfaces associated with co-otating interaction regions in the solar wind. We argue that the magnetic field fluctuations perpendicular to the magnetic discontinuity, and usually also perpendicular to the mean magnetic field, are strongly damped in the vicinity of such a magnetic structure, leading to anisotropic perpendicular diffusion. Assuming that perpendicular diffusion arises from drifts in a turbulent magnetic field, we adopt a simplified approach to derive the relevant perpendicular diffusion coefficient. This approach, which we believe gives the correct principal dependences as expected from more elaborate calculations, allows us to investigate transport in different turbulent geometries, such as longitudinal compressional turbulence that may be present near the heliopause. Implications for particle transport will be illustrated and discussed.

The Magnetopause and Associated Boundary Layers

Abstract ID : 550

Conflict Declaration : None

Content Motivation : None

Additional Information : Representing the MMS science team Inited talk

Dr. Steven Petrinec ,steve.petrinec@gmail.com ,(Physicist Senior Staff) ,United States ,Belmont, CA 94002 ,Not Presenting[1]

1 - Lockheed Martin ATC

The NASA Magnetospheric Multiscale mission (MMS), comprised of a set of four identically-instrumented spacecraft, was designed to sample the Earth's magnetopause and boundary layers as often as possible, targeting the most probable locations where the magnetic reconnection process could be directly observed. The tight formation and unprecedented, multi-point *in situ* sampling of the plasmas and fields have provided significant new understanding of the magnetopause and its associated boundary layers. This presentation discusses some of the recent scientific results from this mission and how they are advancing our understanding of the interaction between the solar wind and Earth's magnetosphere.

Small-scale turbulence in the Earth's magnetosheath affected by the bow shock and the magnetopause

Abstract ID : 622

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Liudmila Rakhmanova ,rakhlud@gmail.com ,(PhD student) ,Russia ,Moscow ,Not Presenting[1]

Dr. Maria Riazantseva ,orearm@gmail.com ,(None) ,Russia , ,Not Presenting[2]

Dr. Georgy Zastenker ,gzastenk@iki.rssi.ru ,(None) ,Russia , ,Not Presenting[2]

1 - Space Research Institute of the Russian Academy of Sciences 2 - Space Research Institute 3 - Space Research Institute

Turbulence in the Earth's magnetosheath develops in the bounded space unlike the solar wind turbulence. The two boundaries - the magnetopause and the bow shock - may play a crucial role in the energy cascade formation. The boundaries may serve as constraints preventing the turbulence to develop "freely". Moreover, a number of instabilities and wave modes are associated with the bow shock and the magnetopause. Both inertial and kinetic range of the turbulent cascade can be affected by the boundaries. At the scales smaller than ion gyroradius, kinetic processes in plasma are supposed to influence the energy cascade. Exploring space plasma at these scales can give us an opportunity to understand the processes of plasma heating and energization. Information concerning the scale at which these processes start to operate can help us to understand their nature. Recently statistical studies of the small-scale plasma turbulence in the magnetosheath were reported indicating the variability of shapes of the plasma fluctuation spectra at kinetic scales. In the present study we consider modification of the spectra shapes and indices by the magnetosheath boundaries. We use rapid ion flux measurements by the BMSW instrument on board the Spektr-R spacecraft. Time resolution of the plasma data - 31 ms - is sufficient to observe the transition between MHD and kinetic scales at spectra. We study the influence of the boundaries on the spectra shape in the transition range. We also compare indices of the spectra in different locations inside the magnetosheath in order to bring out the influence of the boundaries on the plasma turbulence in this region.

Magnetic field fluctuations and energetic particles at the boundary of the heliosphere

Abstract ID : 722

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Vladimir Florinski ,vaf0001@uah.edu ,(None) ,United States ,Huntsville ,Not Presenting[1]

1 - University of Alabama in Huntsville

The heliosphere is separated from the surrounding interstellar cloud by an interface called the heliopause, where the pressure of interstellar gas and magnetic field is balanced by the pressure of the compressed and heated solar wind and the accelerated pickup ions. The Voyager 1 space probe crossed the heliopause in 2012 and is currently exploring the region known as the outer heliosheath, which is an interstellar region affected by the presence of the heliopause. The heliopause crossing event was accompanied by the deep depletions and eventual disappearance of heliospheric energetic particles, including anomalous cosmic rays, the unrolling of the galactic cosmic ray spectrum in two large steps, and a profound change in the character of the magnetic turbulent fluctuations. Galactic cosmic rays, while remarkably steady in interstellar space, nonetheless showed episodic depletions at the 90 degree pitch angle as well as enhancements apparently associated with shock waves. I will review the energetic particle and magnetic field phenomena in the heliopause transition and beyond and discuss their possible theoretical interpretations.

A30 - Advances in Solar and Heliospheric Physics (DIV IV)

Science with the European Solar Telescope

Abstract ID : 149

Conflict Declaration : None

Content Motivation : invited talk

Additional Information : yes

Dr. María Jesús Martínez González ,marian@iac.es ,(Postdoc) ,Spain ,La Laguna ,Not Presenting[1]

1 - Instituto de Astrofísica de Canarias

The European Solar Telescope (EST) is a 4-m class telescope concept that is planned to see first light in 2026. EST will be
optimised for multiwavelength, spectro-polarimetric studies at the highest spatial resolution (25 km). To achieve such large spatial
resolution, the EST will be the first telescope to incorporate a multi-conjugate adaptive optics system that will enable diffraction-limited
observations. These technical capabilities will foster frontier research in the magnetic coupling of the solar atmosphere. In this presentation,
the telescope concept will be presented as well as the future science with the EST, highlighting its potential for the diagnostic of thermal and
magnetic properties of the chromosphere and of chromospheric structures embedded in the corona.

Average characteristic dynamics of parameters in structures of solar wind

Abstract ID : 252

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yuri Yermolaev ,yermol@iki.rssi.ru ,(Head of laboratory) ,Russia ,Moscow ,Not Presenting[1]

Dr. Irina Lodkina ,irina-priem@mail.ru ,(None) ,Russia , ,Not Presenting[1]

Dr. Michael Yermolaev ,michaely2@yandex.ru ,(None) ,Russia , ,Not Presenting[1]

1 - Space Research Institute 2 - Space Research Institute 3 - Space Research Institute

In our report we present results of calculation of average temporal profiles of interplanetary parameters in following large-scale solar wind (SW) phenomena: interplanetary manifestation of coronal mass ejection (ICME) including magnetic cloud (MC) and Ejecta, Sheath-compression region before fast ICME and corotating interaction region (CIR)-compression region before high-speed stream (HSS) of solar wind. We use the OMNI data base, our Catalog of solar wind phenomena (see web-site ftp://ftp.iki.rssi.ru/pub/omni/ and paper by Yermolaev et al., 2009). To take into account of various durations of similar phenomena, we use the Double Superposed Epoch Analyses (DSEA) Method [Yermolaev et al., 2010]. To take into account a possible influence of other SW types, following sequences of phenomena, which include all typical sequences of non-stationary SW events, are analyzed: (1) SW/ CIR/ SW, (2) SW/ IS/ CIR/ SW, (3) SW/ Ejecta/ SW, (4) SW/ Sheath/Ejecta/ SW, (5) SW/ IS/ Sheath/ Ejecta/ SW, (6) SW/ MC/ SW, (7) SW/Sheath/ MC/ SW, (8) SW/ IS/ Sheath/ MC/ SW (where SW is undisturbed solar wind, and IS is interplanetary shock) [Yermolaev et al., 2015]. Average characteristic dynamics of parameters in various SW phenomena, their similarities and distinctions are discussed. The work was supported by the Russian Science Foundation, projects 16-12-10062.

References:

Yermolaev, Yu. I., N. S. Nikolaeva, I. G. Lodkina, and M. Yu. Yermolaev (2009), Catalog of Large-Scale Solar Wind Phenomena during 1976-2000, Cosmic Research, , Vol. 47, No. 2, pp. 81-94.

Yermolaev, Y. I., N. S. Nikolaeva, I. G. Lodkina, and M. Y. Yermolaev (2010), Specific interplanetary conditions for CIR-induced, Sheath-induced, and ICME-induced geomagnetic storms obtained by double superposed epoch analysis, Ann. Geophys., 28, pp. 2177-2186.

Yermolaev, Yu. I., I. G. Lodkina, N. S. Nikolaeva, and M. Yu. Yermolaev (2015), Dynamics of large-scale solar wind streams obtained by the double superposed epoch analysis, J. Geophys. Res. Space Physics, 120, doi:10.1002/2015JA021274.

Solar Wind Measurements on Solar Orbiter: Discovering the Links Between the Solar Wind and the Atmosphere of Our Sun

Abstract ID : 282

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Stefano Livi ,slivi@swri.edu ,(None) ,United States ,San Antonio ,Presenting[1]

Dr. Antoinette Galvin ,toni.galvin@unh.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Frederic Allegrini ,fallegrini@swri.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Susan Lepri ,slepri@umich.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Keiichi Ogasawara ,keiichi.ogasawara@swri.org ,(None) ,United States , ,Not Presenting[5]

Dr. Jim Raines ,jraines@umich.edu ,(None) ,United States , ,Not Presenting[6]

Dr. Lynn Kistler ,lynn.kistler@unh.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Michael Collier ,michael.r.collier@nasa.gov ,(None) ,United States , ,Not Presenting[8]

1 - Southwest Research Institute 2 - University of New Hampshire 3 - Southwest Resea5rch Institute 4 - University of Michigan 5 - Southwest Research Institute 6 - Department of Climate and Space Sciences and Engineering, University of Michigan, Ann Arbor, MI 7 - University of New Hampshire 8 - Goddard Space Flight Center

The Solar Orbiter spacecraft, a collaborative mission between ESA and NASA, will be launched in 2019 and will include the Solar Wind Analyzer instrumentation suite. This space mission will allow for unprecedented data collection of particle characteristics near the Sun at various heliolatitudes during both the quiet and active phases of the solar cycle. The close proximity will allow for determination of the source regions on the sun for the observed events. Of particular interest will be the study of the origins of and processes related to solar energetic particles. This mission will lead to a better understanding of the Sun and the interstellar medium in our solar system. The Solar Wind Analyzer (SWA) suite is composed by a comprehensive set of sensors to characterize the Solar Wind plasma: the Electron Analyzer System to determine the properties of solar wind electrons, the Proton and Alpha Sensor to measure at high cadence the distribution functions of protons and alphas, and the Heavy Ion Sensor to analyze the minor ion components of the solar wind. As a result of the measurements SWA will take, we will be able to: Identify interplanetary shocks and characterize their spatial and temporal evolution; characterize the power spectra of density and velocity fluctuations upstream and downstream of shocks; study the heating and dissipation mechanisms at shocks at various radial distances and latitudes; and identify the mechanisms that hheat thermal solar wind ions near shocks and determine the energy partition at shocks.

Coronal Flux Ropes Constructed from Eruption Data and their Interplanetary Counterparts

Abstract ID : 372

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Nat Gopalswamy ,nat.gopalswamy@nasa.gov ,(Astrophysicist) ,United States ,Greenbelt ,Not Presenting[1]

Dr. Seiji Yashiro ,seiji.yashiro@nasa.gov ,(None) ,United States , ,Not Presenting[2]

Dr. Hong Xie ,hong.xie@nasa.gov ,(None) ,United States , ,Not Presenting[2]

Dr. Sachiko Akiyama ,sachiko.akiyama@nasa.gov ,(None) ,United States , ,Not Presenting[2]

1 - NASA Goddard Space Flight Center 2 - Catholic University 3 - Catholic University 4 - Catholic University

We construct coronal flux ropes using flare reconnected (RC) flux and geometrical properties from coronagraph images. The RC flux is computed using a new technique that combines the area under the post-eruption arcade and photospheric magnetogram as described in Gopalswamy et al. (2017, http://adsabs.harvard.edu/abs/2017arXiv170101943G). Under the assumption of force free flux ropes, and fact that the RC flux is the same as the poloidal flux of the flux rope originating from the reconnection region, we fully define the geometric and magnetic properties of coronal flux ropes. We found that the RC flux is closely related to the soft X-ray flare fluence and the associated CME kinetic energy, suggesting a close relationship between flares and CMEs. The flux rope magnetic field strength derived from the RC flux is higher than typical ambient coronal field strength, confirming that the flux rope is a low-beta plasma. We also found that the coronal flux rope properties are closely related to those of interplanetary flux ropes. In particular, the field strength in the coronal and in the interplanetary flux ropes are significantly correlated, thus providing a simple way to predict interplanetary flux rope properties based on eruption data near the Sun. The results also support the idea that CME flux ropes are formed during eruption rather than pre-existing.

Solar Wind Suprathermal Electrons at Quiet Times

Abstract ID : 393

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Linghua Wang ,wanglhwang@gmail.com ,(Assistant Professor, and Research Professor) ,China ,Beijing ,Not Presenting[1]

Dr. Robert F. Wimmer-Schweingruber ,wimmer@physik.uni-kiel.de ,(None) ,Germany , ,Not Presenting[2]

Mr. Jiawei Tao ,taojiawei@pku.edu.cn ,(None) ,China , ,Not Presenting[3]

Prof. Qiugang Zong ,qgzong@gmail.com ,(None) ,China , ,Not Presenting[3]

Prof. Chuanyi Tu ,chuanyitu@pku.edu.cn ,(None) ,China , ,Not Presenting[3]

Prof. Stuart Bale ,bale@ssl.berkeley.edu ,(None) ,United States , ,Not Presenting[6]

Prof. Jiansen He ,jshept@pku.edu.cn ,(None) ,China , ,Not Presenting[3]

Mr. Liu Yang ,liuyang11@pku.edu.cn ,(None) ,China , ,Not Presenting[3]

Prof. Jiansen He ,jshept@pku.edu.cn ,(None) ,China , ,Not Presenting[3]

1 - 2 - Christian Albrechts University 3 - Institute of Space Physics and Applied Technology, Peking University 4 - Institute of Space Physics and Applied Technology, Peking University 5 - Institute of Space Physics and Applied Technology, Peking University 6 - University of California, Berkeley 7 - Institute of Space Physics and Applied Technology, Peking University 8 - Institute of Space Physics and Applied Technology, Peking University 9 - Institute of Space Physics and Applied Technology, Peking University

Solar wind surpathermal particles carry important information on the common particle acceleration/transport processes at the Sun and in the interplanetary space. We present a statistical survey of the energy spectrum of solar wind suprathermal (~0.1-200 keV) electrons measured by the WIND 3DP instrument at 1 AU during quiet times at the minimum and maximum of solar cycles 23 and 24. All the strahl, halo and superhalo electron populations show no obvious correlation with the solar wind core population. The observed energy spectrum of both (beaming) strahl and (isotropic) halo electrons at ~0.1-1.5 keV generally fits to a Kappa distribution function with an index κ and effective temperature T_{eff}, while the observed energy spectrum of nearly isotropic superhalo electrons at ~20-200 keV generally fits to a power-law function, $J \sim E^{-\beta}$. We find a strong positive correlation between κ and T_{eff} for both strahl and halo electrons, and a strong positive correlation between the

strahl density and halo density. In both solar cycles, κ is larger at solar minimum than at solar maximum for both strahl and halo electrons. For the superhalo population, the spectral index β ranges from ~1.6 to ~3.7, with a broad maximum between 2.4 and 2.8 (2.0 and 2.4) in solar cycle 23 (24). The integrated superhalo density has no clear association with the sunspot number. These results reflect the nature of the generation of solar wind suprathermal electrons.

Blowing in the Wind - Coronal Mass Ejections in Three Dimensions

Abstract ID : 442

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Volker Bothmer ,bothmer@astro.physik.uni-goettingen.de ,(Institute for Astrophysics/Project Lead CGAUSS DLR/NASA/SPP) ,Germany ,Goettingen ,Not Presenting[1]

1 - University Goettingen

Fast Coronal mass ejections (CMEs) are the prime source of space storms and their associated space weather effects. A variety of solar and heliospheric space missions, such as SOHO, STEREO, SDO or ACE have provided over the past decades unprecedented remote sensing and in-situ observations of CMEs. The analysis of multipoint space observations has led to a new understanding of the 3D structure of CMEs. Understanding the 3D topology and interplanetary evolution of CMEs is of key importance to help establish reliable space weather forecasts and to develop methods with which hazardous effects on our modern day technological infrastructure can be mitigated. In my presentation I will summarize the state-of-the-art understanding of CMEs and the related scientific and societal benefits.

Lessons from empirical and neural network space weather forecast models using solar data

Abstract ID : 547

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Yong-Jae Moon ,moonyj@khu.ac.kr ,(Professor) ,South Korea ,Yongin ,Presenting[1]

1 - Kyung Hee University

For the last decade, we have developed several empirical space weather (solar flare, coronal mass ejections, solar proton event, and geomagnetic storm) forecast models based on solar data. In this talk we will review our main results and discuss scientific implications. First, we have examined solar flare (R) and CME occurrence probabilities depending on sunspot McIntosh classification, its area change, and solar cycle phase. We find that sunspot area and its increase (a proxy of flux emergence) greatly enhance solar flare and CME occurrence rates for several sunspot classes. We also developed a daily solar flare peak flux forecast model using regressive and neural network methods. Second, we have developed a solar proton event (S) forecast model depending on flare parameters (flare strength, duration, and longitude) as well as CME parameters (speed and angular width. We find that solar proton event probability strongly depends on these parameters and CME speed is well correlated with solar proton flux for disk events. We also develop a model to forecast the proton flux profiles for well-connected events. Third, we have developed an empirical storm (G) forecast model to predict the probability and strength of a storm using halo CME - Dst storm data. For this we use storm probability maps depending on CME parameters such as speed, location, and earthward direction. Fourth, we have developed a full ice-cream cone model for CME 3-D parameters using single coronagraph data and found that the derived 3-D parameters are similar to those from stereoscopic methods using multi-spacecraft. Fifth, we are developing a set of flare and CME occurrence model based on solar magnetograms and EUV images using deep learning methods such as convolution neural network. Scientific and empirical lessons earned from the models will be discussed in view of future development.

IBEX Observations of the Global Heliosphere and Interstellar Medium

Abstract ID : 549

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Nathan Schwadron ,nschwadron@unh.edu ,(Professor of Physics) ,United States ,Durham ,Not Presenting[1]

1 - University of New Hampshire

Our piece of cosmic real-estate, the heliosphere, is the domain of all human existence - an astrophysical case-history of the successful evolution of life in a habitable system. By exploring our global heliosphere and its myriad interactions, we develop key physical knowledge of the interstellar interactions that influence exoplanetary habitability as well as the distant history and destiny of our solar system and world. IBEX was the first mission to explore the global heliosphere and in concert with Voyager 1 and Voyager 2 is discovering a fundamentally new and uncharted physical domain of the outer heliosphere. The enigmatic IBEX ribbon was an unanticipated discovery demonstrating that much of what we know or think we understand about the outer heliosphere needs to be revised. The next quantum leap enabled by IMAP will open new windows on the frontier of Heliophysics at a time when the space environment is rapidly evolving. IMAP, like ACE before it, will be a keystone of the Heliophysics System Observatory by providing comprehensive cosmic ray, energetic particle, pickup ion, suprathermal ion, neutral atom, solar wind, solar wind heavy ion, and magnetic field observations to diagnose the changing space environment and understand the fundamental origins of particle acceleration. In this talk, we will review recent discoveries of IBEX and their relation to measurements by Voyager 1 and Voyager 2. We will discuss new analyses of IBEX measurements of interstellar neutral matter, which reveal the influences of interstellar structure influenced by the external interstellar magnetic field.

Heating of an erupting prominence associated with a coronal mass ejection on 2012 January 27

Abstract ID : 584

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jin-Yi Lee ,jlee@khu.ac.kr ,(Research Professor) ,South Korea ,Yongin ,Presenting[1]

Dr. John C. Raymond ,jraymond@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[2]

Mr. Katharine K. Reeves ,kreeves@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[2]

Prof. Yong-Jae Moon ,moonyj@khu.ac.kr ,(Professor) ,South Korea ,Yongin ,Not Presenting[4]

Prof. Kap-Sung Kim ,kskim@khu.ac.kr ,(None) ,United States , ,Not Presenting[4]

1 - Kyung Hee University 2 - Harvard-Smithsonian Center for Astrophysics 3 - Harvard-Smithsonian Center for Astrophysics 4 - Kyung Hee University 5 - Kyung Hee University

We investigate the heating of an erupting prominence and loops associated with a coronal mass ejection and X-class flare. The prominence is seen in absorption in EUV at the beginning of its eruption. Later the prominence changes to emission, which indicates heating of the erupting plasma. We find the densities of the erupting prominence using the absorption properties of hydrogen and helium in different passbands. We estimate the temperatures and densities of the erupting prominence and loops seen as emission features using the differential emission measure method, which uses both EUV and X-ray observations. We consider spectra using both photospheric and coronal abundances in these calculations. We verify the methods for the estimation of temperatures and densities for the erupting plasmas. Then we estimate the thermal, kinetic, radiative loss, thermal conduction, and heating energies of the erupting prominence and loops. We find that the heating of the erupting prominence and loop occurs strongly at the earlier time of the eruption. This event shows a writhing motion of the erupting prominence, which may indicate a hot flux rope heated by thermal energy release during magnetic reconnection.

The heliospheric boundaries: global modeling vs. Voyager and IBEX data

Abstract ID : 748

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Vladislav Izmodenov ,izmod@iki.rssi.ru ,(Izmodenov Vladislav, Space Research Institute of the Russian Academy of Sciences (IKI),) ,Russia ,Moscow ,Not Presenting[1]

1 - Space Research Institute (IKI) Russian Academy of Sciences

Modeling of the global heliosphere is essentially important for interpretation of the relevant space experiments both inside the heliosphere and at the boundary of the solar wind (SW) interaction with the local interstellar medium (LISM). Modern models of the SW/LISM interactions are 3D multi-component kinetic-MHD models which take into account effects of both the solar wind and local interstellar plasma, both the heliospheric and interstellar magnetic fields, interstellar hydrogen atoms and pickup protons. In addition, the models may take into account the latitudinal and time variations of the solar wind parameters. In this presentation I will critivally review current status in the modeling of the SW/LISM interactions and compare the model predictions with spacecraft data obtained on boards of Voyager, IBEX, SOHO and HST.

Interface Region Imaging Spectrograph views of how the solar atmosphere is energized

Abstract ID : 812

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Bart De Pontieu ,bart.de.pontieu@gmail.com ,(Principal Physicist) ,United States ,Palo Alto ,Not Presenting[1]

1 - Lockheed Martin Solar & Astrophysics Laboratory

At the interface between the Sun's surface and million-degree outer atmosphere or corona lies the chromosphere. At 10,000K it is much cooler than the corona, but also many orders of magnitude denser. The chromosphere processes all magneto-convective energy that drives the heating of the million-degree outer atmosphere or corona, and requires a heating rate that is at least as large as that required for the corona. Yet many questions remain about what drives the chromospheric dynamics and energetics and how these are connected to the transition region and corona.
The Interface Region Imaging Spectrograph (IRIS) is a NASA small explorer satellite that was launched in 2013 to study how the Sun's magneto-convection powers the low solar atmosphere. I will review recent results from IRIS in which observations and models are compared to study the onset of fast magnetic reconnection in the solar atmosphere, the generation of violent jets and how they feed plasma into the hot corona, and the role of nanoflares in heating the corona.

The quiet Sun at high resolution

Abstract ID : 817

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Luis Bellot Rubio ,lbellot@iaa.es ,(Head of Solar System Department) ,Spain ,Granada ,Not Presenting[1]

1 - I

The advent of high spatial and high temporal resolution spectropolarimetric observations has revolutionized our understanding of the quiet Sun in the last few years. We are starting to resolve the basic building blocks of the photospheric network and the solar internetwork. More importantly, we can now study the evolution of quiet Sun magnetic fields on short, medium, and long time scales, thanks to the availability of uninterrupted, very sensitive observations from space. This has led to several breakthroughs as, for example, the detection of small magnetic loops emerging on the solar surface and rising to higher atmospheric layers or the determination of the flux appearance and disappearance rates in the solar internetwork. In this talk I will describe recent advances in the field of quiet Sun magnetism, identifying the main open questions and the challenges to be addressed in the near future.

Information theoretical approach to discovering causality in solar cycle dynamics

Abstract ID : 974

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Simon Wing ,simon.wing@jhuapl.edu ,(None) ,United States ,Laurel ,Not Presenting[1]

1 - Johns Hopkins University

he solar cycle has a periodicity that is roughly 11 years. The clearest sign of the cycle can be seen in the rise and fall of the sun spot number, but other solar phenomena such as flares, coronal mass ejections, stream interaction regions, etc. also exhibit an 11-year repetitive behavior. In most solar flux transport dynamo models, the solar cycle is basically a cycle of conversion from toroidal to poloidal and back to toroidal magnetic field with a reversal of polarity every 11 years. The latitudinal differential rotation of the sun creates shearing motions that turn the poloidal field to toroidal field. As the toroidal field rises in the convection zone due to magnetic buoyancy, it twists, leading to the active regions in the photosphere. The decay of the active regions give rise to the poloidal field, which is transported to the polar region, down to the tachocline and then back to the equator by the meridional flow. Although much consensus has been reached on the basic dynamo mechanism, there are still debates over which parameters control the amplitude and periodicity of the cycle, and the origin of disruptions in the cycle during grand minima. For example, in some models, the amplitude is controlled primarily by the amount of open flux in the polar region while in others, it is also controlled by the amount of poloidal field converted from the toroidal field in the equatorial region. We apply information-theoretical tools such as mutual information, conditional mutual information, and transfer entropy to measure causal dependencies of solar cycle dynamics on the parameters that have been identified as important drivers in the models and in empirical studies. Proxies are used when these parameters cannot be directly observed. For example, aa and Ap indices and solar faculae have been used as proxies for the amount of open flux in the polar regions. Our investigation determines how much information about the solar cycle dynamics is contained in these parameters, which should have implications to solar cycle preditions.

Comparison of 3D CME Parameters Derived from Single and Multi-view Observations

Abstract ID : 1019

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Harim Lee ,harim@khu.ac.kr ,(None) ,South Korea , ,Presenting[1]

Prof. Yong-Jae Moon ,moonyj@khu.ac.kr ,(Professor) ,South Korea ,Yongin ,Not Presenting[1]

Ms. Hyeonock Na ,nahock87@gmail.com ,(None) ,South Korea , ,Not Presenting[1]

Ms. Soojeong Jang ,sjjang@khu.ac.kr ,(None) ,South Korea , ,Not Presenting[1]

Dr. Jae-Ok Lee ,ljoking@kasi.re.kr ,(None) ,South Korea , ,Not Presenting[5]

1 - Kyung Hee University 2 - Kyung Hee University 3 - Kyung Hee University 4 - Kyung Hee University 5 - Korea Astronomy and Space Science Institute

To prepare for when only single-view observations are available, we have made a test whether the 3-D parameters (radial velocity, angular width, and source location) of halo coronal mass ejections (HCMEs) from single-view observations are consistent with those from multiview observations. For this test, we select 44 HCMEs from December 2010 to June 2011 with the following conditions: partial and full HCMEs by SOHO and limb CMEs by twin STEREO spacecraft when they were approximately in quadrature. In this study, we compare the 3-D parameters of the HCMEs from three different methods: (1) a geometrical triangulation method, the STEREO CAT tool developed by NASA/CCMC, for multiview observations using STEREO/SECCHI and SOHO/LASCO data, (2) the graduated cylindrical shell (GCS) flux rope model for multiview observations using STEREO/SECCHI data, and (3) an ice cream cone model for single-view observations using SOHO/LASCO data. We find that the radial velocities and the source locations of the HCMEs from three methods are well consistent with one another with high correlation coefficients (≥0.9). However, the angular widths by the ice cream cone model are noticeably underestimated for broad CMEs larger than 100$^?$ and several partial HCMEs. A comparison between the 3-D CME parameters directly measured from twin STEREO spacecraft and the above 3-D parameters shows that the parameters from multiview are more consistent with the STEREO measurements than those from single view.

Simulation of an extremely fast coronal mass ejection on July 23, 2012: Follow-up study

Abstract ID : 1359

Conflict Declaration : None

Content Motivation : Awareness of the magnetosphere-ionosphere interaction has increased greatly in the last thirty years. However, understanding the physical characteristics associated with geomagnetic superstorms is still a major challenge.

Additional Information : None

Dr. Chigomezyo Ngwira ,chigomezyo.ngwira@nasa.gov ,(Postdoc) ,United States ,Greenbelt ,Not Presenting[1]

Prof. Antti Pulkkinen ,antti.a.pulkkinen@nasa.gov ,(None) ,United States , ,Not Presenting[2]

Dr. David Sibeck ,david.g.sibeck@nasa.gov ,(None) ,United States , ,Not Presenting[3]

Prof. Benoit Lavraud ,blavraud@irap.omp.eu ,(None) ,France , ,Not Presenting[4]

1 - Catholic University of America 2 - NASA Goddard Space Flight Center 3 - NASA GSFC 4 - Institut de Recherche en Astrophysique et Planétologie

Awareness of the magnetosphere-ionosphere interaction has increased greatly in the last thirty years. However, understanding the physical characteristics associated with geomagnetic superstorms is still a major challenge. In this case study, we present the latest global physics-based University of Michigan Space Weather Modeling Framework (SWMF) simulation of the July 23, 2012 extremely fast CME observed by NASA's STEREO-A. For this new simulation, we use a proxy plasma density input derived by Liu et al. (2014). We show that the modeled global magnetic field perturbations are significantly higher (>15%) than reported by Ngwira et al., (2013). Additionally, the overall ground temporal variation pattern is very different. Our results provide key insight on the electrodynamics behavior of magnetosphere-ionosphere response during extreme space weather events.

Properties of Supersonic Evershed Downflows

Abstract ID : 1439

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sara Esteban Pozuelo ,sara.esteban@astro.su.se ,(Postdoctoral Researcher) ,Sweden ,Stockholm ,Presenting[1]

Dr. Luis Bellot Rubio ,lbellot@iaa.es ,(Head of Solar System Department) ,Spain ,Granada ,Presenting[2]

Dr. Jaime de la Cruz Rodríguez ,jaime@astro.su.se ,(None) ,Sweden , ,Not Presenting[3]

1 - Institute for Solar Physics 2 - I 3 - ISP

Sunspot penumbrae harbor a plethora of intriguing features. Among them are supersonic Evershed downflows. Their existence has been suspected since long ago, being first reported as extreme cases of line asymmetries (Bumba 1960). After that, some authors also found clues of them (Stellmacher & Wiehr 1971; Bellot Rubio et al. 2004; Ichimoto et al. 2007; Bellot Rubio 2010; van Noort et al. 2012; and others), but many questions are still open, as how their polarization profiles are or if they really exist. Furthermore, their temporal evolution is still unknown and is the key element to understand their nature. Our motivation is entirely focused on shed light on these aspects.
We characterize the properties and the temporal evolution of supersonic Evershed downflows in a sunspot penumbra located close to the disk center by means of a temporal sequence of high spatial resolution spectropolarimetric data acquired in the Fe I 617.3 nm line with the CRISP instrument at the Swedish 1-m Solar Telescope. We detect supersonic Evershed downflows considering information from LOS velocities given by the Stokes V zero-crossing wavelength, and the far-wing magnetograms, together with the LOS velocity and the magnetic field vector inferred from two-component inversions performed using the SIR code. Supersonic Evershed downflows show LOS velocities between 7.5 and 9.5 km/s and are contained in compact patches moving outward, mainly located in the mid and outer penumbra. These are observed as bright and roundish features at the outer end of penumbral filaments that resemble penumbral grains. They undergo fragmentations and mergings during their lifetime, even some of them are recurrents. Supersonic Evershed downflows are associated with strong and rather vertical magnetic fields with a reversed polarity compared to that of the sunspot (median values of 1.5 kG and 30º, respectively). We suggest that downflows returning back to the solar surface with supersonic velocities are abruptly stopped in dense deep layers and produce a shock. Consequently, there is a temperature enhancement that increases the continuum intensity and is detected as a bright grain in the continuum filtergrams.

Helioseismology

Abstract ID : 1514

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Laurent Gizon ,gizon@mps.mpg.de ,(None) ,France ,None ,Not Presenting[1]

1 - None

Helioseismology -- the study of solar oscillations to learn about the solar interior -- is making strong progress on several fronts. First, recent observations from the Solar Dynamics Observatory (in operations since 2010) has revealed new aspects of the internal dynamics of the solar convection zone: near-surface internal rotation, evolution of large-scale flows, subsurface helical convection, latitudinal variation of turbulent stresses, flows around active regions, etc.
Second, new advances in computational methods offer exciting opportunities for the interpretation of helioseismic observations, which should lead to more reliable inferences of solar internal properties. In particular, accurate computations of the propagation of solar acoustic waves through solar models with flows (the forward problem of helioseismology) are now routinely available. In this talk I will give an overview of the current status of helioseismology and present a selection of recent observational results.

Coronal seismology with decay-less kink oscillations

Abstract ID : 1516

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sergey Anfinogentov ,Sergey.Anfinogentov@warwick.ac.uk ,(Research Fellow) ,United Kingdom ,Coventry ,Presenting[1]

Prof. V. M. Nakariakov ,V.Nakariakov@warwick.ac.uk ,(None) ,South Korea ,None ,Not Presenting[2]

Mr. Giuseppe Nisticò ,nistico@astro.physik.uni-goettingen.de ,(None) ,South Africa , ,Not Presenting[3]

1 - University of Warwick 2 - University of Warwick/Kyung Hee University 3 - Georg-August University

Magnetohydrodynamic (MHD) seismology of the solar corona measures plasma parameters by using MHD waves as a natural probe. In particular, standing kink oscillations of coronal loops allows for estimating the magnetic field, because it can be easily calculated from the observables, such as the oscillation period, the length of the loop, density contrast, and plasma density inside the loop. Up to the present time, observations of decaying kink oscillations of coronal loops have been relatively rare. These events are mainly associated with solar flares and CMEs, and hence occur occasionally. Therefore, they are not suitable for the routine seismological diagnostics of all solar active regions. The recently discovered kink oscillations of another, decayless type were found to be ubiquitous, and are observed in almost any active region at any time. Hence, they can be applied for the routine seismological diagnostic of the coronal magnetic field in solar active regions. However, analysis of these oscillations is a challenging task because of their small displacements amplitude, less than the pixel size of SDO/AIA. This issue is addressed with the motion magnification technique. It acts like a microscope for low amplitude transverse motions in image sequences (i.e. AIA data cubes), allowing for robust estimation of the oscillation parameters. Thus, the regular diagnostics of the coronal magnetic field in solar active regions became practically possible by analysing the decay-less coronal kink oscillations. Moreover, the interpretation of decayless kink oscillations as self-oscillations reveals the energy balance in active regions and the energy supply channels.

A31 - Waves and turbulence in the solar corona and wind (DIV IV)

Scaling of power spectral densities of solar wind and IMF variations

Abstract ID : 237

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Jana Safrankova ,jana.safrankova@mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

Dr. Lubomir Prech ,lubomir.prech@mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

Prof. Zdenek Nemecek ,zdenek.nemecek@mff.cuni.cz ,(professor) ,Czech Republic ,Prague ,Not Presenting[1]

Dr. Frantisek Nemec ,frantisek.nemec@mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

Dr. Maria Riazantseva ,orearm@gmail.com ,(None) ,Russia , ,Not Presenting[5]

Dr. Georgy Zastenker ,gzastenk@iki.rssi.ru ,(None) ,Russia , ,Not Presenting[5]

1 - Charles University 2 - Charles University 3 - Charles University 4 - Charles University 5 - Space Research Institute 6 - Space Research Institute

Solar wind turbulence has been studied for many decades because understanding its properties is important for a determination of universal features of turbulence and for an estimation of collisionless plasma heating. A broad range of scales is predicted and observed: from the fluid regime where the MHD approximation can be used down to small scales where kinetic effects should be taken into account. Measurements of the solar wind turbulent spectra in the vicinity of ion and electron scales may clarify our understanding of the dissipation (or dispersion) processes of the turbulent energy. The power spectrum can be approximated with a power law within each particular scale and a transition from larger to smaller scales is distinctly seen as an increase of the exponent and the corresponding frequency is called the break frequency.
The paper analyzes solar wind power spectral densities of density, bulk, and thermal speed fluctuations that are computed with a time resolution of 32 ms in the frequency range of 0.001-2 Hz and compares them with the power spectrum of magnetic fluctuations (using the data propagated from the Wind spacecraft). We discuss the break frequency between inertial and ion scales that is usually associated with the ion inertial length or with the proton thermal gyroradius. Our results show

that this transition is generally controlled by the plasma beta but particular quantities behave differently.

Properties of low frequency downstream waves associated with interplanetary shocks

Abstract ID : 258

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Oleksandr Goncharov ,goncharov.oleksandr@gmail.com ,(None) , , ,Not Presenting[1]

Dr. Georgy Zastenker ,gzastenk@iki.rssi.ru ,(None) ,Russia , ,Not Presenting[2]

Dr. Adam Szabo ,adam.szabo@nasa.gov ,(None) ,United States , ,Not Presenting[3]

Dr. Lubomir Prech ,lubomir.prech@mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

Dr. Andriy Koval ,andriy.koval@nasa.gov ,(None) ,United States , ,Not Presenting[3]

Prof. Jana Safrankova ,jana.safrankova@mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

Prof. Zdenek Nemecek ,zdenek.nemecek@mff.cuni.cz ,(professor) ,Czech Republic ,Prague ,Not Presenting[1]

1 - Charles University 2 - Space Research Institute 3 - GSFC NASA 4 - Charles University 5 - GSFC NASA 6 - Charles University 7 - Charles University

The interplanetary (IP) shocks are often associated with high-frequency (several Hz) wave packets in the upstream region. These waves were studied by many authors in fast magnetic ?eld data. *Goncharov et al.* (2014) have presented a comparative analysis of these waves using 32-ms resolution measurements of the solar wind parameters from the BMSW instrument onboard the Spektr-R spacecraft. However, low-frequency waves (up to 1 Hz) are more frequently observed in the downstream region behind the shock. Our previous analysis of downstream waves has shown that their wavelengths are directly proportional to the shock ramp thickness that is controlled by the ion thermal gyroradius. It was found that a phase shift between density and temperature variations is about 90°. Since the magnetometer onboard Spektr-R is not in operation, we compare its plasma observations with Wind/DSCOVR fast magnetic ?eld measurements and discuss a nature and properties of these waves.

First Detection of Radial and Azimuthal Oscillations in Halo CMEs

Abstract ID : 422

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Harim Lee ,harim@khu.ac.kr ,(None) ,South Korea , ,Presenting[1]

Prof. V. M. Nakariakov ,V.Nakariakov@warwick.ac.uk ,(None) ,South Korea ,None ,Not Presenting[2]

Prof. Yong-Jae Moon ,moonyj@khu.ac.kr ,(Professor) ,South Korea ,Yongin ,Not Presenting[1]

1 - Kyung Hee University 2 - University of Warwick/Kyung Hee University 3 - Kyung Hee University

We present the first observational detection of radial and azimuthal oscillations in full halo coronal mass ejections(HCMEs). We analyze nine HCMEs well-observed by the Large Angle and Spectrometric Coronagraph (LASCO)from 2011 February to June. Using the LASCO C3 running difference images, we estimated the instantaneous apparent speeds of the HCMEs in different radial directions from the solar disk center. We find that the development of all these HCMEs is accompanied by quasi-periodic variations of the instantaneous radial velocity with the periods ranging from 24 to 48 minutes. The amplitudes of the instant speed variations reach about a half of the projected speeds. The amplitudes are found to anti-correlate with the periods and correlate with the HCME speed, indicating the nonlinear nature of the process. The oscillations have a clear azimuthal structure in the heliocentric polar coordinate system. The oscillations in seven events are found to be associated with distinct azimuthal wave modes with the azimuthal wave number m = 1 for six events and m = 2 for one event. The polarization of the oscillations in these seven HCMEs is broadly consistent with those of their position angles with the mean difference of 43°. The oscillations may be connected with natural oscillations of the plasmoids around a dynamical equilibrium, or self-oscillatory processes, e.g., the periodic shedding of Alfvénic vortices. Our results indicate the need for an advanced theory of oscillatory processes in coronal mass ejections.

On the slow solar wind: Alfvénic versus non-Alfvénic

Abstract ID : 875

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Raffaella D'Amicis ,raffaella.damicis@esa.int ,(member) ,Italy ,Rome ,Presenting[1]

Dr. Roberto Bruno ,roberto.bruno@iaps.inaf.it ,(None) ,Italy , ,Not Presenting[2]

Dr. Lorenzo Matteini ,l.matteini@imperial.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - ESA - ESRIN 2 - INAF - IAPS 3 - Imperial College

Solar wind turbulence is determined by the nonlinear interaction between inward and outward propagating Alfvén waves. Although the purest examples of Alfvénic fluctuations are found in the trailing edges of fast solar wind streams, with the slow wind usually showing a lower degree of Alfvénicity, it has been found that even slow wind itself can be highly Alfvénic with fluctuations sometimes as wide as that of the fast wind.

This study focuses on the characteristics of the Alfvénic slow solar wind. This is found to be more similar to the fast wind rather than to the typical slow wind suggesting a similar origin for the two types of Alfvénic solar wind. Actually the Alfvénic slow wind does not originate from active regions or the cusp of the helmet streamers as the typical slow wind rather from the boundary between streamers and coronal holes or from small low-latitude coronal holes. This would determine the similarities with the fast solar wind suggesting a major role played by the super-radial expansion responsible for the lower velocity and the lower temperature.

These new findings have relevant implications for the upcoming Solar Orbiter and Solar Probe Plus missions, and, more generally, for turbulence measurements close to the Sun.

Universal scaling laws for magnetic field turbulence in a rope-rope magnetic reconnection event

Abstract ID : 1049

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Rodrigo Miranda ,rmiracer@gmail.com ,(Professor) ,Brazil ,Brasilia ,Presenting[1]

Dr. Abraham Chian ,abraham.chian@gmail.com ,(None) ,Australia , ,Not Presenting[2]

Dr. Qiang Hu ,qh0001@uah.edu ,(None) ,United States , ,Not Presenting[3]

Prof. Pablo Muñoz ,pablocus@gmail.com ,(None) ,Chile , ,Not Presenting[4]

1 - University of Brasilia 2 - School of Mathematical Sciences, University of Adelaide 3 - Department of Space Science and CSPAR, University of Alabama in Huntsville 4 - Department of Physics and Astronomy, University of La Serena

We analize the multifractal scaling of the modulus of the magnetic field |B| during a rope-rope magnetic reconnection event measured by ACE and Cluster on 1 February 2002. This event is characterized by three interplanetary magnetic flux ropes (IMFR), a bifurcated current sheet, and evidence of rope-rope magnetic reconnection. The time series of |B| is divided into five intervals corresponding to interior regions and boundary layers of the three IMFRs. We quantify the degree of intermittency by computing the scaling exponents of the structure functions at each interval. The scaling exponents are then compared with the predictions obtained by the She-Lévêque model of intermittency in anisotropic magnetohydrodynamic turbulence. Our results indicate that, in this event, magnetic reconnection occuring in the interface between two flux ropes can enhance the degree of intermittency and the degree of inhomogeneity related to the presence of sheet-like coherent structures.

A space filter approach to study the energy cascade associated with coherent structures in Kelvin-Helmoltz turbulence

Abstract ID : 1095

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr Enrico Camporeale ,e.camporeale@cwi.nl ,(None) ,Netherlands , ,Not Presenting[1]

Dr. Luca Sorriso-Valvo ,lucasorriso@gmail.com ,(None) ,Italy , ,Not Presenting[2]

Dr. Algo Care' ,algocare@gmail.com ,(None) ,Netherlands , ,Not Presenting[1]

Prof. Francesco Califano ,francesco.califano@unipi.it ,(None) ,Italy , ,Not Presenting[4]

Dr. Alessandro Retino' ,alessandro.retino@lpp.polytechnique.fr ,(None) ,France , ,Not Presenting[5]

1 - CWI 2 - CNR 3 - CWI 4 - University of Pisa 5 - CNRS

The dissipation of turbulent energy at small scales in space plasmas remains an open and challenging problem. Two plausible channels for energy dissipation have been intensively investigated in recent years: linear wave damping and non-linear interactions within coherent structures. However, a general consensus has not yet been reached on what is the relative importance of these two processes. It is now well established that coherent structures in the form of current sheets are associated with localized particle heating, and are generally responsible for the observed intermittent nature of plasma turbulence. Still, the contribution of such structures to the local energy spectrum is not well understood. Here we apply a 'space-filter' technique to a two-fluid plasma simulation of Kelvin-Helmoltz turbulence, in order to obtain a local measure of the inter-scale transfer and to characterize the contribution of coherent structures to the energy spectrum. Despite of being well-known in the hydrodynamics and Large-Eddy-Simulation communities, such technique is applied here for the first time to space plasma turbulence. Specifically, we study in detail the current sheets identified in turbulent Kelvin-Helmoltz vortexes by the Partial Variance of Increments (PVI) technique, and we discuss the correlation between the inter-scale transfer and high values of the PVI index. In particular, by estimating the Mutual Information between the two variables, we are able to infer a degree of interdependence that goes beyond linear correlation.

A32 - Reporter Reviews (DIV IV)

Past, current, and Future Research on Coronal Mass Ejections

Abstract ID : 263

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Angelos Vourlidas ,angelos.vourlidas@jhuapl.edu ,(Astrophysicist) ,United States ,Alexandria ,Not Presenting[1]

1 - Applied Physics Laboratory Johns Hopkins

Coronal Mass Ejections constitute the largest explosive phenomena in the heliosphere, carrying billions of tons of magnetized plasma, out of the solar corona and into the heliosphere, with million km/sec speeds. They are the most spectacular manifestations of solar activity but they are also the main drivers of Space Weather at Earth and other planets. As such, CMEs have been the subject of intense research since the mid-1990s with a series of space missions (SOHO, STEREO) that established their properties while many other missions are investigating their origins (e.g. SDO, Hinode). So where do we stand after the observation and analysis of 1000s of events?
In this talk, I review the current status of CME research, identify some of the open issues and discuss ways to move forward in both the research and operations aspects of these events.

Shocks, Waves, Radio Emissions, and Energetic Particles in the Corona and Heliosphere

Abstract ID : 420

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited

Prof. Iver Cairns ,iver.cairns@sydney.edu.au ,(Professor in Space Physics) ,Australia ,Sydney ,Not Presenting[1]

1 - University of Sydney

Coronal mass ejections (CMEs) are associated with fast-mode shocks moving out into the corona and the solar wind. These shocks accelerate particles, both electrons and ions, and are one contributor to SEPs (solar energetc particles). The shock-accelerated particles generate plasma waves, including Langmuir waves, whistlers, and MHD waves, but also produce type II solar radio bursts. Gyrosynchrotron emission and type IV solar radio bursts are also associated with CMEs and type II bursts, although the precise relationship with the CME material and shock is controversial. Solar flares are another source of SEPs, the electron component of which produces Langmuir waves and type III solar radio bursts. The presentation will review the observations and theory for accelerated particles, plasma waves and radio emissions associated with shocks, CMEs, and flares in the corona and solar wind. It will address the origin of type II and IV bursts and whether SEPs are produced by flares versus shocks versus both flares and shocks.

Coronal Magnetometry

Abstract ID : 751

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sarah Gibson ,sgibson@ucar.edu ,(Senior Scientist/Section Head) ,United States ,Boulder ,Not Presenting[1]

1 - NCAR/HAO

The three-dimensional coronal magnetic field shapes coronal plasma and channels its flow, storing energy in twists and tangles that ultimately drive massive eruptions. Quantifying and analyzing this magnetic field is a critical, but extremely difficult problem to solve. Since different types of multiwavelength coronal data probe different aspects of the coronal magnetic field, ideally these data could be used together in an inverse calculation to validate and constrain specifications of that field. Relevant observations include radio measurements of circular polarization (including gyroresonance effects) and Faraday rotation, infrared and visible forbidden line diagnostics of Zeeman and saturated Hanle effects, and UV permitted-line Hanle diagnostics. In addition, multiwavelength imagery, white light brightness and polarized brightness data, as well as wave and energetic particle phenomena can yield information about the coronal magnetic field. I will review the state of the art of these observations and the methods for inferring magnetic field from them, and consider future observational, modeling, and data inversion developments needed for realizing the full potential of coronal magnetometry.

A33 - Ground magnetic observations: improvements in instrumentation, operations and data processing techniques (DIV V)

Applications of geomagnetic data in services for technological networks

Abstract ID : 236

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Larisa Trichtchenko ,larisa.trichtchenko@canada.ca ,(Research Scientist) ,Canada ,Ottawa ,Not Presenting[1]

1 - Natural Resources Canada

The traditional (original) exploitation of geomagnetic data has been associated with finding directions using knowledge of the Earth's main magnetic field. While this is still the case even today, when GPS/GNSS services are the most popular tools for direction finding, the data produced by ground magnetic observatories have much wider applications in modern days.
These applications are motivated by the fact that geomagnetic and accompanying ionospheric disturbances produced by external sources (space weather) interfere with geophysical applications (magnetic surveys, directional drilling), radio propagation, and operation of ground technological networks.
The geomagnetic data are used for monitoring of geomagnetic activity, on scales from global (through planetary geomagnetic indices) to local (local indices), as well as the data themselves (at different sampling rates), for climatological and real-time applications. The data serve as an input into many numerical models for evaluation of the space weather on the technology operations, and into the forecasts of the expected geomagnetic activity and its impacts on infrastructure.
This presentation will give examples of the various applications listed above, from climatology, to modelling, to forecasting. Different aspects of these applications identify the set of requirements imposed on geomagnetic data quality, continuity, sampling rate and other parameters needed to provide essential solutions for specific users.

Geomagnetic Instruments Design and Operation (invited keynote address)

Abstract ID : 345

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Jean Rasson ,jr@oma.be ,(Head) ,Belgium ,Viroinval ,Not Presenting[1]

Dr. Antoine Poncelet ,anponcel@meteo.be ,(None) ,Belgium , ,Not Presenting[1]

Mr. Alex Gonsette ,alexandre.gonsette@meteo.be ,(None) ,Belgium , ,Not Presenting[1]

Mr. Olivier Hendrickx ,ohendric@meteo.be ,(None) ,Belgium , ,Not Presenting[1]

1 - RMI 2 - RMI 3 - RMI 4 - RMI

We review the state of the instrumentation in geomagnetic observatories worldwide as well as the capacity to realize good measurmenets with them. The successful installations are analized on one hand and attention is drawn on observatories were improvements are still possible on the other hand. New instruments based on increased automatisation and ease of operation are discussed. Will these solve problems of global observatory coverage?

Ground and satellite measurements – a must to complete current geomagnetic needs

Abstract ID : 350

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Mioara MANDEA ,mioara.mandea@cnes.fr ,(Innovation, Application and Science Directorate) ,France ,Paris ,Not Presenting[1]

1 - CNES - Centre National d'Etudes Spatiales

The use of many different approaches in observing the Earth's magnetic field has led to extensive progress in our understanding of geomagnetic field characteristics and properties. During nearly two centuries geomagnetic ground data were obtained from either magnetic observatories providing continuous measurements or from other kind of observations providing punctual measurements. At that time these data were the main sources of information on geomagnetic field spatial and temporal variations. Everything changes in the late '70, with the launch of the very first satellite carrying a vector magnetometer to measure the full magnetic field. The state-of-the-art has dramatically changed over the last nearly three decades with measurements obtained from the Oersted, CHAMP, SAC-C satellites, and mainly with the recent Swarm mission offering a new global perspective.
This new situation has called into question the role of ground measuring and its contribution to the needs of current research. Taking into consideration the three principles of geomagnetic field data collection - instruments, methodology and data quality - I show that current scientific research needs both ground-based and satellites observations, to verify and mainly to complement each other. To illustrate this, a few examples are given, with respect of the crustal and core magnetic fields.

The New Method Of Noise Suppressing In Flux-Gate Variometers

Abstract ID : 477

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Andriy Marusenkov ,marand@isr.lviv.ua ,(Leading Engineer) ,Ukraine ,Lviv ,Not Presenting[1]

Prof. Valery Korepanov ,vakor@isr.lviv.ua ,(None) ,Ukraine , ,Not Presenting[1]

1 - LLC LEMI 2 - LLC LEMI

The flux-gate magnetometers (FGM) are used for measurements of DC magnetic fields and its slow fluctuations in geomagnetic observatories. The geomagnetic variations intensity falls down below FGM noise level (NL) at the frequencies upper than 0.1…1 Hz. Reducing of the FGM NL could help to measure short period variations more reliably, what is an important task for geophysical community. The magnetic noise arising during cyclic magnetization of the flux-gate sensor (FGS) core is a periodically non-stationary process because the different physical processes are involved in the magnetization process at the different parts of a hysteresis loop. So the signal detection in the frequency domain method at the second harmonic traditionally used in FGM could hardly help studying a fine structure of the magnetic noise. In contrast, the direct digitizing of the voltage across the primary and secondary windings of FGS as well as of the excitation current allows performing detailed analysis of the hysteresis loop fluctuations from cycle to cycle. In order to conduct such studies the wide-band high-resolution measurement setup was created and a number of FGS cores with different geometry were tested. In all cases the common behavior of the magnetic flux non-reproducibility was revealed. At the saturated states the cycle to cycle variations of the magnetic flux through the secondary winding is minimal and often reached the noise background of the measurement setup. The intensity of the variations gradually increases as the core leaves a saturated state and becomes maximal at a certain point of the hysteresis loop close to the saturated state of the opposite polarity. After this point the intensity of the cycle to cycle variations decays rapidly to minimal value at the saturated state. The observed distribution of the magnetic noise along hysteresis loop at high-frequency cyclic excitation is proposed to use in order to optimize the signal detection procedure, i.e., to use the time-domain method of useful signal extraction, in contradistinction with the frequency-domain method. As a result, for some specimens, the noise level using the time-domain detection dropped down around twice comparably with the frequency-domain mode.

MagPySV: a python package for processing and denoising geomagnetic observatory data

Abstract ID : 725

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Grace Cox ,Grace.Cox@liverpool.ac.uk ,(Postdoctoral research associate) ,United Kingdom ,Sheffield ,Not Presenting[1]

Dr. Laurence Billingham ,laurence@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. William Brown ,wb@bgs.ac.uk ,(Geomagnetic field modeller) ,United Kingdom ,Edinburgh ,Not Presenting[2]

Prof. Richard Holme ,holme@liverpool.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Liverpool 2 - British Geological Survey 3 - British Geological Survey 4 - University of Liverpool

Measurements obtained at ground-based geomagnetic observatories are crucial to our understanding of secular variation (SV) of the geomagnetic field and permit investigations of Earth's deep interior. Observatory monthly means are widely used for this purpose, but are highly sensitive to measurement errors due to their high temporal resolution and also suffer from significant external magnetic field contamination. These noise sources often obscure fine-scale details required for studying rapid observed features, such as geomagnetic jerks. Many current processing methods rely on piecemeal closed-source codes or are performed by hand on an ad hoc basis. This requires much time, effort and detailed knowledge of observatory data processing, and hampers efforts to reproduce the datasets underlying many published results. The aim of this work is to provide a consistent means of generating high resolution SV time series, with baseline jumps, outliers and external contamination removed. We present MagPySV, a python package designed to process and denoise observatory hourly means distributed by the World Data Centre for Geomagnetism at the British Geological Survey, Edinburgh. This package allows the user to obtain the dataset in WDC format from BGS servers and keep it up-to-date by replacing preliminary data with the most definitive version available. It produces time series of the X, Y and Z components of the field and SV at the desired frequency (typically monthly means), and applies corrections for all documented baseline jumps. Optionally, the user may exclude data using the Ap index, which removes effects from documented geomagnetic storms. Robust statistics are used to identify and remove outliers. The software extends the denoising methods of Wardinski & Holme (2011, GJI) and Brown et al (2013, PEPI), which use the covariance matrix of the residual between the observed SV and that predicted by a global field model to create and remove a proxy for external field signal from the data. This extension creates a single covariance matrix for all observatories of interest combined and applies the external field correction to all

locations simultaneously. Finally, we present a denoised sequence of data produced by MagPySV, and discuss its application to geomagnetic jerks.

Geomagnetic observatory on a moving ice sheet: high quality data from Neumayer Station III, Antarctica

Abstract ID : 820

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Juergen Matzka ,jmat@gfz-potsdam.de ,(scientist) ,Germany ,Potsdam ,Presenting[1]

Dr. Tanja Fromm ,Tanja.Fromm@awi.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Alfons Eckstaller ,Alfons.Eckstaller@awi.de ,(None) ,Germany , ,Not Presenting[2]

Mr. Joelund Asseng ,JoelundAsseng@awi.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Sissy Kuetter ,sissy.kuetter@awi.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Steven Franke ,steven.franke@awi.de ,(None) ,Germany , ,Not Presenting[2]

Mr. Achim Morschhauser ,mors@gfz-potsdam.de ,(Staff Scientist) ,Germany ,Niemegk ,Not Presenting[7]

1 - GFZ 2 - AWI 3 - AWI 4 - AWI 5 - AWI 6 - AWI 7 - GFZ Potsdam

High-quality, absolutely calibrated geomagnetic field vector data require precise knowledge of the geodetic reference frame. Additionally, for the study of secular variation, it is important to take measurements at stable conditions. For this purpose, any artificial or crustal bias fields are required to be constant in time. Neumayer Station III (IAGA code VNA) is the geomagnetic observatory of the German Antarctic station. It is located on the Ekström shelf-ice at 70.7° S and 351.7° E and, along with the shelf ice, it is rotating clockwise by 0.25° per year and drifting by 157 m per year to the north. Here, we present our approach to compensate for the observatory's rotation and drift for obtaining both near real-time and definitive geomagnetic observatory data.

First, the azimuth of the azimuth mark has to be determined and updated regularly, as it also rotates with he ice. Since celestial objects cannot be observed from the ice cave, where the observatory is located in, the azimuth is determined on a monthly basis by a north-seeking gyro.

Second, due to its drift northwards, the observatory is moving within a significant gradient of the crustal magnetic field. Judging from aeromagnetic surveys over the region as well as from ground profiles of total field strength along the drift path, this results in temporal change of the crustal bias of approx. 10 nT per year. Based on the observatory data alone, this signal cannot be separated from the secular variation of the core field. In order to correct the observatory time series for this change in crustal bias, vector absolute measurements were performed along the drift path in austral summer 2016/2017.

One Second quasi-definitive data from Choutuppal Magnetic Observatory

Abstract ID : 845

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Kusumita Arora ,karora_ngri@yahoo.co.uk ,(Scientist) ,India ,Hyderabad, Telengana ,Not Presenting[1]

Dr. Sergey Khomutov ,hom@ngs.ru ,(Head of Geophysical Observatory "Paratunka") ,Russia ,Paratunka ,Not Presenting[2]

Dr. Phanichandra Nelapatla ,phaninelapatla@gmail.com ,(None) ,India , ,Not Presenting[3]

Mr. K. Chandrashakhar Rao ,kcsrao18ngri@gmail.com ,(None) ,India , ,Not Presenting[1]

1 - CSIR-National Geophysical Research Institute 2 - Institute of Cosmophysical Research and Radio Wave Propagation FEB RAS 3 - CSIR-NGRI 4 - CSIR-National Geophysical Research Institute

Stable one second variation measurements from the newly installed 1 second Observatory grade magnetometer (GEOMAG-02MO) and GSM90-F1 operating at Choutuppal (CPL) Magnetic Observatory of CSIR-National Geophysical Research Institute commenced since beginning of Jan 2017. Two sets of absolute observations are regularly being carried out in a week and temporary baselines are being used for the preparation of quasi-definitive data of CPL Observatory. Recently developed MATLAB based processing tools, which are used to treat the effects of known (temperature changes) and unknown noise and the resultant quasi-definitive data will be presented. The paper details the existing conditions like natural and artificial magnetic gradients and the processes involved to achieve best quality data from the new measurements.

Development of the geomagnetic observatory network in Russia: recent progress and plans

Abstract ID : 912

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Roman Krasnoperov ,r.krasnoperov@gcras.ru ,(Senior research scientist) ,Russia ,Moscow ,Not Presenting[1]

Dr. Anatoly Soloviev ,a.soloviev@gcras.ru ,(Deputy Director for Science) ,Russia ,Moscow ,Not Presenting[1]

Dr. Roman Sidorov ,r.sidorov@gcras.ru ,(None) ,Russia , ,Not Presenting[1]

Dr. Dmitry Kudin ,dvkudin@gmail.com ,(None) ,Russia , ,Not Presenting[4]

Dr. Renata Lukianova ,r.lukianova@gcras.ru ,(Principal research scientist) ,Russia ,Moscow ,Not Presenting[5]

1 - Geophysical Center of the Russian Academy of Sciences 2 - Geophysical Center of the Russian Academy of Sciences 3 - Geophysical Center of the Russian Academy of Sciences 4 - Gorno-Altaisk State University 5 - Geophysical Center, Russian Academy of Science

This report presents an outlook of the recent advances in ground geomagnetic observations in Russia. During the past few years considerable progress has been achieved in this area. Institutions of the Russian Academy of Sciences (RAS) have formed an effective collaboration for the development of a modern geomagnetic observatory network. Several existing geomagnetic observatories have been upgraded to meet the INTERMAGNET standards (e.g. 'Saint Petersburg' (SPG), 'Kazan' (KZN), 'Cape Schmidt' (CPS)). In 2016 the 'Saint Petersburg' observatory was officially accepted in the INTERMAGNET. A brand new 'Klimovskaya' (KLI) observatory has been constructed from the scratch. In close collaboration with Paris Institute of Physics of the Earth the 'Borok' (BOX) observatory has been upgraded towards the 1-second data registration standard. The Geophysical Center of RAS developed a new modern hardware and software system for efficient retrieval, storage, processing, and analysis of geomagnetic data with automatization of data management processes. It provides automated filtering of observatory data from technological noise and data verification with accordance to the INTERMAGNET standards. This system facilitates the production of quasi-definitive data from the Russian observatories with a minimal delay. This report will also present the results of analysis of geomagnetic data, registered at the new INTERMAGNET observatory 'Saint Petersburg' (SPG) and the developing observatory 'Klimovskaya' (KLI).

Seafloor geomagnetic observatories: challenge, concept and perspectives

Abstract ID : 982

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Alexandre Gonsette ,agonsett@meteo.be ,(Your Magesty) ,Belgium ,Dourbes ,Not Presenting[1]

Mr. Jean Rasson ,jr@oma.be ,(Head) ,Belgium ,Viroinval ,Not Presenting[2]

Mr. François Humbled ,fhumbled@meteo.be ,(None) ,Belgium , ,Not Presenting[2]

Dr. Antoine Poncelet ,anponcel@meteo.be ,(None) ,Belgium , ,Not Presenting[2]

1 - IRM 2 - RMI 3 - RMI 4 - RMI

Since the dawn of time, the geomagnetic field is in constant evolution going from small rapid variations due to solar activity to full reversals. During the last 160 years the magnetic dipole decreased by about ten percent so that people start to think that the field is reversing again. Effects on our planet, health or anthropogenic activity are not known since the last reversal occurred about 8 My ago. More than ever we must continue to observe the geomagnetic field and provide long-term and stable data. Magnetic observatories are therefore crucial for the future. In 1994, a Geomagnetic Observatory Task Group addressed the need of improving the geomagnetic observatories coverage. It estimated that a 2000km spacing would require 40 new observatories of which 8 are located on the seafloor. More than 20 years later, only few experiences in the Tyrrhenian Sea and North-West Pacific have been made but none of them are a full magnetic observatories. We present here a new concept of full magnetic observatory for seafloor operation. The station will be developed and validated in shallow water during the next three years. The observatory will be composed of a variometer, a scalar magnetometer and a GyroDIF for automatic absolute declination and inclination measurement. Power supply, data transfer and maintenance are the major challenges we will face for the magnetic observatory to meet Intermagnet standards.

Longtime series of baselines of Paratunka observatory, Kamchatka, Russia: the estimation of the quality, stability and errors

Abstract ID : 1010

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sergey Khomutov ,hom@ngs.ru ,(Head of Geophysical Observatory "Paratunka") ,Russia ,Paratunka ,Not Presenting[1]

1 - Institute of Cosmophysical Research and Radio Wave Propagation FEB RAS

Complete magnetic observations (variation and absolute) in accordance with IAGA standards will started at observatory Paratunka (PET) of IKIR FEB RAS, Kamchatka, Russia, in 1967. With the beginning of the new Millennium the Observatory moved from analogue to digital variation magnetometers and to new technology of determination of absolute values of the magnetic field components. In 2013 Observatory received the status of an INTERMAGET Magnetic Observatory. This report presents the results of analysis of PET longtime (over ten years) series of baselines values for the various variation magnetometers. The sources of baseline instability and errors are considered, including errors of different absolute devices, personal systematic errors of observers, instability of magnetic field distribution at absolute hut and its surroundings, etc. It is noted the importance of methods of calculation of regular adopted baselines using the irregular observed values, including the adequacy of the mathematical methods to physical reasons of baseline instability. The examples of software and mathematical methods of baselines corrections and its efficiency are shown. The results of measurements with new vector magnetometer POS-4, providing the estimations of full field vector in quasi-absolute sense and its prospects as absolute instruments, are considered.

Towards meeting the INTERMAGNET one-second standards for absolute magnetic observatories

Abstract ID : 1018

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Ellen Clarke ,ecla@bgs.ac.uk ,(Geomagnetism Scientist) ,United Kingdom ,Edinburgh ,Presenting[1]

Mr. Chris Turbitt ,cwtu@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Mr. Anthony Swan ,apsw@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Mr. Thomas Martyn ,tmartyn@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Mrs. Orsi Baillie ,orba@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Ms. Sarah Reay ,sjr@bgs.ac.uk ,(None) ,United Kingdom ,None ,Not Presenting[2]

1 - British Geological Survey, Edinburgh, United Kingdom 2 - British Geological Survey 3 - British Geological Survey 4 - British Geological Survey 5 - British Geological Survey 6 - British Geological Survey

The British Geological Survey (BGS) operates a network of nine absolute magnetic observatories, eight of which are members of the INTERMAGNET real-time observatory network. Member observatories are annually assessed against a published INTERMAGNET data quality and delivery standard for a base data interval of one minute. In 2013, INTERMAGNET published a new quality standard for higher frequency data in response to new developments in instrumentation and the requirements of the research community. The INTERMAGNET definitive one-second standard sets not only a more demanding data interval, but also sets higher tolerances on noise, absolute level and frequency response of the published data sets.

A description is given of the work carried out by BGS towards upgrading the observatory instruments and data processing methods to meet the INTERMAGNET definitive one-second standard. This has included specific testing conducted at Eskdalemuir Observatory to assess the candidate instrument, a Lemi-025 magnetometer, against the noise performance and transfer function parameters laid out in the standard. We show how the release of a new digital filter by the manufacturer based on previous results (e.g. Swan et al, 2014) helps towards meeting the standards required for the frequency response.

In addition, a comparison study between the long-term instrument performance of the Lemi-025 and that of the DTU FGE is described. The latter being the instrument operational at the BGS observatories for the production of one-minute data, the standard base data interval. The initial findings of this study are presented.

Absolute magnetic measurement techniques with the FluxSet digital D/I station: the conventional methods and beyond these

Abstract ID : 1277

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Ádám Domján ,adomjan@mingeo.hu ,(Geophysicist) ,Hungary ,Budapest ,Presenting[1]

Mr. László Hegymegi ,hegymegi@mingeo.com ,(None) ,Hungary , ,Not Presenting[1]

Mr. Csaba Hegymegi ,cshegymegi@mingeo.hu ,(None) ,Hungary , ,Not Presenting[1]

Mr. János Szöll?sy ,szjanos@humic.kfkipark.hu ,(None) ,Hungary , ,Not Presenting[4]

1 - MinGeo Ltd. 2 - MinGeo Ltd. 3 - MinGeo Ltd. 4 - Individual contractor

Geomagnetic observatories and repeat station surveys need to determine the absolute values of declination and inclination angles of the Earth's magnetic field to monitor the long term baseline changes and calibration parameters of their vector magnetometers. These measurements are performed by classical theodolites equipped with fluxgate magnetometers known as declination inclination magnetometers (DIM) using the null or the residual techniques. These basic absolute methods have limitations because of the classical DIMs. Data acquisition is carried out manually, which is difficult and time consuming. These measurements are physically complicated especially in magnetic equatorial regions even with the usage of a diagonal eyepiece. Since the data is not provided and stored digitally, the computation of magnetic meridian is calculated by the operator during the measurements. In order to eliminate above disadvantages, a digital, cable-less, non-magnetic DIM instrument has been developed, known as the Declination/Inclination Digital Station 1 (DS-1), which can overcome these obstacles to make faster and precise absolute magnetic measurements. The DS-1 measures declination and inclination angles of the geomagnetic field vector with digital angle encoders and it measures the magnetic field by the attached single axis FluxSet magnetometer. Data is transmitted via radio to a central processor unit, which also receives time stamp information from a built-in GPS receiver. A local scalar absolute magnetometer can also be connected through a serial port to the central unit, where all the data is stored for further processing. The data can be sent to a laptop or tablet through WiFi connection, where it can be visualized. The aim of this presentation is to demonstrate through real measurement results that the DS-1 can determine the accurate values for the D, I elements of the Earth's magnetic field. Usage of DS-1 is more convenient and user-friendly than the regularly used manually operated instruments. Since this equipment enables the observer to obtain more data in a shorty time, DS-1 opens the possibility to testing and evaluating new and more sophisticated absolute measurement technique beyond the traditional methods. One of these case study of this new method will be shown in detailed.

Error statistics of Chambon- la Forêt observatory definitive data

Abstract ID : 1286

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Benoit Heumez ,heumez@ipgp.fr ,(Engineer) ,France ,Chambon la foret ,Not Presenting[1]

Dr. Vincent Lesur ,lesur@ipgp.fr ,(Head of magnetic observatories) ,France ,Paris ,Presenting[2]

Mr. Kader Telali ,telali@ipgp.fr ,(None) ,France , ,Not Presenting[3]

Mr. Xavier Lalanne ,lalanne@ipgp.fr ,(None) ,France , ,Not Presenting[3]

Dr. Anatoly Soloviev ,a.soloviev@gcras.ru ,(Deputy Director for Science) ,Russia ,Moscow ,Not Presenting[5]

1 - Institut de Physique du Globe de Paris 2 - Institut de Physique du Globe de Paris 3 - IPGP 4 - IPGP 5 - Geophysical Center of the Russian Academy of Sciences

We propose a new algorithm for calibrating definitive observatory data with the goal of providing users with estimates of the data error standard deviations (STD). The algorithm has been implemented and tested using Chambon-la-Forêt observatory (CLF) data. The calibration process uses all available data. It is set as a large, weakly non-linear, inverse problem that ultimately provides estimates of baseline values in three orthogonal directions, together with their expected standard deviations. For this inverse problem, absolute and variometer data error statistics were estimated from series measurements. The comparisons of these time series led us to use an autoregressive process of order 1 (AR1 process) as a prior for the baselines. The obtained baselines do not vary smoothly in time. They have relatively small STDs, well below 300 pT when absolute data are recorded twice a week - i.e. within the daily to weekly measures recommended by INTERMAGNET. Two sets of definitive data were calibrated using the new algorithm. Their comparison shows that the definitive data STDs are less than 400 pT and may be slightly over-estimated by our process.

Dôme C Magnetic Observatory on Concordia Station

Abstract ID : 1406

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Aude Chambodut ,aude@unistra.fr ,(None) ,France ,Strasbourg ,Presenting[1]

Dr. Armelle Bernard ,armelle.bernard@unistra.fr ,(None) ,France , ,Not Presenting[2]

Mr. Marcellin Fotze ,marcellin.fotze@unistra.fr ,(None) ,France , ,Not Presenting[2]

Mr. DOMENICO DI MAURO ,domenico.dimauro@ingv.it ,(None) , , ,Not Presenting[4]

1 - EOST - University of Strasbourg 2 - EOST - CNRS UMS830 3 - EOST - CNRS UMS830 4 - INGV

Dôme C magnetic observatory was officially opened at the beginning of 2005 in the inland of Antarctica (lat. 75deg06'S, long. 123deg23'E). Since 2009, the field is recorded continuously at 1Hz. The baselines of the triaxial variometer are controlled by standard absolute measurements made at a regular rate all over the year.
The magnetic observatory's logistic and technical issues are numerous arising from the fact that observers and instruments operate in such extreme conditions, as for instance:
- an external temperature varying between -30degC and -75degC,
- a total darkness lasting two months, and
- an ice shelf movements noticeable in baselines.
Comparisons are done with data provided by the nearest observatories (Dumont d'Urville, Terra Nova Bay, Vostok, …) and with various global models.

A low-power Raspberry Pi data logger system and its installation at the Tatuoca observatory in Brazil

Abstract ID : 1471

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Achim Morschhauser ,mors@gfz-potsdam.de ,(Staff Scientist) ,Germany ,Niemegk ,Not Presenting[1]

Dr. Katia Pinheiro ,kpinheirogeomag@gmail.com ,(None) ,Brazil , ,Not Presenting[2]

Mr. Juergen Haseloff ,haseloff@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Gabriel Brando-Soares ,soaresbrando@gmail.com ,(None) ,Brazil , ,Not Presenting[2]

Mr. Oliver Bronkalla ,bronki@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Juergen Matzka ,jmat@gfz-potsdam.de ,(scientist) ,Germany ,Potsdam ,Not Presenting[6]

1 - GFZ Potsdam 2 - Observatorio Nacional 3 - GFZ Potsdam 4 - Observatorio Nacional 5 - GFZ Potsdam 6 - GFZ

The INTERMAGNET 1 Hz standard requires a modern data logging system that is capable of high sampling rates, digital filtering, and high timing accuracy. Also, a low-power consumption is important for observatories at remote locations, and real-time capability is mandatory for space weather applications. Here, we present such a system, which is based on a Raspberry Pi embedded PC and a newly developed open-source C++ software package. The system was designed to be modular and adaptable to different observatory instrumentation and setups. Recently, we have installed this system along with a suspended fluxgate magnetometer and a scalar magnetometer at the Tatuoca magnetic observatory (IAGA code: TTB) in Brazil. This observatory is located at a scientifically interesting location within the South Atlantic Anomaly region and currently close to the equatorial electrojet (EEJ). Along with the new data logging system and its recent installation in TTB, we will also present data and baselines from this observatory.

A34 - Lithospheric field, WDMAM, and geological/tectonic interpretations (DIV V)

Long Wavelength Magnetic Anomalies at Subduction Zones

Abstract ID : 242

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. David Gubbins ,gubbins@earth.leeds.ac.uk ,(Emeritus Professor of Geophysics) ,United Kingdom ,None ,Not Presenting[1]

Dr. Simon Williams ,simon.williams@sydney.edu.au ,(None) ,Australia , ,Not Presenting[2]

1 - University of Leeds 2 - University of Sydney

Many subduction zones correspond to strong long-wavelength magnetic signatures that are not predicted by forward models in which magnetisation is confined to the continental crust and unsubducted oceanic lithosphere. Previous studies have proposed this signature to be sourced within hydrated, serpentinised mantle wedge. Alternatively, thermal models of subducting oceanic lithosphere suggest slab material cool enough to hold magnetisation may persist >200 km below the Earth's surface. Here we investigate the origin of long wavelength magnetic anomalies by constructing alternative predictions of the lithospheric geomagnetic field, which we compare to the MF7 model based on satellite observations. We separate the magnetisation into Vector Spherical Harmonics and isolate that part responsible for generating an observed magnetic field; its fraction as a percentage of the total magnetisation is a crude measure of whether the geometry is suitable for producing an anomaly at satellite altitude. Generally subduction zones trending north-south in low latitudes produce little or no anomaly. We compare 2 models for subduction zone magnetisation, one in which the wedge is magnetised and one in which the subducted slab is magnetised. Magnetisation deeper than the Moho of the overriding plate helps to reconcile the observed anomalies for a number of subduction zones, including Sumatra, the Aleutians, and along the Pacific margin of North and Central America. In some instances the anomaly arising from two adjacent, distinct, lithospheres has the opposite sign to that of our subduction magnetisation. A magnetic anomaly persists along the Baja and Mexican west coast, indicating that the fossil subduction zone continues from California through Central America despite limited seismic evidence of a slab there. Distinguishing between the two competing models is difficult because it depends critically on the trend in magnetic anomaly away from the

A lost generation of impact structures on Earth

Abstract ID : 326

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Michael Purucker ,michael.e.purucker@nasa.gov ,(Lab Chief, Planetary Magnetosphere Lab, Solar System Science Division) ,United States ,Greenbelt ,Not Presenting[1]

1 - NASA

The process of convection that drives plate tectonics has fragmented the early record on the continents, and subducted it in the oceans. Erosion has blurred the upper surface of impact structures, exposed to the atmosphere, beyond recognition, after a few million years. The largest confirmed impact structures on the Earth are Vredefort, Chicxulub, and Sudbury, with crater diameters averaging 150 km, and maximum ages of about 2 Ga. Contrast this with the situation at Mars or the Moon, where the largest confirmed impact structures have diameters of 2000 km, and ages of 4 Ga (Anca et al., 2016). The giant impact basins that form the most ancient, and most prominent, visible structures on the other terrestrial planets and moons have vanished on the Earth (Melosh, 2011). Only with the use of techniques like magnetics and gravity is it possible to see deeper within the crust, and we should not expect to see whole impact structures. In this invited talk, we review our knowledge of this lost generation of impacts on Earth, and speculate on possible fragments of older, larger impacts.

Earth's crust magnetization model of the Nether-Polar and Polar Urals

Abstract ID : 435

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Lev Muravyev ,mlev@igeoph.net ,(Scientific associate) ,Russia ,Ekaterinburg ,Not Presenting[1]

Prof. Petr Martyshko ,pmart71155@gmail.com ,(HEAD of LAB) ,Russia ,EKATERINBURG ,Presenting[1]

Dr. Natalia Fedorova ,nataliavf50@mail.ru ,(None) ,Russia , ,Not Presenting[1]

1 - Institute of Geophysics UB of RAS 2 - Institute of Geophysics UB of RAS 3 - Institute of Geophysics UB of RAS

We performed a study of the anomalous magnetic field features of the Nether-Polar and Polar sectors of the Urals (48-72° E and 60-68° N). We identified and mapped magnetic anomalies due to the Earth's crust layers. The calculated local magnetic anomalies map allows allocating basic-ultrabasic massifs in the upper parts of the basement within the sedimentary basins. After interpretation of the regional magnetic anomalies and deep seismic sounding data along profiles, located in the study area we build a model of the Earth's crust structure.
Comparison of the deep structure of the cross-sections produced by independent interpretation methods using seismic and magnetic data has enabled us to extract two layers with different magnetic properties from the consolidated crust. Top layer of the Earth's crust does not make a significant contribution into regional magnetic field and is characterized by a low magnetization (less than 0.3 A/m). Within this layer we identified magnetized local sources. The lower layer has greater crustal magnetization. As a result of the magnetic data interpretation we defined that the magnetization value of the basalt layer of the crust is 3-4 A/ m. The average depth to the top surface of the layer is 18-20 km. The resulting parameters were used for three-dimensional modeling. We considered a model with uniform magnetization directed along the modern geomagnetic field. Thus, we built the upper surface of the magnetized layer, which allowed to clarify mafic layer in the space between the deep seismic sounding profiles. It was found that at the Northern, Circumpolar and Polar Urals basalt layer plunged to a considerable depth of 26-30 km. This work was supported by a Russian Science Foundation grant ?14-27-00059 "3D models of Urals region Nether-Polar zone deep structure construction based on new geophysical fields complex interpretation methods and modern computer grid modelling technologies".

Regional lithospheric field modelling using monopoles and a combination of airborne and satellite data

Abstract ID : 603

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Livia Kother ,livia@space.dtu.dk ,(PhD student) ,Denmark ,Lyngby ,Presenting[1]

Dr. Chris Finlay ,cfinlay@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[2]

Prof. Nils Olsen ,nio@space.dtu.dk ,(None) ,Denmark ,None ,Not Presenting[3]

Mr. Dhananjay Ravat ,dhananjay.ravat@uky.edu ,(None) ,United States , ,Not Presenting[4]

1 - DTU Space 2 - DTU Space, Technical University of Denmark 3 - DTU 4 - University of Kentucky

We present a technique for modelling the local lithospheric magnetic field of the North American continent using an equivalent source inversion scheme on both satellite and airborne magnetic data. Regional measurements are provided by NURE_NAMAM2008, whereas the satellite data involve vector, scalar and gradient measurements from CHAMP and Swarm. To ensure stable downward continuation to the Earth's surface we implement regularization of the equivalent sources. We present resulting maps of the vertical field and scalar anomaly field at the Earth's surface and compare the results with previous models based on both satellite and aeromagnetic data (e.g. WDMAM2, EMM2015). Finally, we discuss the possibility of applying this technique to other areas of the globe.

LCS-1: First lithospheric magnetic field model from CHAMP and Swarm satellites magnetic gradient observations and implications for magnetic anomaly interpretation

Abstract ID : 798

Conflict Declaration : None

Content Motivation : None

Additional Information : Invited by Session Chairs

Mr. Dhananjay Ravat ,dhananjay.ravat@uky.edu ,(None) ,United States , ,Presenting[1]

Prof. Nils Olsen ,nio@space.dtu.dk ,(None) ,Denmark ,None ,Not Presenting[2]

Dr. Chris Finlay ,cfinlay@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[3]

Ms. Livia Kother ,livia@space.dtu.dk ,(PhD student) ,Denmark ,Lyngby ,Not Presenting[4]

1 - University of Kentucky 2 - DTU 3 - DTU Space, Technical University of Denmark 4 - DTU Space

Gradients of the magnetic field have higher spatial resolution than the fields themselves and are helpful in improving the resolution of downward continued satellite magnetic anomaly maps (Kotsiaros et al., 2015, Geophys. J. Int.; Sabaka et al., 2015, Geophys. J. Int.). Higher spatial resolution and fidelity of the magnetic field downward continued to the Earth's surface translate into improvements in the interpretation of anomalies for recognition of geologic variability and tectonic processes (e.g., recognizing details of geologic provinces, anomalous seafloor spreading patterns, etc., that can help understand the evolution of the Earth). In addition, magnetic anomalies have sensitivity to thermal variations in the Earth's lithosphere through the phenomenon of Curie temperature of ferromagnetic minerals. Despite having global sets of observations from POGO, Magsat, Ørsted, CHAMP, and Swarm satellites (altitude > 300 km), preservation of intermediate wavelengths from about 100 to 375 km proves challenging (known as the "spectral gap" in the magnetic coverage). Since the gradients of magnetic field have higher spatial resolution than the fields themselves, they are helpful in improving the coverage in the spectral gap. North-South (along orbit) gradients from low altitude CHAMP and North-South and East-West gradients from Swarm magnetic field satellites have resulted in a lithospheric field model (LCS-1, Olsen et al., 2017) that can be used to examine the improvement in the anomaly coverage in the spectral gap and its effect on the interpretation. We examine the resolution of anomalies from the LCS-1 model and also their resulting interpretation using the U.S. and Australian aeromagnetic data where full spectrum magnetic anomaly coverage is available (Ravat et al., 2009, USGS open files report OF09-1258; Millegan et al., 2010). We also examine critically the oceanic regions with the help of WDMAM2.0 (Dyment et al., 2015) and MF7 (S. Maus, https://geomag.colorado.edu/magnetic-field-model-mf7.html). In addition to its intrinsic value for geologic interpretation, LCS-1 has significant potential for improving the spectral coverage in many regions of the world where anomalies and their interpretations are still affected by the spectral gap.

Utility of aeromagnetic data for structural mapping in areas of limited out crop: A case study from the Mesozoic Kutch rift basin, India.

Abstract ID : 843

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Radhika P R ,radhuponoly@gmail.com ,(Research Scholar) ,India ,Navi Mumbai ,Not Presenting[1]

Dr. Anand S P ,aerospl@yahoo.co.uk ,(None) ,India , ,Not Presenting[1]

Dr. Mita Rajaram Empty ,mitarajaram@yahoo.com ,(None) ,India , ,Not Presenting[3]

1 - Indian Institute of Geomagnetism 2 - Indian Institute of Geomagnetism 3 - IIG

Kutch is an east-west oriented pericratonic rift basin at the western most periphery of the Indian craton. It is widely believed that the formation of the Kutch basin is associated with the breakup of Gondwanaland into the Eastern and western in the Mesozoic. The basin conspicuously featured by uplands surrounded by lowlands, has a distinctive asymmetric structure, having a tilt towards south. No outcrop is seen within the featureless plains and consequently subsurface information is limited. The Kutch regions witnessed one of the largest intraplate earthquake with a magnitude of 7.8 on 26th January 2001. Hence much of the studies in this region are mainly concentrated to understand the seismo-tectonics of the region. Basin configuration has been studied only using surface geological data and available geophysical data collected along sparsely spaced profiles. A major challenge in acquiring data over the region is the inaccessibility in the slat covered panes of Great Rann of Kutch and the little Rann of Kutch. To overcome this difficulty and to have a better understanding of the structural configuration of the basin a semi detailed high resolution aeromagnetic data was acquired over the basin. The generated aeromagnetic anomaly map depicts several major E-W, NE-SW and NW-SE oriented lineaments/faults, which represent structural trends associated with different stages of evolution of this rift basin. The deep seated NW-SE lineaments/faults may be associated with the initial rifting of India from Africa during Gondwana period while the NE-SW trends are interpreted to represent the imprints left behind by the interaction of the Indian lithosphere with the Reunion Plume during its northward drifting following Gondwana breakup. Basement depth map generated from magnetic data corroborated well with depths calculated from converted Sp phases and two one-shore wells drilled in the region. Our analysis suggests that the Banni basin is divided into western and eastern sub-basins in the region covered by Rann of Kutch to the north of the Kutch Mainland Fault (KMF). Integration of aeromagnetic data with the available sparse seismic, well and gravity data help provide a better image of the basin configuration of the Kutch rift basin.

How sensitive is the global lithospheric magnetic field to the geometry of the inducing field and the shape of the magnetized layer?

Abstract ID : 999

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jinsong Du ,jinsongdu@cug.edu.cn ,(None) ,China ,Wuhan ,Presenting[1]

Prof. Chao Chen ,chenchao@cug.edu.cn ,(None) ,China , ,Presenting[2]

Dr. Foteini Vervelidou ,foteini@gfz-potsdam.de ,(Postdoctoral researcher) ,Germany ,Potsdam ,Presenting[3]

1 - China University of Geosciences (Wuhan) 2 - Hubei Subsurface Multi-scale Imaging Key Laboratory, Institute of Geophysics and Geomatics, China University of Geosciences, Wuhan 430074, China 3 - GeoForschungsZentrum Potsdam

Forward calculations of the lithospheric magnetic field have been widely used as a tool to infer information about properties of the Earth's lithosphere, such as thickness and compositional variations. In this study, we present analytical formulas for the spherical harmonic (SH) coefficients of the induced lithospheric magnetic field for an inducing field of arbitrarily high maximum expansion degree and for a magnetic shell of variable thickness. Based on the derived formulas, we perform several synthetic tests from which the following three main conclusions are drawn.
(1) The impact of the radial variation of the inducing field on the forward calculation of the global lithospheric magnetic field of SH degrees 16-90, is approximately ±0.5 nT at the typical LEO satellite altitude of 300 km and ±4 nT at the Earth's geomagnetic reference radius, for a 75 km thick magnetic shell. We conclude that neglecting this effect does not introduce a significant error in the forward calculations of the large scales of the lithospheric magnetic field.
(2) Ignoring the non-axial dipolar terms of the inducing field produces an error in the forward calculation of the global lithospheric magnetic field of SH degrees 16-90, that is about ±10 nT at the typical LEO satellite altitude of 300 km and about ±80 nT at the Earth's geomagnetic reference radius, for a 75 km thick magnetic shell. We conclude that neglecting the non-axial dipolar terms of the inducing field significantly reduces the accuracy of the forward calculation of the lithospheric magnetic field.
(3) The geometric shape of the Earth's magnetic lithosphere has a strong impact on the induced lithospheric magnetic field. Lithospheric fields generated by two spherical shell models with different geometric shapes but with identical vertically integrated susceptibility distribution are different even at satellite altitudes.
Our study, in combination with the available global lithospheric magnetic field models, based on the WDMAM and on satellite measurements, e.g., of the CHAMP and *Swarm* missions, opens up the possibility for improved estimations of the apparent susceptibility distribution and the depth to the bottom variations of the magnetic lithosphere.

Inclusion of shipboard three-component magnetometer data in global marine magnetic anomaly data compilation

Abstract ID : 1069

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Takemi Ishihara ,t-ishihara@aist.go.jp ,(Researcher) ,Japan ,Tsukuba ,Not Presenting[1]

1 - Geological Survey of Japan, AIST

The magnetic data coverage of the world oceans is still inadequate in the WDMAM compilation. These data were obtained by towed marine magnetometers, but there are also many shipboard three-component magnetometer (STCM) data, which could help filling the data gaps. I studied magnetic data collected in a cruise with simultaneous observations with a towed magnetometer and an STCM. Their total intensity values usually differ by 100 nT or more, and the STCM values depend on the ship's heading, although their short period variations coincide very well. This suggests that the STCM total intensity data after removing their longer period variations are useful in the global compilation of marine magnetic anomaly data. Hundreds of STCM data, which were obtained from cruises of JAMSTEC research vessels, are available now. The results of processing of these data will be presented.

High-resolution crustal field models from the Earth Magnetic Anomaly Grid

Abstract ID : 1190

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Arnaud Chulliat ,arnaud.chulliat@noaa.gov ,(None) ,United States ,Boulder ,Not Presenting[1]

Mr. Brian Meyer ,brian.meyer@noaa.gov ,(None) ,United States , ,Not Presenting[1]

Dr. Rick Saltus ,rick.saltus@noaa.gov ,(None) ,United States , ,Not Presenting[1]

1 - University of Colorado Boulder 2 - University of Colorado Boulder 3 - University of Colorado Boulder

Global magnetic anomaly grids such as NOAA's Earth Magnetic Anomaly Grid at 2-arc-minute resolution (EMAG2) and the World Digital Magnetic Anomaly Map (WDMAM) are used in a wide range of applications, from research into the geological and tectonic evolution of the lithosphere to resource exploration and science education. These grids depict the total field (scalar) magnitude of the Earth's magnetic field. Some applications such as accuracy-sensitive navigation and directional drilling require knowledge of the field direction and not just its magnitude. The field direction can be derived from the scalar grids by inverting these anomaly grids for high-resolution, spherical harmonic models of the lithospheric field. We report on new, high-resolution models derived from: (a) the EMAG2 compiled by Maus et al. (2009), a grid that includes some a priori information provided by an oceanic crustal age model through directional gridding; and (b) a recent update of the EMAG2 "version 3" compiled by Meyer et al. (2016), which relies solely on data and includes more than 11.5 million new trackline data. The inverse problem is linearized and the normal equation matrix is pre-calculated, allowing for multiple model calculations and a rigorous estimation of model error. This capability is used to test the inversion algorithm using synthetic data and explore various model regularizations to minimize the so-called Backus effect caused by the lack of three-component data in the inverted dataset. In this presentation we also report on the latest EMAG2 version 3 and the new data it contains.

New geothermal heat flux distribution of Greenland and its relationship with the Iceland hotspot

Abstract ID : 1309

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yasmina M. Martos ,yasmar@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Manuel Catalán ,mcatalan@roa.es ,(Head of Geomagnetism Department) ,Spain ,San Fernando ,Presenting[2]

Dr. Tom A Jordan ,tomj@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Jonathan Bamber ,ggjlb@bristol.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. Tom Jordan ,Tom.Jordan@bristol.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. David Vaughan ,dgv@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - British Antarctic Survey 2 - Real Observatorio de la Armada 3 - British Antarctic Survey 4 - University of Bristol 5 - University of Bristol 6 - British Antarctic Survey

Greenland is the second largest reservoir of water on Earth and about 80% of its surface is covered by ice. It is mainly composed by Archean blocks that collided during the Early Proterozoic. Indirect methods have been used to study its subglacial thermal conditions, geology and lithospheric structure. Numerous regions of basal melting are identified in the central and north Greenland but their relationship with geothermal heat flux is not yet clear. Crustal thickness derived by seismology and gravity data are consistent, showing no significant lateral variations, and providing average values of about 40 and 36 km respectively. Even though Greenland is considered a craton its crust has been affected by the presume passage of the Iceland hotspot since at least 100 Ma.
Here we present the newest and highest resolution Curie Depth and geothermal heat flux distributions for Greenland as well as their associated uncertainties. For estimating the Curie Depths we applied spectral methods to aeromagnetic data from WDMAM2.0. Calculated Curie Depths vary from 25 to 50 km with shallower values located to the east. After estimating the Curie Depth we apply a thermal model based on the 1D heat conduction equation and considering steady state conditions. The thermal parameters are then optimized using local values derived from direct measurements, temperature profiles and more indirect methods. The heat flux distribution shows higher spatial variability and a very different pattern than previously proposed and with values ranging from 50-80 mW/m^2. Especially, we identify a NW-SE high heat flux feature crossing Greenland which we correlate with the Iceland hotspot track.
Additionally, we calculate the Bouguer anomaly from GOCO5s satellite free air data and perform several gravity models across the proposed hotspot track. We identify a linear region of dense lower

crust and lithospheric thinning along the track, which we attribute to impact of the plume on the base of the crust and in the lithosphere.
Finally, our new geothermal heat flux pattern is consistent with already identified thaw areas and together with the gravity it allows us to understand the history, location and geodynamic movement of Greenland and the Iceland hotspot.

New aeromagnetic and airborne gravity views of the South Pole frontier in East Antarctica

Abstract ID : 1443

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Fausto Ferraccioli ,ffe@bas.ac.uk ,(Science Leader Geology and Geophysics) ,United Kingdom ,Cambridge ,Not Presenting[1]

Dr. Tom A Jordan ,tomj@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Prof. Rene Forsberg ,rf@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[3]

Dr. Arne Olsen ,avo@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[3]

Dr. Graeme Eagles ,geagles@awi.de ,(None) ,Germany , ,Not Presenting[5]

Dr. Tania Casal ,tania.casal@esa.int ,(None) ,Netherlands , ,Not Presenting[6]

1 - NERC/British Antarctic Survey 2 - British Antarctic Survey 3 - DTU 4 - DTU 5 - AWI 6 - ESA - ESTEC

The South Pole region has remained one of the largest "poles of ignorance" on Earth, as very little data have been acquired here since pioneering aerogeophysical surveys performed in the 1970's and a more detailed US corridor flown in the late 1990's from the Transantarctic Mountains to South Pole During the 2015-2016 Antarctic campaign we flew a major aerogeophysical survey over the South Pole, collecting ca 30,000 line km of new aeromagnetic, airborne gravity and radio echo sounding, and laser altimetry data. The main aim of the PolarGAP project, supported by the European Space Agency was to fill in the data void in GOCE (Gravity Field and Steady-State Ocean Circulation Explorer) satellite gravity south of 83.3S.
Here we present the new magnetic and gravity anomaly images derived from the survey and interpret them to investigate the crustal architecture and tectonic evolution of the South Pole frontier. The Free-air gravity and radar data reveal the form and extent of the Pensacola-Pole Subglacial Basin. Linear free-air gravity lows within the basin are interpreted here as glacially overdeepened grabens flanked by uplifted horst blocks, including the Pensacola Mountains, Patuxent Range and the Argentine Range. The grabens are linked to the Jurassic Transantarctic rift system, which at regional to continental-scale, is associated with voluminous magmatism of the Ferrar Large Igneous province, which is clearly imaged by aeromagnetic anomaly data.
By combining the new PolarGAP aeromagnetic data with recent aeromagnetic data acquired over the Recovery Glacier region (ICEGRAV & RECISL projects) and satellite magnetic (MF7) data we investigate the influence of basement provinces and their tectonic boundaries on the Pensacola-Pole basin. We show that eastern flank of the basin is controlled by the southern edge of a hitherto unknown composite Precambrian microplate, extending from the Shackleton Range to the Pensacola-Pole basin. The proposed microplate forms a key "missing link" between the Ross and Pan-African orogenic belts in this sector of East Antarctica.

A35 - Magnetic data, indices and derived products for space weather and space climate research (DIV V – DIV II – DIV III – DIV IV – DIV VI)

Prediction of the magnetic index am based on development and performance comparisons of static and dynamic neural networks

Abstract ID : 155

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Marina Gruet ,gruet.marina@gmail.com ,(PhD student) ,France ,Toulouse ,Not Presenting[1]

Dr. Guy Rolland ,guy.rolland@cnes.fr ,(None) ,France , ,Not Presenting[2]

Dr. Nathalie Bartoli ,nathalie.bartoli@onera.fr ,(None) ,France , ,Not Presenting[1]

Dr. Thomas Pellegrini ,thomas.pellegrini@irit.fr ,(None) ,France , ,Not Presenting[4]

Dr. Sandrine Rochel ,sandrine.rochel@onera.fr ,(None) ,France , ,Not Presenting[1]

Dr. Angélica Sicard ,angelica.sicard@onera.fr ,(None) ,France , ,Not Presenting[1]

1 - ONERA 2 - CNES 3 - ONERA 4 - IRIT 5 - ONERA 6 - ONERA

Space weather forecast aims to predict solar events and its impact on human activities. It is based on the knowledge gathered from years of research and on statistical models. Here we focus on the development of particular statistical models called neural networks. They have the ability to estimate an output using various inputs, after a phase of learning and optimisation using large training databases.
Databases consist of solar wind data and magnetic index values. Solar wind parameters are propagated data from OMNI databases and magnetic parameters are provided by INTERMAGNET network. We aim to develop neural networks to predict magnetic index using solar wind parameters collected by the satellite ACE, located at the Lagragian Point L1.
To characterise the intensity of geomagnetic activity on a planetary scale, existing models predict the magnetic index Kp. So far, there is no model predicting am, which just as Kp, has a time resolution of 3h but is based on a network better distributed and better located in latitude and longitude. It also has the advantage of being defined in terms of amplitude, and is not based on a logarithmic scale between 0 and 9.

The terrestrial magnetosphere is a very complex and dynamic system, so the main challenge is to find the neural network that will be the most adapted to represent this system.
Most of the time, networks such as Multilayer Feedforward neural networks are considered to predict Kp (Boberg et al., 1999, Bala et al., 2005). Those are by definition quite simple model that are limited as they do not account for dynamics. We consider dynamic models such as time delay neural networks and recurrent networks that already proved their efficiency to predict the Dst index (Wu et al.,1996) and the AE index (Gleisner et al., 2001).
With this presentation, we would like to show ongoing developments and performance comparisons of various neural networks, to find the network the most adapted for the prediction of the magnetic index am from solar wind data.

A new proxy for the geomagnetic signal of magnetospheric currents on Earth derived from observatory data

Abstract ID : 512

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Leonie Pick ,leonie.pick@gfz-potsdam.de ,(PhD student) ,Germany ,Potsdam ,Not Presenting[1]

Ms. Monika Korte ,monika.korte@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

1 - Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences 2 - Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences

The near-Earth magnetic field generated by magnetospheric currents is globally southward directed and aligned with the internal dipole axis thus opposing the horizontal component of the core field at low to mid geomagnetic latitudes. This main field reduction determines the amplitude of the Dst index that is traditionally used to characterize the strength of the magnetospheric ring current. However, as the Dst baseline varies in time the alternative RC index was introduced as part of the CHAOS model series (Olsen et al., 2014) valid from 1997 onwards. It is based on night-time hourly means of 21 observatories from which estimates of the core and crustal fields are removed. The lithospheric signal is taken to be the quiet-time mean of station residuals estimated at each site. Since these biases also include an external part the RC index underestimates the true magnetospheric field intensity by this background field. We introduce a new index (MC) aiming to improve two aspects of RC: MC should provide the correct absolute level of magnetospheric field intensity variations as well as a standard deviation that assesses the uncertainty of the main field model used. Initially we focus on decadal timescales and base MC on annual means from 16 globally distributed observatories spanning 1960-2010. This has the advantages that the ionospheric Sq daily variation does not need to be removed explicitly and a long-term core field model COV-OBS (Gillet et al., 2013) including prior error information is available. Key aspects of our derivation are the recalculation of observatory biases that do not include the average magnetospheric background field (~13 nT) as well as a Bayesian inversion scheme to adequately propagate main field model errors. The resulting standard deviations of MC generally increase with a decreasing number of observatories. MC is validated against solar (F10.7) and geomagnetic activity (Ap) indices and can be used e.g. to correct observatory secular variation in order to draw conclusions on core flow dynamics. Current work is concerned with increasing MC time resolution to hourly means making the index more attractive to the main field or space weather modeling community.

Assessment of GIC risk based on transfer function analysis

Abstract ID : 545

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Malcolm Ingham ,Malcolm.Ingham@vuw.ac.nz ,(None) ,New Zealand , ,Not Presenting[1]

Prof. Craig Rodger ,craig.rodger@otago.ac.nz ,(Head of Department) ,New Zealand ,None ,Not Presenting[2]

Dr. Tim Divett ,tim.divett@otago.ac.nz ,(Postdoctoral Research Fellow) ,New Zealand ,Dunedin ,Not Presenting[2]

Mr. Michael Dalzell ,Michael.Dalzell@transpower.co.nz ,(None) ,New Zealand , ,Not Presenting[4]

Dr. Tanja Petersen ,T.Petersen@gns.cri.nz ,(None) ,New Zealand , ,Not Presenting[5]

1 - School of Chemical and Physical Sciences, Victoria University of Wellington 2 - University of Otago 3 - University of Otago 4 - Transpower New Zealand Limited, Wellington 5 - GNS Science, Lower Hutt, New Zealand

The modelling of the effect of geomagnetically induced currents (GIC) on electrical transmission networks is often based on numerical models of the 3-dimensional electrical conductivity structure. Such models have several limitations. In particular, as well as being highly dependent on a detailed knowledge of conductivity structure, they may be only valid for a limited range of periods of magnetic variation or, alternatively, are computationally very expensive. Other possible approaches to assessing the risk posed to electrical networks by geomagnetic activity include direct use of magnetotelluric impedances to calculate the expected electric field response to magnetic activity, and the formulation of transfer functions relating measured GIC to magnetic observatory data.
In this study we use data recorded at the Eyrewell geomagnetic observatory in New Zealand to calculate transfer functions which predict the expected GIC at several substations in the New Zealand electrical grid at which measurements of GIC have been made. Although the approach does not make predictions for the network as a whole it does allow, for individual substations, extension of the period range over which the risk posed by GIC can be assessed.

Verification study of geomagnetic K-index forecasts

Abstract ID : 897

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yuki Kubo ,kubo@nict.go.jp ,(Research Manager) ,Japan ,Toyko ,Not Presenting[1]

1 - National Institute of Information and Communications Technology

Recently, forecast verification has been recognized as one of the most important topic in space weather forecast operation. While a forecast verification study has long history in terrestrial weather forecast community, it is still in the early stage in space weather forecast community. Some Regional Warning Centers (RWCs) belonging to the International Space Environment Service (ISES) have started to verify their operational forecasts. National Institute of Information and Communications Technology (NICT), as ISES/RWC Japan, has a web platform of the operational solar flare and geomagnetic K-index forecast, which compares forecasts of some RWCs. However, as the conditions of the forecasts among the RWCs are not the same, it is hard to directly compare the forecast performances. While comparing forecast performances is informative, we have to proceed the efforts to compare operational space weather forecast among some RWCs. Verifying own forecast performance is the first step to compare the performance of forecast. For the reasons, we have verified own forecast performance. While we have already performed operational solar flare forecast verification, we have just started a verification study of operational geomagnetic K-index forecast by using forecast data issued by RWC Japan for 16 years as Ursigram code. In this presentation, we introduce methods and the first results of the verification study of our operational geomagnetic K-index forecast.

ULF Wave Power Index for Space Weather and Geophysical Applications

Abstract ID : 988

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Vyacheslav Pilipenko ,space.soliton@gmail.com ,(head of laboratory) ,Russia ,Moscow ,Not Presenting[1]

Dr. Olga Kozyreva ,kozyreva@ifz.ru ,(Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences) ,Russia ,Moscow ,Presenting[2]

Dr. Anatoly Soloviev ,a.soloviev@gcras.ru ,(Deputy Director for Science) ,Russia ,Moscow ,Not Presenting[3]

Prof. Mark Engebretson ,engebret@augsburg.edu ,(Professor) ,United States ,Minneapolis ,Not Presenting[4]

1 - Geophysical Center 2 - Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences 3 - Geophysical Center of the Russian Academy of Sciences 4 - Augsburg College, Minneapolis

A ULF wave index, characterizing the level of the geomagnetic field variability in the frequency range 2-7 mHz, has been suggested to the space physics and geophysical community. This global wave index is produced from all available arrays of magnetometers and isolated stations in the Northern hemisphere. A similar ULF wave index is calculated using magnetometer data from geostationary (GOES) and interplanetary (Wind, ACE) satellites. In this review we demonstrate that a wide range of space physics studies, such as the solar wind-ionosphere coupling, wave energy transport, substorm physics, relativistic electron energization, ring current formation, electrodynamics of the ionosphere and magnetosphere, search for electromagnetic precursors of earthquakes, etc., has benefited from the introduction of the provisional ULF wave index. Possible ways of the ULF index advancement and development are discussed. The permanently updating ULF-index database is freely available via the website http://ulf.gcras.ru/ for all interested researchers for further validation and statistical studies.

Applications of magnetometer data to Space Weather modelling and now-casting

Abstract ID : 1029

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Pierre Cilliers ,pjcilliers@sansa.org.za ,(Senior Researcher) ,South Africa ,Hermanus ,Not Presenting[1]

1 - SANSA

This paper presents several innovative uses of magnetic data for Space Weather modelling and operational now-casting of geomagnetically induced currents (GICs). Magnetotellurometers (MTs) are used by the exploration community to map the conductivity of the Earth. However, the surface impedance data that can be derived from MT measurements are very useful for the estimation of the geo-electric fields required to calculate GICs in power lines. The E-field measurements from MT instruments also provide a valuable means for the verification of E-field modelling based on Earth conductivity structures. By using the difference between the magnetic fields measured underneath high voltage power lines, and a suitably transformed magnetic field from a nearby magnetic observatory or alternative magnetometer, it is possible to infer the GIC in the power line. This differential magnetometer method (DMM) has been applied in Finland, South Africa and in the USA, and is gaining widespread interest in the Space Weather prediction community as a means to verify models for predicting GICs in power lines. For GIC modelling in a power network, the E-field and surface impedance along each power line is needed. Techniques for the interpolation of near real-time magnetic field measurements at INTERMAGNET observatories to the locations of power lines, using the Spherical Equivalent Current System (SECS), can be verified by means of MT measurements. Now-casting of GICs can be done by the real-time convolution of current magnetic field measurements with the GIC impulse response of a network node derived from historical measurements. Magnetic field measurements at high sampling rates and pT levels using SQUID magnetometers have the potential to reveal seismic precursors. Magnetometer measurements at 1-sec, which are now available from all INTERMAGNET observatories in Southern Africa, can be used to determine the spectral components of dB/dt up to 0.5 Hz, which may be relevant for GIC modelling and to assess the frequency of occurrence of events with significant spectral components in dB/dt above 8 mHz (as determined from 1-min data). The use of geomagnetic indices as measures of disturbance of the near-Earth space environment is discussed. Examples and challenges with these applications will be presented

Recent Updates on the developing of the Ksa magnetic index for South America based on the Embrace Magnetometer Network

Abstract ID : 1138

Conflict Declaration : The authors declare that they have no competing interests.

Content Motivation : None

Additional Information : The authors thank the Embrace/INPE Program for providing the magnetic data.

Dr. Clezio Marcos De Nardin ,clezio.denardin@inpe.br ,(Head of the Embrace Space Weather Program/INPE Head of the Aeronomy Division/INPE) ,Brazil ,Sao Jose dos Campos ,Not Presenting[1]

Prof. Sony Chen ,sony.chen@inpe.br ,(None) ,Brazil , ,Not Presenting[2]

Mr. Andreos Bilibio ,andreos.bilibio@inpe.br ,(None) ,Brazil , ,Not Presenting[2]

Dr. Juliano Moro ,julianopmoro@gmail.com ,(Postdoctoral Researcher) ,Brazil ,Santa Maria, RS ,Not Presenting[4]

Dr. Laysa Resende ,laysa.resende@inpe.br ,(None) ,Brazil , ,Not Presenting[2]

Miss. Thainá de Oliveira Bertollotto ,thaina.bertollotto@inpe.br ,(None) ,Brazil , ,Not Presenting[1]

Mr. Vitor Vaz Schultz ,xultezz@gmail.com ,(None) ,Brazil , ,Not Presenting[7]

Prof. Claudio Paulo ,claudio.paulo@inpe.br ,(None) ,Brazil , ,Not Presenting[2]

Prof. Paulo Barbosa Neto ,pafraneto@gmail.com ,(None) ,Brazil , ,Not Presenting[2]

Dr. Paulo Nogueira ,paulo.nogueira@ifsp.edu.br ,(None) ,Brazil , ,Not Presenting[10]

1 - National Institute for Space Research – INPE - MCTIC, São José dos Campos, SP, Brazil 2 - National Institute for Space Research 3 - National Institute for Space Research 4 - National Space Science Center, Chinese Academy of Science, Beijing, China & Southern Regional Space Research Center – CRS/INPE – MCTIC 5 - National Institute for Space Research 6 - National Institute for Space Research – INPE - MCTIC, São José dos Campos, SP, Brazil 7 - Southern Regional Space Research Center – CRS/INPE – MCTIC, in collaboration with the Santa Maria Space Science Laboratory – LACESM/CT – UFSM, Santa Maria, RS, Brazil 8 - National Institute for Space Research 9 - National Institute for Space Research 10 - Instituto Federal de Educação, Ciência e Tecnologia São Paulo

The present work shows the recent evolution on the developing of the Ksa magnetic index for South America based magnetic measurements from the Embrace Magnetic Network (MagNet), which provides information from several latitudes in South America. We provide details on the use of the seasonal variation of the Solar quiet (Sq) Earth's magnetic field that we used to remove the seasonal variation. We also provide the results of a comparison of an equipment belonging to the Embrace

MagNet with the magnetometer that is part of the Intermagnet network installed at the same observatory in order to demonstrate the quality of the data collected by the Embrace MagNet. In addition, we the results of a single comparison between the Ksa and the Kp are presented. In addition the first results of a comparison between the Embrace MagNet DH (as a proxy of the Dst) and the Dst are introduced.

The First Statistical and Wavelet Analysis of the New Magnetometer Installed on Mid-West of Brazil

Abstract ID : 1147

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Maurício Bolzan ,mauricio.bolzam@gmail.com ,(Professor) ,Brazil ,Jataí ,Not Presenting[1]

1 - Federal University of Jataí

The three years first analysis of the data from new magnetometer installed on mid-west of Brazil, Jataí city, are reported. Results from wavelet transform indicated a seasonality for the 2014, 2015 and 2016 years, where some periods are influenced by this phenomenon. Furthermore, in order to study some particular cases of geomagnetic storm, the Coherence Wavelet Transform was applied. Results of this procedure revealed important correlation between some geomagnetic indices and H-component time series and also an anti-phase relationship between these variables in some periods found. The results are explained through of the nonlinear phenomenon called self organizing criticality (SOC).

Reconstructions of solar and solar wind activity for past centuries

Abstract ID : 1227

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Leif Svalgaard ,leif@leif.org ,(Senior Research Scientist) ,United States ,Petaluma ,Not Presenting[1]

1 - Stanford University

The last decade of vigorous research have produced a remarkable consensus [as well as some dissent] about the long-term variation of solar and heliospheric parameters. Using geomagnetic observatory data from centuries past have resulted in reliable reconstructions of properties of the solar wind since at least the 1840s and of solar EUV well back into the 18th century. On the solar side, errors and inconsistencies of the sunspot number series have been identified and corrected leading to a revision of the fundamental datasets of solar activity. The geomagnetic-based and sunspot-related reconstructions of past solar activity support and complement each other forming a solid base for long-term research into the response of the terrestrial system in which we live and spurred renewed interest research of long-term variations, including rescue and digitization of historical data.

Space physics and space weather quantification from geomagnetic observations at ground and in space

Abstract ID : 1265

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Claudia Stolle ,cstolle@gfz-potsdam.de ,(Professor) ,Germany ,Potsdam ,Presenting[1]

Mr. Chao Xiong ,bear@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Tarqiue Siddiqui ,tarqiue@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Juan Rodríguez-Zuluaga ,juanrz@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Juergen Matzka ,jmat@gfz-potsdam.de ,(scientist) ,Germany ,Potsdam ,Not Presenting[5]

Mr. Hermann Lühr ,hluehr@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Yosuke Yamazaki ,yamazaki@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

1 - GFZ Potsdam 2 - GFZ Potsdam 3 - GFZ Potsdam 4 - GFZ Potsdam 5 - GFZ 6 - GFZ Potsdam 7 - GFZ Potsdam

Geomagnetic observations are sensitive to electric currents in the ionosphere and magnetosphere. These currents are in response to the solar wind, solar irradiance and their variations, and also partly modified by the neutral atmosphere processes. Geomagnetic observations are therefore suitable to characterize the physical processes and the variability of the Earth's space environment. Likewise, they can be used to specify space weather conditions, e.g., as an alert tool for certain space weather events, e.g. by means of geomagnetic indices.
This talk will present recent space physics and space weather studies based on geomagnetic observations from ground and low Earth orbit satellites. For example, both ground and CHAMP observations reveal that the equatorial electrojet shows enhanced amplitudes of waves with lunitidal periods during times of weakening of the stratospheric polar vortex, also known as stratospheric warming events. Here, magnetic observations point to a close connection of global atmospheric wave patterns. We also look at multi-instrument observations from the Swarm mission that reveal new evidence for directional electromagnetic energy fluxes within equatorial plasma irregularities. As an example for space weather research, we investigate the validity of geomagnetic indices to predict malfunctioning of GPS receptions.

A36 - From the Kaapvaal Craton to the Red Sea Rift: electromagnetic and geomagnetic studies of geodynamic processes (DIV VI)

Precambrian crust architecture of SE Fennoscandia evidenced by new geophysical models

Abstract ID : 188

Conflict Declaration : No conflict of interests

Content Motivation : research motivation: modern MT/MV soundings have to provide solid constrains for the studies of Precambrian geological evolution of Fennoscandian Shield

Additional Information : Community of researches of LADOGA WORKING GROUP: Nina Golubtsova, Victor Glaznev, Victor Kulikov, Maria Kosnyreva, Pavel Pushkarev, Maxim Smirnov, Andrey Yakovlev, Ludmila Zolotaya, Pavel Ryazantsev, - collective co_Author

Mrs. Elena Sokolova ,sokol_l@mail.ru ,(None) ,Russia , ,Not Presenting[1]

Mr. Igor Rokityansky ,rokityansky@gmail.com ,(None) ,Ukraine , ,Not Presenting[2]

Mrs. Yana Taran ,yanataran@hotmail.com ,(post graduate student Moscow State University) ,Russia ,Moscow ,Not Presenting[3]

Mr. Michael Mints ,michael-mints@yandex.ru ,(None) ,Russia , ,Not Presenting[4]

1 - IPE RAS 2 - IG NANU 3 - MSU 4 - GI RAS

The structures and stages of crust formation in SE Fennoscandian Shield are analyzed in the course of integrated interpretation of geological and modern geophysical data on seismic, magnetotelluric and potential fields. For the central part of Palaeoproterozoic Svecofennian accretionary orogen the basic understanding are derived from compiling surface geology and reflection seismic data, which reveals a sequence of inclined deep crustal sheets underthrusting Archaean Karelian craton for more than hundred of km as well as overthrusting upper-crustal sequences in Raahe suture zone. Comparison with magnetotelluric results on Central Finland verifies seismostructural pattern charging one by material properties to distinguish between blind bodies of granitic and metasedimentary composition. The absence of appropriate seismic data on the most SE part of the study area is compensated by data of new MT/MV profile of 2013-2015 (50 broad-band and 20 long period synchronous soundings) across prominent Lake Ladoga conductivity anomaly (LLA). This anomaly was discovered by pioneer MV soundings forty years ago at the boundary between Karelia craton and Svecofennian orogen but still had no clear understanding of the nature. Increased possibilities of modern MT/MV soundings provide solid geophysical constrains for studies of Precambrian geological

evolution. Two-dimensional inversions of new ensemble of MT/MV responses have demonstrated: LLA is a complicated ensemble of conductive features of different structural identity. At mid- and lower-crustal levels they are generally characterized by SW dip reflecting thrust zones along graphite-bearing slippery surfaces of supracrustal formations during their accretion to the SW border of Karelian Craton in the late Palaeoproterozoic. In the upper crust of NE profile segment bowl-formed association of conductive faults reveals the structure of Raahe-Ladoga suture zone. The enhance upper-crustal conductivity is connected with graphite- and sulphide-bearing sedimentary-volcanic series. In SW part of resistivity cross-section we found inflation of deep-crustal conductive layer producing the very LLA (originally found by long-period MVS) constituted by deeply metamorphosed complexes of South-Finland Granulite-Gneiss Belt inreached by crystal graphite. Relevant correspondences of geoelectric, density and magnetization images of deep structures in profile cross-section are discussed to support obtained tectonic inferences. New evidence relevant to crustal evolution of Southeastern Fennoscandian shield are summarized.

Interpretation of the geomagnetic anomalies in the Kaapvaal Craton in Botswana

Abstract ID : 315

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Calistus Ramotoroko ,ramotorokoc@biust.ac.bw ,(None) , , ,Not Presenting[1]

Prof. Kevin Mickus ,KevinMickus@missouristate.edu ,(None) ,Botswana , ,Not Presenting[2]

Prof. Rubeni Ranganai ,ranganai@mopipi.ub.bw ,(None) ,Botswana , ,Not Presenting[3]

Prof. Elisha Shemang ,shemange@biust.ac.bw ,(None) ,Botswana , ,Not Presenting[1]

1 - BIUST 2 - Missouri State University 3 - University of Botswana 4 - BIUST

Knowledge of both the surface and subsurface structure and configuration of rocks in the craton is crucial to understanding how they formed and the occurrence of the minerals. The overall extent of the Archaean Kaapvaal Craton in Botswana is also of general geological importance/relevance, including definition of the boundaries with the adjoining Neoarchaean Limpopo orogenic belt; but complex mechanism of formation and stabilization of these early continents still incompletely understood. There is a general paucity of geological outcrop in the region due to cover by the Kalahari sediments, and critically, the structure of rock units at depth is unknown. This information can be provided by geophysics. Geomagnetic data offer a valuable insight to bedrock geology obscured beneath surficial cover and inherently contain information on the configuration of rock formations at depth. In this paper a quantitative interpretation of regional aeromagnetic data is conducted in the Kaapvaal Craton in Botswana, to estimate magnetic and geometrical parameters of the causative bodies using spectral analysis and 3D modeling, and to constrain previous interpretations based on tentative geologic maps and provide new information to link these structural features to known tectonic events. Constrained models of geotectonic evolution of the craton will considerably assist in discussion of geodynamical implications for the tectonic evolution in the region. Gaining an insight into the 3D structure of the craton will also considerably assist in prospecting for more mineral deposits in this region.

Electrical resistivity structure of Arsanjan Block, Zagros Fold and Thrust Belt, obtained from magnetotelluric data

Abstract ID : 452

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Nikolay Palshin ,palshin@ocean.ru ,(Head of Laboratory) ,Russia ,Moscow ,Not Presenting[1]

Mr. Alireza Aliyari ,ar.aliyari@gmail.com ,(None) ,Iran , ,Not Presenting[2]

Mrs. Elena Aleksanova ,alex-len@inbox.ru ,(None) ,Russia , ,Not Presenting[3]

Mr. Alireza Liaghat ,a_liaghat@yahoo.com ,(None) ,Iran , ,Not Presenting[4]

Mr. Mohammad Javad Bolourchi ,mjbolourchi@gmail.com ,(None) ,Iran , ,Not Presenting[2]

1 - Shirshov Institute of Oceanology, RAS 2 - Zamin Ab Pey CE 3 - Nord-West Ltd 4 - None 5 - Zamin Ab Pey CE

Broadband (10^{-4} - 1000 s) magnetotelluric (MT) data were acquired along 7 profiles in Arsanjan Block, part of High Zagros and Zagros Fold and Thrust Belt (ZFTB) at 363 sites. The data are sensitive to petrophysical and hydrophysical properties of rocks and provide valuable information about geological structure of the ZFTB. We present and interpret results of 2D MT data inversion to provide a regional scale view of electrical resistivity of the upper part of crust up to depth of 25 km.
The thickness of sediments was found to be of about 15-20 km, which is significantly greater than it was considered earlier. The resistivity structure is characterized by lateral heterogeneity: several mini basins could be outlined. Most of mini basins are filled with Mesozoic and Paleozoic formations. Mini basins are underlined by well-pronounces conductive layers, which could be explained by saline water saturated rocks. Number of fault zones could be outlines. Profiles cross the Main Zagros Fault and a distinct change in resistivity structure between ZFTB and Central Iran is seen as well as a complicated structure of the thrust zone itself.

2.5D inversion of multi-component long offset transient electromagnetic data

Abstract ID : 587

Conflict Declaration : None

Content Motivation : None

Additional Information : Roland Martin is the first author of this paper. Unfortunately, he could not take part at the conference and I will present this paper

Prof. Buelent Tezkan ,tezkan@geo.uni-koeln.de ,(None) ,Germany ,Cologne ,Not Presenting[1]

Dr. Roland Martin ,Roland2Martin@bundeswehr.org ,(None) ,Germany , ,Not Presenting[2]

1 - University of Cologne 2 - Bundeswehr Geoinformation Center, Euskirchen, Germany

A 2.5D inversion algorithm for long offset transient electromagnetic (LOTEM) data was developed. LOTEM model responses were solved for 3D conductivity distributions and 3D sources. The forward solution is obtained by means of solving Maxwell's equations directly in time domain utilizing the Spectral Lanczos Decomposition method. The field values are calculated on a staggered grid and the field values are interpolated by using a linear eight point interpolation algorithm to account for receiver positions within the inversion program. The ill-posed and non-linear LOTEM inverse problem is solved by means of a regularized Gauss-Newton type of optimization. The computation of sensitivities is carried out by using the adjoint Green functions approach which is realized by convolution of the background electric field originating from the primary signal with the impulse response of the receiver acting as a secondary source. The computation time for the inversion is reduced by distributing the multiple forward simulations within a parallel computer environment. LOTEM measurements over 2D/3D structures often involve sign reversals. Different methods exist to take both large amplitude variations and different signs into account. We use the Area-Sinus-Hyperbolicus-transformation for the model responses and sensitivities within the inversion procedure. The developed 2D inversion algorithm was tested on synthetic data successfully. In addition, the 2D inversion algorithm was applied on a LOTEM field data observed on the Arava fault (Jordan). The LOTEM setup was centered perpendicular to the fault and had a total length of 12 km with 4 different transmitter/receiver setups. 168 transient soundings combining electric and magnetic field responses from 4 different transmitter sites were jointly inverted resulting in a conductivity structure from a depth of 50 m down to 4 km and supporting the conductivity model derived by the inversion of magnetotelluric data from the same profile

Magnetotelluric imaging of the Central Main Ethiopian Rift - Implications for magma pathways and storage

Abstract ID : 873

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Juliane Huebert ,juliane.huebert@ed.ac.uk ,(Post-doctoral researcher) ,United Kingdom ,Edinburgh ,Not Presenting[1]

Prof. Kathy Whaler ,kathy.whaler@ed.ac.uk ,(None) ,United Kingdom ,Edinburgh ,Presenting[1]

Dr. Shimeles Fisseha ,wmikel99@gmail.com ,(None) ,Ethiopia , ,Not Presenting[3]

1 - University of Edinburgh 2 - University of Edinburgh 3 - University of Addis Ababa

The Main Ethiopian Rift (MER) is part of the East African rift with its unique geological setting as an active continental breakup zone. The MER includes a number of understudied active volcanoes with potentially high risks for the densely populated developing country of Ethiopia. Using newly recorded (2016) broadband and long-period magnetotelluric (MT) data along a 110 km long transect crossing the whole width of the rift, we present a regional 2-D model of electrical resistivity of the crust with a number of distinct anomalies. The derived model endorses a previous study that drew the surprising conclusion that there was no highly conductive region associated with a magma chamber directly under the central-rift-volcano Aluto. This has implication for the estimation of the amount of magma present, its water content and the storage conditions, as the volcano is actively deforming and results from seismics and CO_2-degassing studies all indicate magma storage at 5 km depth. Additionally, the existence of a strong conductor under the Silti-Debre Zeyit Fault Zone ca. 40 km to the north-west of the rift centre is confirmed. It is located with a slight offset to the Butajira volcanic field, which hosts a number of scoria cones at the boundary between the NW plateau and the rift. Conductive anomalies with this amplitude (<10 Ohmm) are very likely to be associated with partial melt and/or fluids in dikes or faults. The Butajira area was previously classified as a failed volcanic segment with a high number of volcanic vents but low seismicity. With the evidence presented by MT new light can be shed onto magma pathways in the crust, as this offset between a central rift volcano and a potential deeper magmatic source is enigmatic.

Estimation of the mean magnetic thickness and magnetization over southern Africa by means of a high resolution lithospheric magnetic field model

Abstract ID : 1274

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Foteini Vervelidou ,foteini@gfz-potsdam.de ,(Postdoctoral researcher) ,Germany ,Potsdam ,Not Presenting[1]

1 - GeoForschungsZentrum Potsdam

In this study, a lithospheric magnetic field model over southern Africa is presented, up to Spherical Harmonic (SH) degree and order 1000 (40 km spatial resolution). The model is obtained by means of the potential modeling method known as the Revised-Spherical Cap Harmonic Analysis (R-SCHA), which allows for the joint modeling of data at various altitudes. Here, the input data set consists of Swarm gradient magnetic field data, CHAMP magnetic field data, aeromagnetic and marine data, data from three local magnetic observatories and repeat stations data obtained between 2005 and 2010. By means of the regional power spectrum of this model, a mean estimate for the magnetic thickness and magnetization over southern Africa is provided. These estimates rely on the combined use of the R-SCHA power spectrum and a recently proposed statistical expression of the Earth's lithospheric magnetic field SH power spectrum. The results are compared to the ones obtained by means of traditional magnetic thickness estimates methods that rely on the cartesian reference frame.

Transitional magmatic-amagmatic segmentation during continental breakup imaged with 3-magnetotellurics

Abstract ID : 1326

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sophie Hautot ,sophie.hautot@imagir.eu ,(Manager) ,France ,Brest ,Not Presenting[1]

Dr. Kate Selway ,kate.selway@mq.edu.au ,(None) ,Australia , ,Not Presenting[2]

Dr. Matthieu Plasman ,matthieu.plasman@univ-brest.fr ,(None) ,France , ,Not Presenting[3]

Prof. Pascal Tarits ,tarits@univ-brest.fr ,(None) ,France ,Plouzane ,Not Presenting[4]

1 - Imagir 2 - Macquarie University 3 - University of Brest 4 - IUEM

The North Tanzanian Divergence (NTD) is part of the eastern branch of the East-African rift system (EARS). The NTD propagates southward along the eastern margin of the Tanzanian craton and is characterized by two different deformation systems delimited by the EW trending Ngorongoro-Kilimanjaro volcanic belt. The Northern part of the NTD is the Natron magmatic segment, the southern limit of the Kenya Rift, with a typical half-graben structure and several volcanoes. The southern part is characterized by a wide zone (>300 km) where the rift splits into three amagmatic arms, the Eyasi rift, the Manyara rift and the Pangani rift.
Two major magnetelluric surveys were carried out to study at different scales the origin of the continental breakup in the NTD region. A large scale array (Selway 2015) provided insight on the hydrogen content of the proterozoic basement through which the EARS propagates. Data in two smaller scale arrays were collected across the magmatic Natron segment and the amagmatic Manyara segment (Plasman et al. 2017) to better understand the interactions between faults and magma, the role of inherited structures and rheological heterogeneities of the lithosphere that may explain the NS transition from a magmatic to amagmatic rift system. The result of the 3D inversion of MT data along each profile separately provides evidence of two very different crustal structures with magma control deformation to the north and lithosphere structure control deformation to the south. From these two studies on the NTD, the transition from a magmatic to a amagmatic rifting system, if confirmed is still not fully understood. Here we combine the data from both surveys that encompass the NTD. This large array includes the two Natron and Manyara profiles, sites at mid-distance between these two profiles as well as sites south of the Manyara rift and on the Tanzanian Craton to the west. We used the whole data set to obtain a resistivity model at the scale of the NTD from 3D inversion. Results are discussed in terms of the structure of the lithosphere and new insights on the anomalous propagation of the rift.

MT sounding experiment across the Bushveld Massive

Abstract ID : 1417

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Valeriya Hallbauer-Zadorozhnaya ,valeriya.hallbauer@gmail.com ,(None) ,South Africa ,Pretoria ,Not Presenting[1]

1 - Tshwane University of Technology

The integrated MT sounding profile experiment was started in October 2015 over the western part of the
Bushveld Massive in South Africa. The Bushveld Massive is one of the greatest crystalline structures of this
type. It extends for more than 300 km and includes a number of strict crustal conducting structures at its
slopes and inside. The study area is rich in mineral resources, however, its deep structure is poorly
investigated with EM and, particularly, MT methods due to a strong industrial noise from DC train system
around the Johannesburg-Pretoria agglomeration, mining activities and electric fences.
MT soundings were made with 4 Phoenix and 2 LEMI instruments in three period ranges (AMT, 42 sites,
0.0002-2s; BMT, 12 sites, 0.003-1000 s; LMT, 15 sites, 10-5000 s), BMT and LMT sites were observed
simultaneously with permanent site RR1, located east from the massive, and two geomagnetic
observatories, namely, HBK, at its western edge, and HER, far away to SW. AMT soundings were located at
all BMT/LMT sites and between them at an average distance ~4.5 km. The impedance, tipper and horizontal
magnetic responses were estimated at the major part of LMT and BMT sites with simultaneous RRMC noise
reduction technique, and conventional single site impedance and tipper data got at AMT sites.
We discuss pseudo sections of the estimated transfer functions and first interpretation models derived from
them. The most reliably estimated horizontal magnetic responses outline strong subsurface conducting
structures at the western edge of the Bushveld Massive going deeper towards its center. The AMT
impedances give details of the outcrop zone of these bottom intrusive ore-bearing formations.
This study was supported by the bi-lateral Russian - South African research program of the Russian RFBR
and South African NRF agencies, and additionally funded by the Council for Geoscience, SAR. We are
grateful to all members of the BUSHVELD Working Working Group for the assistance during the field experiment.

A37 - Electromagnetic contributions to hydrological, environmental, archaeological and other near surface studies (DIV VI)

Resistivity images of Zagros Fault Belt

Abstract ID : 80

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Nikolay Palshin ,palshin@ocean.ru ,(Head of Laboratory) ,Russia ,Moscow ,Not Presenting[1]

1 - Shirshov Institute of Oceanology, RAS

New MT collected

Imaging a potential shale gas bearing formation in the Eastern Karoo basin, South Africa, with magnetotellurics

Abstract ID : 710

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ute Weckmann ,uweck@gfz-potsdam.de ,(Senior Scientist) ,Germany ,Potsdam ,Not Presenting[1]

Ms. Jade C. Greve ,jadegreve@gmail.com ,(None) ,South Africa , ,Not Presenting[2]

Ms. Anna Platz ,aplatz@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[3]

Dr. Naser Meqbel ,meqbel@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[3]

Prof. Moctar Doucouré ,Moctar.Doucoure@nmmu.ac.za ,(None) ,South Africa , ,Not Presenting[2]

1 - GFZ 2 - Africa Earth Observatory Network (AEON-ESSRI), Nelson Mandela Metropolitan University, Port Elizabeth 3 - German Research Centre for Geosciences - GFZ 4 - German Research Centre for Geosciences - GFZ 5 - Africa Earth Observatory Network (AEON-ESSRI), Nelson Mandela Metropolitan University, Port Elizabeth

With the current search for new energy resources, shale gas has become an increasingly important resource alternative. Thus, there is renewed interest in the hydrocarbon bearing potential of the Karoo Basin with special focus on the black organic shales of the Whitehill Formation. The aim of an extensive research launched by the Nelson Mandela Metropolitan University in South Africa is to obtain a fundamental understanding of the geology, petrology and hydrology of the sedimentary Karoo Basin.

In 2014, magnetotelluric (MT) measurements were conducted by the GFZ in the Eastern Karoo Basin to image the electrical conductivity structure of the shallow subsurface and to develop 2D and 3D models of the subsurface. Previous studies have shown that the potential shale gas bearing Whitehill Formation is characterized as a high conductive sub-horizontal layer, which covers large parts of the Karoo Basin.

The experimental layout allows high resolution 2D inversions along 7 profiles as well as regional 3D inversion of the entire array. 2D inversions reveal a sub-horizontal conductive layer in 3 - 5 km depth which seems to be disrupted in the South of the Karoo Basin. Above, several pockets and layers of enhanced conductivity can be observed which may possibly correlate with locations of water wells. 3D inversions of full MT impedance data, vertical magnetic transfer functions and interstation transfer functions show different resolution capability to the shale gas bearing layer. To interpret electrical conductivities as an indicator for the presence of shale gas, it is important to constrain layer

thicknesses and to observe resulting variations of the electrical conductivity within this layer. Alongside with the inversion models we incorporate additional data sets (aeromagnetic, seismic, borehole logs and hydrocensus) collected in the study area that will assist in the interpretation.

Constraint 3D Inversion of Magnetotelluric data from San Felipe (Mexico) for geothermal exploration

Abstract ID : 733

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Diego Ruiz Aguilar ,ruiz-aguilar@geo.uni-koeln.de ,(Phd Student) ,Germany ,Cologne ,Not Presenting[1]

Prof. Buelent Tezkan ,tezkan@geo.uni-koeln.de ,(None) ,Germany ,Cologne ,Not Presenting[2]

Dr. Claudia Arango-Galván ,claudiar@geofisica.unam.mx ,(None) ,Mexico , ,Not Presenting[3]

1 - IGM University of Cologne 2 - University of Cologne 3 - Institute of Geophysics-UNAM

San Felipe's area, which is located in the northeastern part of Baja California peninsula (Mexico), shows geothermal surface manifestations such as hot springs and high temperature in drinking water wells. In order to define the geometry and volume of this feasible geothermal system, a regional geophysical was carried out. In 2014, 17 TEM (Transient Electromagnetic) and MT (Magnetotellurics) soundings were recorded along 4 different lines. Both techniques were applied in the same spots, so that the static shift correction for MT data and a constrained inversion could be performed. TEM soundings were acquired using 50 x 50 m single-loop configuration with a TerraTEM device (Geonics Ltd.). MT signals were recorded using Metronix systems in the frequency range from 0.001 to 100 s. Additionally, we used 5 MT stations measured from 0.01 to 1000 s by CICESE (Mexico) and D.C soundings with electrode spacing up to 1 km acquired by CONAGUA (Mexico). As first step, 1D inversion of TEM data was done, using Marquardt and Occam inversion techniques. TEM inversion results have yielded three-layers resistivity models in which a resistive layer is sandwiched by two conductive layers. MT data was processed with robust single-site and robust remote reference methods. We used ModEM software to perform 3D MT Forward Modeling and Inversion. In order to investigate the detectability of structures with the deployed MT stations, we conducted modeling studies by varying the stations layout. The results of the 3D modeling studies helped us to validate the important structures that resulted from the inversion to field data. We used TEM and D.C models information to constrain the shallow subsurface of the 3D MT model. 3D-MT constraint inversion results show a conductive body in the central part of the survey, between 400 m and 2 km deep, and can be correlated to the sediments that fill the valley and to the aquifer from the area. Finally, a resistive structure is also mapped in the western area with 2 km of thickness, which might be the source of heat of the geothermal system.

Subsurface Investigations of Carbonate Geologies of Bonaire, Caribbean Netherlands using Ground Penetrating Radar

Abstract ID : 767

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Roy Bowling ,rbowling42@tamu.edu ,(Graduate Student) ,United States ,Bryan, Texas ,Not Presenting[1]

Dr. Mark Everett ,everett@geo.tamu.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Juan Laya ,layajc@geos.tamu.edu ,(None) ,United States , ,Not Presenting[1]

Mr. Charles Stanford ,chasestanford@tamu.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Timothy deSmet ,tdesmet@binghamton.edu ,(None) ,United States , ,Not Presenting[5]

1 - Dept. Geology and Geophysics Texas A&M University 2 - Department of Geology and Geophysics Texas A&M University 3 - Dept. Geology and Geophysics Texas A&M University 4 - Dept. Geology and Geophysics Texas A&M University 5 - Department of Anthropology, Binghamton University

Bonaire is a small island located offshore Venezuela as part of the Caribbean Netherlands. The island is composed of successions of geologically modern terraced carbonates overlying a Cretaceous volcanic basement. The growth of the carbonates on Bonaire has been attributed to uplift caused by tectonic forces between the Caribbean and South American plates (Hippolyte and Mann, 2011) as well as glacioeustatic sea level changes (Bandoian and Murray, 1974). Previous studies have geologically mapped the lithologies on the island (Hippolyte and Mann, 2011), and developed models of depositional environments based on outcrop investigations (Sulacia, 2015). Subsurface features have been largely inferred due to previous lack of geophysical surveys. We present here the application of ground penetrating radar (GPR) for improving the geologic understanding of Bonaire through structural mapping of the subsurface. The carbonate lithologies observed on the island have low values of electrical conductivity, which reduces the attenuation of electromagnetic waves at GPR frequencies (Cassiday, 2009). This combined with the arid climate of the island, which further reduces the bulk conductivities of the rocks, allows for signal penetration depths to be up to 10m. Such depths of investigation present an opportunity to image subsurface structures related to significant geologic features, including clinoform geometries representing progradation of the carbonate terraces over time. Multiple surveys were conducted on the island, including a cross-island transect, and several smaller transects at an outcropping of carbonate terraces known as Seru Grandi. The identification of radar facies in the cross-island transect was facilitated by the development of a k-means clustering algorithm for the automatic discrimination of structures in the GPR data. At the Seru Grandi site, multiple intersecting GPR transects were used to internally map surfaces representing distinct periods

of carbonate growth. Both core samples and hi-resolution photogrammetry provided ground-truthing for the GPR interpreted features. The detailed structural knowledge of the subsurface gained from the GPR surveys allows from a more complete geologic understanding of the island, and can provide necessary constraints in numerical carbonate growth models.

Near-surface structure of the Central Ganga Plain by magnetotellurics: Implications for deep groundwater exploration and depositional environment of sediments

Abstract ID : 833

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. AJAI MANGLIK ,ajay@ngri.res.in ,(Chief Scientist) ,India ,Hyderabad ,Not Presenting[1]

Dr. S Thiagarajan ,sthiagarajan@ngri.res.in ,(None) ,India , ,Not Presenting[1]

Ms. L. Adilakshmi ,lakshmigeo2008@gmail.com ,(None) ,India , ,Not Presenting[1]

Dr. M Suresh ,surleela@gmail.com ,(None) ,India , ,Not Presenting[1]

1 - CSIR-National Geophysical Research Institute 2 - CSIR-National Geophysical Research Institute 3 - CSIR-National Geophysical Research Institute 4 - CSIR-National Geophysical Research Institute

A thick succession of Recent and Quaternary sediments has been deposited in the Ganga Plains, especially in the northern part of the basin, by many major Himalayan rivers. These sediments preserve the records of past climate change especially Monsoon variability as well as form good layered groundwater aquifers. However, high electrical conductivity of the sediments limits the depth of investigation of most often used artificial source electrical and electromagnetic exploration techniques to the upper few hundred meters. Ever increasing demand for groundwater and the quest to understand the climate change signatures back in time require exploration of deeper sections of the sediments. In the present work, we use very high frequency (0.001 - 10 kHz) magnetotellutic (MT) data acquired along a number of profiles across the basin to delineate a broad subsurface structure of the Central Ganga Plain down to 500 m depth. The results reveal a significant contrast in the near-surface geoelectric structure across the basin and the presence of a consistent highly conductive (< 10 Ωm) clay/silt dominated layer of about 100 - 200 m thickness, underlain by a moderate resistivity zone possibly representing deep sandy aquifer, in the interfluve region between the Ganga and Yamuna rivers. In contrast, near-surface resistivity is moderate in the region north of the Ganga River indicating good sandy aquifer conditions. The clay/silt layer in this region gets buried to deeper levels implying a change in the sediment transport and depositional environment across the central Ganga Plain.

Mapping lake sediment thickness and conductivity using an exploration-industry helicopter electromagnetic data set

Abstract ID : 1196

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ian Ferguson ,ij_ferguson@umanitoba.ca ,(Professor (Geophysics)) ,Canada ,Winnipeg ,Presenting[1]

Mr. Mitchell Traa ,mitchell.traa@gmail.com ,(None) ,Canada , ,Not Presenting[1]

1 - University of Manitoba 2 - University of Manitoba

Data from an exploration helicopter electromagnetic (HEM) survey conducted over the northwest part of Shoal Lake, Ontario, Canada were used to delineate the sediment thickness and conductivity along test profiles in the lake. Earlier studies revealed strong changes in the HEM responses adjacent to islands in the lake, suggesting that the responses were sensitive to sediment thickness. Shoal Lake is a major recreational area, encompasses traditional lands for several First Nations, and supplies the water for the nearby city of Winnipeg which has population of 700,000 people. Mapping of its sediment properties is important for understanding its past and present geological processes. In this project, the responses from three test profiles from the HEM survey data are analyzed using resistivity depth imaging and 1-D inversion. The resistivity depth images provide a valuable initial view of the resistivity structure, e.g., revealing areas of thicker sediments. The results are perturbed strongly by magnetic zones in the bedrock that often coincide with the islands. Initial 1-D inversions of the HEM data from sites at which core samples had previously been taken, defined a lacustrine clay resistivity of 10 ohm.m and demonstrated the ability of the method to delineate sediment thickness. The inversion approach was then applied to data from the full length of the test profiles in order to map the unknown bathymetry and sediment thickness. The inversion results provide a reasonable fit to the 56,000 Hz, 7,000 Hz and 900 Hz coplanar HEM responses in most locations. The final inversion models provide useful definition of the bathymetry of Shoal Lake, and indicate water depths of up to 25 m along the test profiles. Sediment thickness exceeds 25 m in places, and the results image a highly variable Precambrian bedrock surface beneath the sediments. The methods established in this project will allow determination of the sediment resistivity structure over a larger area of Shoal Lake.

Membrane polarization and Maxwell-Wagner model: petrophysical and electrical difference

Abstract ID : 1414

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Valeriya Hallbauer-Zadorozhnaya ,valeriya.hallbauer@gmail.com ,(None) ,South Africa ,Pretoria ,Presenting[1]

Prof. Giovanni Santarato ,giovanni.santarato@unife.it ,(None) ,Italy , ,Not Presenting[2]

1 - Tshwane University of Technology 2 - University of FerraraNone

As is known, effects caused by polarization are superimposed on inductive processes of the electromagnetic field. By carrying out an interpretation of these electromagnetic and electrical soundings, one should know what types of polarization are recorded in a particular response curve or dataset. It was shown that sometimes several types of IP effects can be observed on measurements of a single sounding. The purpose of this paper is to show the difference between two types (among others) of polarization that arise in rocks, namely, between Maxwell-Wagner effect and membrane polarization. Using diffusion equations with specified boundary conditions, we have created mathematical solutions for these types of polarization.
From the sedimentological point of view, the membrane IP effect occurs in porous low and relatively low resistive rocks/sediments containing connected pores and channels whereas Maxwell-Wagner effect occurs in low porous high resistive rocks containing numerous isolated pores.
The membrane polarization is based on constrictivity of pores. When electrical current flows through porous rocks containing channels and pores with different size and saturated by (fresh) water, an excess/loss of ions accumulates at the boundaries. Membrane effect is therefore caused by to transfer number difference at the ends of pore. If transfer numbers are the same the membrane effect does not arise: the membrane IP effect is based on different concentrations of solution at the ends of each pore. In contrast Maxwell-Wagner effect is a classical capacitor with ions separation at the ends of isolated pores.
Membrane polarization occurs when both an electrical current and voltage are applied. Maxwell-Wagner effect occurs only due to voltage. Maxwell Wagner effect is linear, membrane effect is non-linear. In the Maxwell-Wagner effect the presence of a DEL (Double Electric Layer) can only reduce amplitude of IP effect.
The main results of our research (measurements and respective mathematical-physical models) are presented.

A38 - Recent advances in theory and methodology of electromagnetic induction studies (DIV VI)

Anisotropic three-dimensional inversion of marine controlled-source electromagnetic data based on a secondary-field Nédélec finite element forward operator and unstructured grids

Abstract ID : 283

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Feiyan Wang ,wangfeiyan03@gmail.com ,(None) ,Germany , ,Not Presenting[1]

Dr. Jan Petter Morten ,jpmorten@emgs.com ,(None) ,Norway , ,Not Presenting[2]

Prof. Klaus Spitzer ,klaus.spitzer@geophysik.tu-freiberg.de ,(Professor) ,Germany ,Freiberg ,Presenting[1]

1 - TU Bergakademie Freiberg 2 - EMGS ASA 3 - TU Bergakademie Freiberg

We present a three-dimensional (3D) inversion algorithm for controlled-source electromagnetics (CSEM) in the frequency domain incorporating vertical transverse isotropic conductivities. Discretization and parametrization are based on unstructured grids to achieve a high degree of geometric flexibility and to efficiently integrate many artificial sources in only one locally refined mesh. The forward operator is based on a secondary field approach and higher-order Nédélec finite elements (FE). The secondary field formulation is particularly advantageous because the large conductivity contrast at the flat sea surface can be covered by a stratified background model, thereby avoiding large discretization errors. The inverse problem is characterized by an inexact Gauss-Newton approach where the search for a minimum of a regularized nonlinear least-squares functional is carried out. The resulting systems of linear equations are solved using parallel direct solvers (forward) and the iterative least-squares solver LSQR (inverse). The scheme is tested using a synthetic marine CSEM scenario with rough bathymetry and a large industrial-size field data set from the Troll oil and gas field in the North Sea.

Magnetotellurics with magnetic observatory data affected by the ocean effect: Methodology and Results

Abstract ID : 454

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Achim Morschhauser ,mors@gfz-potsdam.de ,(Staff Scientist) ,Germany ,Niemegk ,Not Presenting[1]

Dr. Alexander Grayver ,agrayver@erdw.ethz.ch ,(Lecturer) ,Switzerland ,Zurich ,Not Presenting[2]

Prof. Alexey Kuvshinov ,kuvshinov@erdw.ethz.ch ,(None) ,Switzerland , ,Not Presenting[2]

1 - GFZ Potsdam 2 - ETH Zürich 3 - ETH Zürich

More and more geomagnetic observatories provide electric field measurements in addition to long-term geomagnetic data. Among them, seven observatories are located at the coasts of Japan (IAGA codes: KAK, MMB, KNY), Poland (HLP), the UK (HAD, LER), and Ireland (VAL), and two observatories are located on islands in the Atlantic Ocean (Tristan da Cunha; TDC) and in the Indian Ocean (Gan on the Maldives; GAN). Here, we use a selection of these observatories to derive magnetotelluric (MT) transfer functions, including phase tensors, which we aim to invert for the electrical conductivity structure underneath. The main challenge is that these data are severely affected by the conductivity contrast between seawater and land which results in a three-dimensional (3-D) behavior of the responses. Therefore, we use an adaptive 3-D finite-element MT forward solver in order to properly account for this 3-D effect by including the available bathymetry and topography data into the model. Then, the MT transfer functions can be properly inverted for upper mantle conductivities. For this purpose we use the Covariance Matrix Adaptation Evolution Strategy (CMAES), a stochastic optimization method which explores the parameter space globally and provides uncertainties of the recovered model parameters. CMAES requires to solve thousands of 3-D forward problems. The resulting computational burden is mitigated through running the inversion on a large cluster. The obtained conductivities are then used to estimate thermo-chemical properties of the mantle below these observatories, thereby improving our understanding of the geophysical setting of these regions. Further, the presented methodology and obtained conductivity models will allow for a proper characterization of induced fields when studying ionospheric and ocean tidal magnetic fields using observatory data.

Topographic Distortions of Magnetotelluric Transfer Functions: a High Resolution 3-D Modelling Study using Real Topography

Abstract ID : 596

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Johannes Käufl ,johannes.kaeufl@erdw.ethz.ch ,(PhD Student) ,Switzerland ,Zurich ,Not Presenting[1]

Dr. Alexander Grayver ,agrayver@erdw.ethz.ch ,(Lecturer) ,Switzerland ,Zurich ,Not Presenting[2]

Prof. Alexey Kuvshinov ,kuvshinov@erdw.ethz.ch ,(None) ,Switzerland , ,Not Presenting[2]

1 - ETH Zurich 2 - ETH Zürich 3 - ETH Zürich

The influence of topography on magnetotelluric data is a long standing issue. Common understanding is, that topographic distortions are of galvanic nature and result in a static shift of the apparent resistivity without affecting the phase of the magnetotelluric impedance. Previous studies on the topographic distortion of magnetotelluric transfer functions were often limited to simplified scenarios and few individual periods, therefore lacking realistic complexity.
We performed a systematic study of the topographic effect using both, a simple synthetic example and real topography. This study helps to understand the influence of topographic distortions in general and specifically for the data from a currently ongoing 3-D magnetotelluric survey in the Hangai Mountains in Mongolia, a region with significant topography. To this end, we utilized a high order 3-D FEM-modelling code together with a high resolution digital elevation model. High-order Nedelec elements combined with the locally refined unstructured meshes allow us to accurately represent topography and keep modelling errors low. The resulting models consisted of up to $2 \cdot 10^8$ unknowns and required efficient parallelized solvers to be used. We calculated responses for a wide frequency range and showed that, depending on the frequency and size of the topographic feature, the effect can manifest itself both as a galvanic and inductive distortion, affecting not only the apparent resistivities but also the phase. In addition to the impedance tensor we also looked at the effect on other magnetotelluric transfer functions, namely the phase tensor and tippers.

Controlled-source electromagnetic induction from a perspective of. non-equilibrium statistical mechanics

Abstract ID : 1112

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Mark Everett ,mark.e.everett@gmail.com ,(None) ,United States , ,Not Presenting[1]

1 - Texas A&M University

The controlled-source electromagnetic method of geophysical prospecting is based on the induction of electric current in an electrically neutral geological medium that is populated by a sea of positive and negative ionic and electronic charge carriers, whose spatial density generates the observed length-scale dependent heterogeneity of electrical conductivity. In the absence of a definite applied source, it is presumed that the charge carriers inside the Earth exercise a haphazard continuous motion, including both diffusion and drift contributions, but essentially they are in equilibrium or at least a steady state. It is supposed that the charge-carrier motions are due somewhat to random thermal effects but primarily they result from ubiquitous incoherent environmental or ambient fields, some of which could be due to natural sources such as lightning and some of which could be man-made such as electric power infrastructure. The definite application, to this system, of an external source at a specified time, such as the switch-off of a nearby transmitter loop, forces the charge-carrier ensemble out of its steady background state. Linear response theory from non-equilibrium statistical mechanics describes how such systems respond to applied fields. The work herein described is motivated by the early studies of Nyquist in which he determined the electrical resistance of a circuit without any current flowing in it. The mean square voltage fluctuations were found to be proportional to the circuit's electrical resistance. The explanation is that each of the individual tiny random fluctuations in the voltage can be viewed as the response to an infinitesimal applied force, ultimately described by the kinematics of vast numbers of molecular-scale collisions. Does such a physical description scale up to the applied geophysical scenario? Field experiments with a controlled-source system will be described in an attempt to explore this hypothesis, or at least to better understand the transition from the background steady-state to the CSEM response as it is conventionally understood. The objective of the research is to enable new physical insights by thinking about controlled-source electromagnetics within the framework of non-equilibrium statistical mechanics.

A39 - Developing and Using Realistic External Source Models for Imaging global deep Earth conductivity with Satellite and Ground-based Data (DIV VI – DIV II – DIV V)

Studying mantle structure with magnetospheric and tidal satellite magnetic signals: recent advances and challenges

Abstract ID : 367

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Alexander Grayver ,agrayver@erdw.ethz.ch ,(Lecturer) ,Switzerland ,Zurich ,Not Presenting[1]

1 - ETH Zürich

Satellite-detected magnetic signals of magnetospheric and oceanic origins have been shown to carry information on electrical conductivity of the Earth's mantle. These signals sense different parts of the mantle. Tidal magnetic signals are sensitive to the conductivity distribution in the upper mantle, whereas magnetospheric signals lack resolution there, but can constrain regions across the mantle transition zone and below. This prompts simultaneous inversion of both signals in order to get improved resolution across the whole range of depths. However, extraction of these signals with sufficient accuracy remains challenging because of the complex structure of the source and superposition with other signals. The challenge becomes more severe if one aims at constraining lateral variations of the electrical conductivity in the mantle because signals are attenuated at the satellite altitude. In this contribution, we report results related to inversion of satellite magnetic signals, state current challenges and outline possible ways to mitigate them.

Modeling the high-latitude field-aligned currents using coupled magnetosphere-ionosphere models

Abstract ID : 540

Conflict Declaration : None

Content Motivation : Invited to speak on this topic by session conveners

Additional Information : None

Dr. Michael Wiltberger ,wiltbemj@ucar.edu ,(Scientist III) ,United States ,Denver ,Not Presenting[1]

Dr. E Josh Rigler ,erigler@usgs.gov ,(None) ,United States , ,Not Presenting[2]

Dr. Viacheslav Merkin ,Slava.Merkin@jhuapl.edu ,(None) ,United States , ,Not Presenting[3]

Dr. John Lyon ,lyon@tinman.dartmouth.edu ,(None) ,United States , ,Not Presenting[4]

1 - NCAR 2 - USGS 3 - JHU/APL 4 - Dartmouth College

Using three resolutions of the Lyon-Fedder-Mobarry global magnetosphere-ionosphere model (LFM) and the Weimer 2005 empirical model, the structure of the high latitude field-aligned current patterns is examined. Each resolution was run for the entire Whole Heliosphere Interval (WHI), which contained two high-speed solar wind streams and modest interplanetary magnetic field strengths. Average states of the field-aligned current (FAC) patterns for 8 interplanetary magnetic field clock angle directions are computed using data from these runs. Generally speaking the patterns obtained agree well with results obtained from the Weimer 2005 computing using the solar wind and IMF conditions that correspond to each bin. As the simulation resolution increases the currents become more intense and confined. A machine learning analysis of the FAC patterns shows that the ratio of Region 1 (R1) to Region 2 (R2) currents decreases as the simulation resolution increases. This brings the simulation results into better agreement with observational predictions and the Weimer 2005 model results. The increase in R2 current strengths also results in the cross polar cap potential (CPCP) pattern being concentrated in higher latitudes. Current-voltage relationships between the R1 and CPCP are quite similar at the higher resolution indicating the simulation is converging on a common solution. We conclude that LFM simulations are capable of reproducing the statistical features of FAC patterns.

Characterizing external influences on the large-scale polar ionospheric current system

Abstract ID : 645

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Karl Laundal ,karl.laundal@ift.uib.no ,(Researcher) ,Norway ,Bergen ,Presenting[1]

Dr. Chris Finlay ,cfinlay@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[2]

Prof. Nils Olsen ,nio@space.dtu.dk ,(None) ,Denmark ,None ,Not Presenting[3]

Dr. Jone P. Reistad ,Jone.Reistad@ift.uib.no ,(None) ,Norway , ,Not Presenting[1]

Mr. Paul Tenfjord ,paul.tenfjord@ift.uib.no ,(None) ,Norway , ,Not Presenting[1]

Dr. Nikolai Østgaard ,Nikolai.Ostgaard@ift.uib.no ,(None) ,Norway , ,Not Presenting[1]

Mr. Anders Ohma ,andersohma@gmail.com ,(None) ,Norway , ,Not Presenting[1]

Dr. Kristian Snekvik ,Kristian.Snekvik@ift.uib.no ,(None) ,Norway , ,Not Presenting[1]

Dr. Stein Haaland ,Stein.Haaland@ift.uib.no ,(None) ,Norway , ,Not Presenting[1]

Dr. Steve Milan ,steve.milan@ion.le.ac.uk ,(None) ,United Kingdom , ,Not Presenting[10]

1 - University in Bergen 2 - DTU Space, Technical University of Denmark 3 - DTU 4 - University in Bergen 5 - University in Bergen 6 - University in Bergen 7 - University in Bergen 8 - University in Bergen 9 - University in Bergen 10 - University in Leicester

Over the past decades there have been several efforts to develop general empirical models of the ionospheric current systems as functions of solar wind parameters and seasonal conditions. These models aim to reduce a very complex system to a relatively small set of parameters. Inevitably, the results depend very much on the choice of basis functions, and on the parameters used to describe variations in the solar-terrestrial coupling e.g. the solar wind, the Interplanetary Magnetic Field direction, and season. Here we describe some of the approaches which have been employed previously, and compare them to a newly developed model, based on low Earth orbit measurements from the Swarm and CHAMP satellites. This model goes beyond earlier models by properly taking the geometric effect of the Earth's main field into account, allowing for inter-hemispheric differences, and by including both the global ionospheric E-layer horizontal and field-aligned currents. The external parameters of our model includes proxies of reconnection rates between the interplanetary magnetic field and closed and open (lobe) terrestrial field lines. These parameters are coupled with parameters that represent the orientation of the interplanetary magnetic field, and with the dipole tilt

angle. We discuss how this expansion differs from previous models, and test how well our new model, which is only constrained by measurements from space, predicts magnetic field disturbances on ground.

Earth's mantle electrical conductivity and temperature profiles

Abstract ID : 930

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Erwan Thebault ,erwan.thebault@univ-nantes.fr ,(?) ,France ,Nantes ,Not Presenting[1]

Dr. Olivier Verhoeven ,Olivier.Verhoeven@univ-nantes.fr ,(None) ,France , ,Not Presenting[1]

Dr. François Civet ,fcivet@vr2planets.com ,(None) ,France , ,Not Presenting[3]

Mr. Benoit Langlais ,benoit.langlais@univ-nantes.fr ,(None) ,France , ,Not Presenting[1]

Mr. Aymeric Houliez ,aymeric.houliez@etu.univ-nantes.fr ,(None) ,France , ,Not Presenting[5]

1 - LPG Nantes 2 - LPG Nantes 3 - VR2Planets 4 - LPG Nantes 5 - University of Nantes

We present a 1-D electrical conductivity profile of the Earth's mantle down to 2000 km derived from L1b Swarm satellite magnetic field measurements from November 2013 to December 2016. We first derive a model for the main magnetic field, correct the data for a lithospheric field model, and additionally select the data to reduce the contributions of the ionospheric field. We then model the primary and induced magnetospheric fields and perform a Bayesian inversion to obtain the probability density function for the electrical conductivity as function of depth. The conductivity profile is then interpreted in terms of a 1D mantle temperature profile.

Approximate source field characterization for global 3-D electromagnetic induction inversion

Abstract ID : 1060

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Pascal Tarits ,tarits@univ-brest.fr ,(None) ,France ,Plouzane ,Not Presenting[1]

1 - IUEM

The purpose of global 3-D electromagnetic induction inversion of Earth electromagnetic fields is to infer the 3-D distribution of electrical conductivity in the Earth down to mantle depths. Inversion algorithms are now available and tested either on real observatory data or on synthetic satellite data. The applications to real satellite data (such as the Swarm constellation) encounter difficulties due to limited knowledge to characterize the inducing field and the awkward acquisition mode (magnetic time series sample both time and space) with regard to ordinary processing techniques of fixed magnetic observatory. For the internal induction community, the challenge is to extract from the reduced data (that is the static global and lithospheric field have been removed) the tiny induced magnetic field arising from 3-D structures in the earth mantle from a transient field controlled by magnetospheric and ionospheric sources while perturbed by field aligned currents (FAC) at high latitudes making the global coverage limited to a ±50-60° latitudinal band. Here we explore a scheme to process the SWARM reduced data based on i) a 1-D model of the earth conductivity with a high degree and order spherical harmonic expansion to characterize the frequency domain source field at magnetospheric, ionospheric and FAC wavelengths; ii) the analysis of the external field to restrict the source terms to fields of low degree and orders and iii) the use of this forcing field in the 3-D inversion. The process may be repeated to upgrade the source field.

Towards Improved Modeling of Ionospheric Sources for EM Induction Studies

Abstract ID : 1151

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Gary Egbert ,egbert@coas.oregonstate.edu ,(None) ,United States ,Corvallis ,Not Presenting[1]

Dr. Patrick Alken ,alken@colorado.edu ,(Research Scientist) ,United States ,Boulder ,Not Presenting[2]

Dr. Astrid Maute ,maute@ucar.edu ,(None) ,United States ,None ,Not Presenting[3]

Dr. Arthur Richmond ,richmond@ucar.edu ,(None) ,United States , ,Not Presenting[4]

1 - Oregon State University 2 - University of Colorado at Boulder 3 - National Center for Atmospheric Research 4 - High Altitude Observatory

Three-dimensional imaging of the electrical resistivity of Earth's upper mantle, from ~200 km depth into the transition zone requires separating the subtle internal signals associated with induction from spatially complex and temporally variable magnetic fields due to currents in the ionosphere and magnetosphere. Simplified source models, of the sort used to develop our current understanding of globally averaged conductivity profiles, are not sufficiently accurate for 3D imaging. Here we present progress on our efforts to improve external source models, and thence 3D images of mantle resistivity, focusing initially on ionospheric fields in the daily variation band. Our ultimate goal is to use all
available geomagnetic data (historical and modern, ground based and satellite) to invert for both external source structure and Earth conductivity. There are two novel aspects to our approach. First, we use robust Principal Components Analysis (PCA) to reduce the large (and heterogeneous) set of historical and modern geomagnetic observatory data to a set of dominant spatial and temporal modes. Our PCA scheme allows for large data gaps, and provides an approach toward merging data from different eras. We illustrate this approach through analysis of daily variations in ground based data for the past ~60 years, and sketch how these ideas can ultimately be extended into the time domain to incorporate modern satellite data. Second, we use a mature physics based numerical model, the Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIE-GCM) to constrain source spatial structure. TIE-GCM external magnetic field outputs are analyzed in the frequency domain using PCA, with the results used to define a reduced-rank spatial covariance, which is then used with optimal interpolation to define global source structure for each data mode. Initially, we focus on modeling of ground based data, allowing for internal fields with a global thin-sheet model of ocean/continent conductivity variations. The resulting estimates of sources are then used to invert for Earth conductivity, allowing
refinement of Earth models and iterative improvement of source estimates. Initial efforts to model

sources an also feed-back to refine our computations with TIE-GCM - e.g., variability in the observations may suggest need for enhanced forcing of one sort or another.

A new approach for separation of inducing and induced magnetic fields of magnetospheric origin

Abstract ID : 1498

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Alexey Kuvshinov ,kuvshinov@erdw.ethz.ch ,(None) ,Switzerland , ,Presenting[1]

Dr. Alexander Grayver ,agrayver@erdw.ethz.ch ,(Lecturer) ,Switzerland ,Zurich ,Presenting[1]

Dr. Terence Sabaka ,terence.j.sabaka@nasa.gov ,(None) ,United States , ,Not Presenting[3]

Prof. Nils Olsen ,nio@space.dtu.dk ,(None) ,Denmark ,None ,Not Presenting[4]

Dr. Lars Tøffner-Clausen ,lastec@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[5]

1 - ETH Zürich 2 - ETH Zürich 3 - NASA 4 - DTU 5 - DTU Space

3-D electrical conductivity distribution at mid mantle depths (400-1500 km) was envisaged to be one of the *Swarm* Cat-1 L2 products. In order to detect 3-D variations of conductivity it was planned to exploit *Swarm* and observatory magnetic field signals of magnetospheric origin and to invert the so-called Q-matrix. These responses relate spherical harmonic (SH) coefficients of internal (induced) and external (inducing) parts of the magnetic potential. Time series of these coefficients are estimated within Comprehensive Inversion framework using potential method. Analysis of Q-matrix estimated from more than 3 years of *Swarm* reveals that many elements of this matrix are poorly constrained, most probably due to imperfect recovery of the induced coefficients responsible for 3-D effects.
We propose an alternative approach for retrieving time series of induced (and inducing) coefficients. It is based, in particular, on the fact that the horizontal magnetic field components are much less influenced by effects from 3-D inhomogeneities of the Earth compared to the vertical component. This suggests a two-step procedure for retrieving time series of the inducing and induced coefficients: First, by analysing horizontal component and assuming that the Earth's background conductivity is known, one determines time series of inducing coefficients. Second, with the retrieved time series of inducing coefficients one determines induced coefficients by analysing vertical component only. This study discusses challenges and numerical details of the proposed approach.

A40 - Geophysical characterization of continental cratons and implications for mineral systems and exploration (DIV VI – DIV I – DIV V)

Proterozoic collisional suture between the Archean Dharwar and Coorg Blocks of South India and their tectonic history as inferred from magnetotelluric data

Abstract ID : 688

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Abdul Azeez Kizhakkekara Kunjavaran ,azeez@ngri.res.in ,(Scientist) ,India ,Hyderabad ,Presenting[1]

Dr. Veeraswamy K ,kv.swamy@gmail.com ,(None) ,India , ,Not Presenting[2]

Mr. Arvind K Gupta ,arvind56578@yahoo.com ,(None) ,India , ,Not Presenting[2]

Mr. Narendara Babu ,jnarenmts@gmail.com ,(None) ,India , ,Not Presenting[2]

Mr. Sateesh Chandrapuri ,schandrapuri@gmail.com ,(None) ,India , ,Not Presenting[2]

1 - CSIR-National Geophysical Research Institute 2 - CSIR-National Geophysical Research Institute, Uppal Road, Hyderabad 3 - CSIR-National Geophysical Research Institute, Uppal Road, Hyderabad 4 - CSIR-National Geophysical Research Institute, Uppal Road, Hyderabad 5 - CSIR-National Geophysical Research Institute, Uppal Road, Hyderabad

The Coorg Block (CB), located in the SW margin of peninsular India or Indian subcontinent, has been thought to be part of the Dharwar Craton (DC) entity, which expose some of the oldest lower crustal rocks (>3.0 Ga) found on the Earth. Recent geological and geochronological studies, however, showed that the CB hosts the oldest rocks (~4 Ga) of peninsular India and identified it as an exotic terrain due to the lack of any obvious resemblance with the neighbourhood geological terrains. In order to study the lithospheric architecture and tectonic boundary of the Archean terrains, long-period and broad-band magnetotelluric (MT) measurements were made along a ~250 km east-west profile that covers the northern part of the Coorg Block and neighbouring Western Dharwar Craton (WDC). Two-dimensional lithospheric resistivity section retreived from the MT data showed low resistivity zones in the crust and two prominent upper mantle conductive features within the high resistive Archean lithosphere. The isolated moderately conductive zones in the WDC crust showed good spatial match with the exposed greenstone formations and are interpreted as the resistivity images of

the sheared greenstone formation. Low resistivity zones within the Coorg crust are attributed to the relatively young (~933 Ma) metamorphic processes in the area and/or possible fluids derived from the Cretaceous passage of Reunion plume in the proximity of Coorg area. A near vertical upper mantle conductive feature imaged beneath the Coorg shear zone, which hosts both the WDC lithologies and the granulites of Coorg Block, represents the suturing of the two tectonic blocks and thus presents the first geophysical evidence of separate origin and characteristics of the two Archean terrains. MT image also shows an anomalous upper mantle conductive zone beneath the DC nucleus, which indicates an enriched and modified cratonic lithosphere. The modification of the cratonic lithosphere might have initially occurred during the juxtaposition between Coorg and Dharwar Blocks in the Proterozoic and survived through the geological period due to its periodic reactivation by subsequent tectono-thermal events operated in the region.

New and revised crustal and upper mantle terraine boundaries in Southern Africa: Implications for regional metallogenesis

Abstract ID : 1081

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. David Khoza ,davidk@spectrem.co.za ,(Manager: Geophysics) ,South Africa ,Johannesburg ,Not Presenting[1]

1 - SPECTREM AIR

It is well appreciated that crustal and lithospheric structures affect the emplacement of some economic mineral deposits (kimberlites, nickel-sulphide mineralization). Certainly in Southern Africa, the majority of kimberlite clusters appear to be located in close proximity to crustal structures defined from regional magnetic data and deep probing electromagnetic data.
The majority of Southern African geology is under thich sedimentary cover of the Kalahari and Karoo. This makes geological mapping challenging. The magnetotelluric method is one of the few techniques that one can use to map the structure of the Earth at all scales (from crust to mantle lithosphere).
In this work, a new crustal and upper mantle lithospheric structure map beneath Archean and Proterozoic terraines is presented. We use deep probing magnetotelluric data to map the electrical lithosphere up to depths of over 300 km. The new map reveals previously unknown thick lithosphere in places such as the Central Kalahari (Okwa Terrane) and southern Congo craton and provides a targeting tool in these enigmatic terraines.
While the presence of hydrous minerals, which affect the strength of the lithosphere, was not the primary focus of the current study the presence of thick, resistive, cratonic material in some of the terraines point to rigid lithosphere that was not previously documented. A combination of paleo-magnetic data, electrical structures and ages from kimbelite xenoliths provide constraints in placing the mapped terranes in the geo-tectonic framework.

MT imaging of golden deposits across the SW Amazon Craton, Brazil

Abstract ID : 1123

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Clarisse Monteiro Fernandes ,clarissefernandes@on.br ,(Geologist) ,Brazil ,Rio de Janeiro ,Not Presenting[1]

Dr. Sergio Fontes ,sergio@on.br ,(None) ,Brazil , ,Not Presenting[1]

Dr. Emanule F. La Terra ,laterra@on.br ,(None) ,Brazil , ,Not Presenting[1]

Dr. Leonardo G. Miquelutti ,leomiquelutti@gmail.com ,(None) ,Brazil , ,Not Presenting[1]

Dr. Ved P. Maurya ,vedankur@gmail.com ,(None) ,Brazil , ,Not Presenting[1]

1 - Observatório Nacional/MCTIC 2 - Observatório Nacional/MCTIC 3 - Observatório Nacional/MCTIC 4 - Observatório Nacional/MCTIC 5 - Observatório Nacional/MCTIC

We present the results of data processing, analysis and 2-D inversion of MT data acquired along a NNE-SSW, 200 km of extent transect encompassing 35 broadband and 12 long-period stations, across the southwestern border of the Amazon Craton, Brazil. This border is related to an ancient arc-accretion setting with associated golden mineralization and thus the Brazilian Geological Survey - CPRM is sponsoring the study. We adopt skew angle. Strike analysis considered invariants of the impedance tensor, phase tensor azimuth and tipper strike estimations. The results agreed with a 3-D regional geoelectrical dimensionality in a NW-SE a data processing scheme based on robust estimators over the EM cross-spectra for combined single and remote reference stations. The dimension/distortion analysis considered WAL invariants, thresholds of 1.5 for I3 to I7, and 1.0 for Q, along with phase tensor parameters, threshold for 3-D as 0.2 for ellipticity, and ±4° for structural framework, with the perspective of reasonable results with 2-D inversion restricted to an efficient distortion assessing and removal. A central resistive anomaly is consistent in both TE and TM modes pseudosections. This anomaly exhibits high tipper magnitude values just for high frequencies. The apparent resistivity long period data for TM mode, below the anomaly, indicates a layer of highly conductive material. The phases in TE and TM modes are low for short periods and high for longer periods in almost all transect, except the southernmost sector, which is conductive for both TE and TM modes in all period extent. Disagreement between TE and TM modes occurs northwards for all period range, with TE mode exhibiting anomalous negative values, while TM mode shows anomalously high values (above 90°), interpreted as an evidence of inductive distortion and anisotropy. Two-dimensional model was generated by a smooth inversion scheme based on nonlinear conjugate gradient minimization algorithm. The results are consistent with a cratonic fragment at the central sector, bordered by conductors extending towards its base, suggesting previous lithospheric hydration and presence of chemically enriched mineral phases.

3D COnductivity of the US Lithosphere: Results from the EarthScope MT-TA

Abstract ID : 1150

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Gary Egbert ,egbert@coas.oregonstate.edu ,(None) ,United States ,Corvallis ,Not Presenting[1]

1 - Oregon State University

As part of the EarthScope USArray project nearly 1000 long-period magnetotelluric (MT) sites have been collected across the continental USA on a quasi-regular 70 km grid between 2006-16. With the goal of achieving stable estimates from 10-10,000 s, typical site occupation times are 20 days. I will summarize some of the key results obtained from a series of 3D inversions of these data, including results from 4 large (overlapping) footprints (thousands of km on a side, 250-350 sites) together covering a swath that spans the North American continent, from Pacific to Atlantic. Large scale architecture of the continental lithosphere, together with hints at the underlying aesthenosphere, are revealed in the resulting conductivity images,
which resolve structures from mid-crust to the LAB and below. Cratons in the center of the continent (Wyoming, Medicine Hat, Hearne, Superior) appear
as massive resistive blocks extending to 200 km depth or greater. Conductive sutures often mark boundaries of these blocks, and of more juvenile Proterozoic terranes, which are generally
less resistive. One intriguing exception is a large very deep resistive domain underlying the Piedmont and Coastal Plain east of the modern Appalachian front.
Resistivitiy in this area exceeds 1000 ohm-m to at least 200 km depth, implying an anomalously thick, cold and dry lithosphere. The expansive coverage of the USArray MT data also reveals clear (if unsurprising) systematic differences between active and more stable regions. Lower crustal/near moho conductors are ubiquitous in the actively deforming western US, but almost
completely absent in more stable areas to the east. This very clear difference demonstrates that these sub-horizontal conductive features are transient, and almost certainly associated with magmatic processes (i.e., melt, fluid exsolution). Although we are still working to understand deeper (aesthenospheric) variations, there is a suggestion of higher conductivities (perhaps greater hydration) below deep resistive blocks such as cratons. In the west where the mantle lithosphere is very thin, and active upwelling and decompression melting are expected, the aesthenospheric resistivity is ~100 ohm-m, consistent with dry olivene.

Stephan Thiel : Please correct the title for correct spelling from "3D COnductivity of the US Lithosphere: Results from the EarthScope MT-TA" to "3D Conductivity of the US Lithosphere: Results from the EarthScope MT-TA" Tammy Maart : None

Capricorn Orogen (Western Australia): Analysis, inversion and interpretation of an unusual magnetotelluric dataset with widespread out-of-quadrant phase responses

Abstract ID : 1215

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Perla Piña-Varas ,ppinavaras@gmail.com ,(None) , , ,Not Presenting[1]

Dr. Michael Dentith ,michael.dentith@uwa.edu.au ,(None) ,Australia , ,Not Presenting[2]

1 - 2 - Centre for Exploration Targeting, School of Earth Sciences, The University of Western Australia

The Capricorn Orogen (Western Australia) is a zone of deformed and metamorphosed igneous and sedimentary rocks formed during the convergence and collision between the Yilgarn Craton, the Pilbara Craton and the intervening Glenburgh Terrain. At its southern margin the orogen comprises several Palaeoproterozoic basins, the plutonic and metamorphic Gascoyne Complex and the deformed northern margin of the Yilgarn Craton. This craton is one of the most intensively mineralised areas of continental crust with world-class deposits of gold and nickel. However, the region to its north, the Capricorn Orogen, has surprisingly few deposits. The northern margin of the Yilgarn is poorly defined because of the overlying sedimentary basins.

We present some of the results of an extensive on-going magnetotelluric (MT) study across the Capricorn Orogen, a component of large multi-disciplinary geoscience project on the 'Distal Footprints of Giant Ore Systems'. Analysis of the MT dataset reveals a clear 3-D geoelectrical behaviour and extreme complexity for most of the sites, including an unusually high number of sites with phases out-of-quadrant. These anomalous responses are usually observed in small groups of sites and have been interpreted as mainly due to electrical anisotropy or L-shaped conductors. 3-D forward models and data analysis of real and synthetic datasets show that the observed anomalous phases are most likely caused by strong resistivity contrasts with complex 3-D geometries.

3-D inverse modelling of the MT data shows high resistivity Archean units and low resistivity Paleoproterozoic basins, including very low resistivity structures at depth. These strong resistivity contrasts allow us to successfully map the northern margin of the Yilgarn Craton beneath the overlying basins. The resistivity model provides valuable information regarded the relationship between the different Archean blocks involved in this deformed craton margin, and consequently helps to better understand the geodynamic evolution of this area. Major faults occurring at cratonic margins are considered to be key indicators of increased mineral prospectivity at a regional scale so locating the margin is potentially important as a guide for mineralisation in the southern Capricorn Orogen. Thus, our results suggest MT surveys are useful tool in the study area for regional-scale exploration.

Magnetotelluric characterization of cratonic lithosphere and controls on mineral deposits: examples from South Australia

Abstract ID : 1238

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Stephan Thiel ,stephan.thiel@sa.gov.au ,(Principal Geophysicist) ,Australia ,Adelaide ,Not Presenting[1]

Prof. Graham Heinson ,graham.heinson@adelaide.edu.au ,(None) ,Australia , ,Not Presenting[2]

Dr. Anthony Reid ,anthony.reid@sa.gov.au ,(None) ,Australia , ,Not Presenting[1]

Dr. Kate Robertson ,kate.robertson@adelaide.edu.au ,(None) ,Australia , ,Not Presenting[2]

1 - Geological Survey of South Australia 2 - University of Adelaide 3 - Geological Survey of South Australia 4 - University of Adelaide

Exploration under cover remains one of the main impediments to mineral exploration in Australia. With a lack of conclusive mineral pointers from upper crustal and near-surface geophysical techniques, such as potential field methods, the push to understanding mineral systems across the entire lithospheric column provides a promising addition to mineral exploration strategies. Additionally, the constraints on lithospheric architecture and insights into composition shed a crucial light on the tectonic setting mineral fertility corridors. With an increased understanding of a whole lithosphere approach to exploration (Griffin et al., 2013), deep probing geophysical techniques such as magnetotellurics (MT) (Heinson et al., 2006; Thiel and Heinson, 2010; Thiel and Heinson, 2013) seismic tomography (Rawlinson et al., 2014) as well as geochemical sampling of the sub-continental lithospheric mantle (SCLM) (O'Reilly and Griffin, 2010) will play an increasingly important role in terrane-to-province selection of target areas for mineral exploration.
The Gawler Craton in South Australia has been an area of extensive focus for magnetotelluric deployment over the last 15 years. Here we present results of the long-period AusLAMP MT deployment across South Australia and the result of smaller scale in-fill surveys using broadband equipment. The deployments show a heterogeneous distribution of resistivity structure in both the mantle and crustal lithosphere. In the first order, the lithospheric cratons seem to exert a primary control on focussing fluid and magmatic events in the Proterozoic. As a result the location of major IOCG deposits and prospects across the Gawler Craton align with the observed craton margins. In-fill MT survey using broadband equipment illustrate crustal structural control on the position of IOCG and uranium deposits at the surface. It shows that magnetotellurics is a pivotal tool for mineral exploration and for understanding the fertility of the lithosphere.

A41 - Retrospective Review of Geomagnetic Studies: key figures and discoveries since the 13th century (IDCH)

After about 350 years – zero declination again in Paris

Abstract ID : 356

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Mioara MANDEA ,mioara.mandea@cnes.fr ,(Innovation, Application and Science Directorate) ,France ,Paris ,Not Presenting[1]

Mr. Jean-Louis LE MOUEL ,lemouel@ipgp.fr ,(None) ,France ,None ,Not Presenting[2]

1 - CNES - Centre National d'Etudes Spatiales 2 - IPGP

The main geomagnetic field - produced by a dynamo process in the Earth's outer liquid core - changes its direction and strength in time, over timescales from months to centuries, even millennia. Its temporal variations, named secular variation and secular acceleration, are crucial ingredients for understanding the physics of the deep Earth's interior. Very long series of measurements therefore play an important role. An updated of geomagnetic declination in Paris series is updated, shortly after a very special occasion: its value has reached zero after some 350 years of westerly values. Indeed, during October and November 2013, the declination at the Chambon la Forêt geomagnetic observatory changed from westerly to easterly values, the agonic line then passing through this place. This special occasion offers us the possibility to emphasize the importance of long series of continuous measurements.

History of satellite geomagnetic missions in the former USSR and Russia

Abstract ID : 1329

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Roman Krasnoperov ,r.krasnoperov@gcras.ru ,(Senior research scientist) ,Russia ,Moscow ,Presenting[1]

Mr. Artem Smirnov ,a.smirnov@gcras.ru ,(None) ,Russia ,Moscow ,Not Presenting[1]

1 - Geophysical Center of the Russian Academy of Sciences 2 - Geophysical Center of the Russian Academy of Sciences

This report will focus on the key satellite missions of the former USSR and Russia, aimed for studying the Earth's magnetic environment. The launch of the first artificial Earth satellite on October, 4 1957 started a new phase in exploration of our planet. In the late 1950s the first Soviet satellite carrying magnetometric instruments (Sputnik 3) performed measurements of the Earth's magnetosphere parameters over the territory of the country. In 1964 during the International Quiet Sun Year two scientific satellites (Kosmos-26 and Kosmos-49) made the first global-scale absolute magnetic measurements which covered 75% of the Earth's territory. Analysis of the mission results revealed that lithospheric magnetic anomalies can be registered at the LEO heights. Later missions performed mapping of more than 90% of the Earth's territory. The obtained magnetometric data were used for compiling the first global models of the Earth's magnetic field. For decades, the Academy of Sciences has been among the developers of spaceborne magnetometric instrumentation and organizers of the major satellite missions for studying the Earth's magnetic environment.

A42 - Historical Understanding of Solar-Terrestrial Interactions: Research and Applications (IDCH – DIV IV – DIV V)

The First Space Weather Prediction

Abstract ID : 87

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Trey Cade ,william_cade@baylor.edu ,(Director, Baylor Institute for Air Science) ,United States ,Waco, Texas USA ,Not Presenting[1]

1 - Baylor University

In the mid 18th century, little was known about the nature of space weather. The aurora had been observed for centuries, but its nature and cause remained enigmatic. The discovery of magnetic disturbances, on the other hand, was relatively new, and no one knew what to make of this unusual phenomenon. However, a few pioneering scientists (including a name well-known today, Anders Celsius) made significant strides in understanding the connections between the aurora and magnetic measurements; their new scientific insights enabled the first space weather prediction to be made a few years later.

Historical View of Deep-Dielectric Spacecraft Charging and Operational Impacts

Abstract ID : 95

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Daniel Baker ,daniel.baker@lasp.colorado.edu ,(Director and Distinguished Professor, Laboratory for Atmospheric and Space Physics, University of Colorado Boulder) ,United States ,Boulder ,Not Presenting[1]

1 - University of Colorado Boulder

The earliest phases of the Space Age involved powerful high altitude nuclear explosion (HANE) events that wreaked havoc on spacecraft due to acute electron radiation dose effects. Later in the 1960s and 1970s, a greater understanding emerged of "natural" (rather than anthropogenic) impacts on spacecraft operations. Many of the most significant spacecraft operational problems in Earth's magnetosphere over time have been shown to be due to intense, transient radiation phenomena. Early work at the Los Alamos National Laboratory placed particular emphasis on highly relativistic electrons (3-10 MeV). Electron fluxes and energy spectra were measured by two high-energy electron sensor systems at 6.6 RE from 1979 through the 1980s. Large, persistent increases in this population were found to be relatively infrequent and sporadic in 1978-81 around solar maximum. During the approach to solar minimum (1981-1985) it was observed that the highly relativistic electrons occurred with a regular 27-day periodicity, and were well associated with observed high-speed solar wind stream structures. Through a superposed epoch analysis technique it was shown that energetic electron enhancements typically rise on a 2- to 3-day time scale and decay on 3- to 4-day scale at essentially all energies above ~ 3 MeV. Key early spacecraft operational anomalies were seen to correlate closely with the electron enhancements. The analysis suggested that these electrons have a very deleterious influence on spacecraft systems due to deep dielectric charging and low-dose susceptibility effects. These discoveries have greatly informed subsequent space weather thinking. This presentation looks at the broad history of spacecraft charging from both a national and manmade perspective.

The Historical Development of Solar-Terrestrial Relations

Abstract ID : 1220

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Leif Svalgaard ,leif@leif.org ,(Senior Research Scientist) ,United States ,Petaluma ,Not Presenting[1]

1 - Stanford University

We discuss the historical development of our understanding of the influence of solar activity on geospace; from the first glimmer of awareness to today's practical applications of hard-won knowledge gained over several centuries. Faraday's words in a letter [1852] to Rudolf Wolf: "The discovery of periods and the observation of their accordance in different parts of the great system, of which we make a portion" underscores the notion of being part of a System. Many cause and effect interactions work together to modulate and drive each other. Our modern technological civilization depends in ever-increasing ways on the behaviour of that Great System; for better and for worse. Great advances in data collection and international cooperation [e.g. the IGY] have from time to time spurred on and deepened our understanding. To tell that story is a privilege. The lesson to be extracted is that unselfish cooperation and sharing form the bedrock on which future progress must be build.

The Global Magnetic Observatory Network: Untapped Possibilities?

Abstract ID : 1234

Conflict Declaration : None

Content Motivation : None

Additional Information : this is an invited abstract

Dr. Arnaud Chulliat ,arnaud.chulliat@noaa.gov ,(None) ,United States ,Boulder ,Not Presenting[1]

1 - University of Colorado Boulder

The International Geophysical Year (IGY) marked a steep increase in the number of magnetic observatories and other ground magnetic stations worldwide. Soon after, the advent of scientific satellites allowed in-situ observations of magnetospheric phenomena, which led to numerous discoveries and advances in the field of solar-terrestrial physics. Although the history of magnetospheric physics in the space age is fairly well documented, space-based observations often overshadow the role played by magnetic observatories during the same period. Since the IGY, magnetic observatories have undergone tremendous evolution in their instrumental setup, how they are operated and how their data are distributed. This presentation will provide an overview of how the global observatory network was modernized from the IGY until today, and how it was used to improve our understanding of solar-terrestrial interactions. It will also review new technical capabilities such as data distribution in near real-time, which have become more widespread among observatories in recent years and provide new opportunities for not only research but also applications benefiting government, industry and the society at large.

A43 - Engaging Scientists and Researchers in Education and Outreach (IDCEO)

Sparkling Geomagnetic Field: Geomagnetic observations with schools in Austria

Abstract ID : 428

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Rachel Bailey ,r.bailey@zamg.ac.at ,(None) ,Austria ,Vienna ,Not Presenting[1]

Mr. Roman Leonhardt ,r.leonhardt@zamg.ac.at ,(None) ,Austria , ,Not Presenting[1]

Ms. Barbara Leichter ,b.leichter@zamg.ac.at ,(None) ,Austria , ,Not Presenting[1]

1 - Zentralanstalt für Meteorologie und Geodynamik 2 - Zentralanstalt für Meteorologie und Geodynamik 3 - Zentralanstalt für Meteorologie und Geodynamik

The project "Sparkling Geomagnetic Field" was a project in Austria's Sparkling Science programme, which aims to involve schools in active scientific research to encourage the interest in science. Researchers from the Zentralanstalt für Meteorologie und Geodynamik (ZAMG) in Vienna worked hand-in-hand with three schools across Austria to set up regional geomagnetic stations consisting of state-of-the-art scalar and vector magnetometers to monitor the effects of the solar wind on the geomagnetic field. The students were an active part of the research team from the beginning, first searching for a suitable location to set up the stations as well as later overseeing the continued running of the equipment and the data output. Through this project the students gained experience in contemporary scientific methods: data processing and analysis, field work, as well as equipment setup and upkeep. A total of three stations were established with the schools at roughly equal distances across Austria to run alongside the already active station in the Conrad Observatory near Vienna.

Fifteen years of Educational Activities at the European Geosciences Union (EGU)

Abstract ID : 523

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Carlo Laj ,carlo.laj@ens.fr ,(Emeritus professor) ,France ,Paris ,Not Presenting[1]

1 - Ecole normale Supérieure

The Committee on Education of EGU, which coordinates the EGU activities related to primary, secondary and tertiary education, was created in 2002. Since then it has been active in a number of different way. One of the committee's main activities is the organisation of GIFT (Geosciences Information for Teachers) workshops, held annually during the EGU General Assembly in Vienna. These established and successful workshops aim to spread first-hand scientific information to science teachers of primary and secondary schools. Typically, these workshops bring together approximately 80 teachers from about 20-25 different countries around a general theme that changes every year. Since 2010, EGU GIFT workshops have been organized beyond Europe, in connection with EGU Alexander von Humboldt Conferences and other major International Conferences (http://www.egu.eu/education/gift/workshops/). Other initiatives of the CoE include a series of "Distinguished lectures" given by top scientists who have previously participated as speakers in GIFT workshops during EGU General Assemblies. High school teachers, high school directors and educators for teachers from the European area are encouraged to request a lecture, for which the EGU Committee on Education will cover the travel and subsidise the costs of the speaker. The only requirement is that the lecture is included in a well organized educational event for high school science teachers, in which a minimum of 80-100 teachers will attend. A 'Teachers at Sea' program has also been developed for teachers to be able to take part in an Oceanographic cruise. This year we will participate in a summer school that includes high-school teachers, university students and professors, and researchers. This is a first step towards including tertiary education in our objectives. Finally, in collaboration with the media and communications manager of the EGU the Committee has participated in " Planet Press", a program of geoscience press releases for children.

Edgar Bering : None Tammy Maart : None

PITFALLS AND DRAWBACKS OF ENGAGING JUNIOR FACULTY IN INTERACTIVE EDUCATION AND OUTREACH ACTIVITIES

Abstract ID : 997

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Edgar Bering ,eabering@uh.edu ,(Professor of Physics and ECE) ,United States ,Houston, TX ,Presenting[1]

Prof. Robert Talbot ,rtalbot@central.uh.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Andrew Kapral ,ajkapral@uh.edu ,(None) ,United States , ,Not Presenting[1]

1 - University of Houston 2 - University of Houston 3 - University of Houston

The participation of professional working scientists is essential to the development of outreach programs that are based on authentic scientific experiences. It is often the case that junior faculty have the energy, enthusiasm, physical stamina, current knowledge, and ability to relate to young people that senior faculty do not. Many junior faculty are really excited about the prospects of engaging in outreach activities. In spite of this, the number of junior faculty actively participating in outreach activities is relatively small. This paper will present real life examples of how poorly conceived administrative policies hamper efforts by senior faculty to reach out and engage junior colleagues. Both examples are programs that the authors have run for years and need more help to improve and expand. The first example is the University of Houston's Undergraduate Student Instrumentation Project. Relocation of a senior Engineering professor required recruitment of junior faculty to join the team. The talk will explore why their participation has been less than hoped for, The second example is the University's Mars Rover Model Celebration STEM enrichment program for Grades 3-8. After 15 years, the first author needed to move on from being event Chair to other duties. The multi-year efforts to recruit and train a successor will be described.

Real-time geomagnetic data from a Raspberry Pi magnetometer network in the UK

Abstract ID : 1022

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. William Brown ,wb@bgs.ac.uk ,(Geomagnetic field modeller) ,United Kingdom ,Edinburgh ,Not Presenting[1]

Dr. Ciaran Beggan ,ciar@bgs.ac.uk ,(None) ,United Kingdom ,Edinburgh ,Not Presenting[1]

Dr. Steve Marple ,s.marple@lancaster.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - British Geological Survey 2 - British Geological Survey 3 - University of Lancaster

In 2014, BGS and the University of Lancaster won an STFC Public Engagement grant to build and deploy 10 Raspberry Pi magnetometers to secondary schools across the UK. The system uses a Raspberry Pi computer as a logging and data transfer device, connected to a set of three orthogonal miniature fluxgate magnetometers. The system has a nominal sensitivity of around 1 nanoTesla (nT), in each component direction (North, East and Down). This is around twenty times less sensitive than a current scientific-level instrument, but given its relatively low-cost, at about £250 per unit, this is an excellent price-to-performance ratio given we could not improve the sensitivity unless we spent a lot more money. The magnetic data are sampled at a 5 second cadence and sent to the AuroraWatch website at Lancaster University every 2 minutes. The data are freely available to view and download. The primary aim of the project is to encourage students from 14-18 years old to look at how sensors can be used to collect geophysical data and integrate it together to give a wider understanding of physical phenomena. A second aim is to provide useful data on the spatial variation of the magnetic field for analysis of geomagnetic storms, alongside data from the BGS observatory and University of Lancaster's SAMNET variometer network.
We show results from the build, testing and running of the sensors including some recent storms and we reflect on our experiences in engaging schools and the general public with information about the magnetic field. The information to build the system and logging and analysis software for the Raspberry Pi is all freely available.

Edgar Bering : None

A Brief History of the American Geophysical Union Space Physics and Aeronomy Section Education and Public Outreach Committee

Abstract ID : 1203

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Edgar Bering ,eabering@uh.edu ,(Professor of Physics and ECE) ,United States ,Houston, TX ,Presenting[1]

Dr. Nicholas Gross ,gross@bu.edu ,(None) ,United States , ,Not Presenting[2]

Prof. Ramon Lopez ,cosmicrel@gmail.com ,(None) ,United States , ,Not Presenting[3]

Prof. Mark Moldwin ,mmoldwin@umich.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Cherilynn Morrow ,cherilynn.morrow@gmail.com ,(None) ,United States , ,Not Presenting[5]

Dr. Laura Peticolas ,laura@ssl.berkeley.edu ,(None) ,United States , ,Not Presenting[6]

Prof. Patricia Reiff ,reiff@rice.edu ,(None) ,United States , ,Not Presenting[7]

Dr. Deborah Scherrer ,dscherrer@solar.stanford.edu ,(None) ,United States , ,Not Presenting[8]

1 - University of Houston 2 - Boston University 3 - University of Texas, Arlington 4 - University of Michigan 5 - Aspen Global Change Institute 6 - University of California, Berkeley 7 - Rice University 8 - Stanford University

The American Geophysical Union Space Physics And Aeronomy Section Education And Public Outreach Committee (AGU SPA-EPO Committee) was established in 1990 to foster the growth of a culture of outreach and community engagement within the SPA Section of the AGU. The SPA was the first AGU Section to establish an EPO Committee. The Committee has initiated several key Section EPO programs that have grown to become Union programs. These programs include the Student Paper Competition, Exploration Station, a precursor to the GIFT workshops, the Student mixer. This paper will review the triumphs, the failures, and the lessons learned about recruiting colleagues to join with us from the last quarter century of effort.

A44 - Tidal Forcing of the Equatorial Mesosphere-Thermosphere-Ionosphere (MTI) Region (ICDC)

Planetary Wave-Tide Interactions in Atmosphere-Ionosphere Coupling

Abstract ID : 168

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Jeffrey M Forbes ,forbes@colorado.edu ,(Professor) ,United States ,Boulder ,Presenting[1]

Dr. Astrid Maute ,maute@ucar.edu ,(None) ,United States ,None ,Not Presenting[2]

Dr. Xiaoli Zhang ,Xiaoli.Zhang@colorado.edu ,(None) ,United States , ,Not Presenting[3]

Prof. Maura E Hagan ,maura.hagan@usu.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Federico Gasperini ,gasperini@usu.edu ,(Postdoctoral Research Fellow) ,United States ,Logan ,Not Presenting[4]

1 - University of Colorado 2 - National Center for Atmospheric Research 3 - Unviersity of Colorado 4 - Utah State University 5 - Utah State University

The existence of secondary waves in the mesosphere and thermosphere due to nonlinear interactions between atmospheric tides and longer-period waves have been revealed in both satellite data and in the National Center for Atmospheric Research (NCAR) Thermosphere Ionosphere Mesosphere Electrodynamics General Circulation Model (TIME-GCM). The longer-period waves include the quasi-2-day and 6-day westward-propagating "normal modes" of the atmosphere, and eastward-propagating ultra-fast Kelvin waves with periods between 2 and 4 days. The secondary waves add to both the temporal and longitude variability of the atmosphere beyond that associated with the linear superposition of the interacting waves, thus adding "complexity" to the system. Based on our knowledge of the processes governing atmosphere-ionosphere interactions, similar revelations are expected to occur in electric fields and vertical plasma drifts, F-region electron densities, and ground magnetic perturbations. Towards this end, examples of such ionospheric manifestations planetary wave-tide interactions will be presented based on analyses of CHAMP electron density measurements, ground magnetic data, and TIE-GCM simulations.

Subramanian Gurubaran : None

MTI coupling using MU radar and CMAT2 model

Abstract ID : 269

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Balan Nanan ,balannanan@gmail.com ,(Senior Researcher) ,United Kingdom ,Derby ,Not Presenting[1]

1 - ISEE, Nagoya University, Japan

The MU (middle and upper atmosphere) radar (35ºN, 136ºE) of Japan and CMAT2 (coupled middle atmosphere-thermosphere) model of UCL (UK) are used to study mesosphere-thermosphere-ionosphere coupling. The MU radar was operated in alternate meteor and incoherent scatter modes to simultaneously measure the zonal and meridional wind velocities at MLT altitudes (80-95 km), meridional wind velocity in upper thermosphere (220-450 km), and electron density and peak height in ionosphere (200-600 km) with a time resolution of 1.5 hours under a project called MTECS (mesosphere-thermosphere experiments for coupling studies). Four long MTECS campaigns each lasting one to two weeks were conducted in the four seasons in 2000-2001. Analysis of the data indicates that the upper atmospheric regions are dynamically coupled through mean winds, tides, and waves. 24-hour, 12-hour and 6-hour tides and waves of periods 16-20 hours and 35-55 hours coexist at MLT and upper thermosphere altitudes in all seasons, and the waves become stronger than tides at mesopause altitude (88 km) at equinoxes.
CMAT2 solves the coupled non-linear equations of continuity, momentum and energy, and includes mesospheric energetics, dynamics, composition, high latitude energy input and a model for the electrodynamic coupling between the ionosphere and thermosphere. Lower altitude limit is at 15 km where diurnal and semi-diurnal tidal forcing are introduced using the Hough modes (1,1), (2,2), (2,3), (2,4) and (2,5), and 10 iteration days are used for stabilization. The 24-hour and 12-hour tidal amplitudes at the lower height of MU radar observation (80km) are accessed to produce height variations of 600 m and 100 m at 15 km height over the equator, which are introduced according to the Hough modes. Preliminary model results show that the 24- and 12-hour tides propagate to upper thermosphere and affect the wind systems and electron density at all altitudes. Observations and model results are presented and discussed.

Subramanian Gurubaran : None Tammy Maart : None

Mesospheric temperature inversions over a low latitude location and their possible causes

Abstract ID : 486

Conflict Declaration : The authors declare that they have no conflict of interest

Content Motivation : MTIs and their possible causes will be discussed. Please see the attached letter of motivation.

Additional Information : Oral mode of presentation will be preferred. Please see the grant application request.

Mr. Ravindra P Singh ,ravindra@prl.res.in ,(Scientist) ,India ,Ahmedabad ,Not Presenting[1]

Prof. Duggirala Pallamraju ,raju@prl.res.in ,(None) ,India , ,Not Presenting[1]

1 - Physical Research Laboratory 2 - Physical Research Laboratory

Mesospheric temperature inversions over a low latitude location and their possible causes

Ravindra Pratap Singh1,2, Duggirala Pallamraju1
ravindra@prl.res.in, raju@prl.res.in
[1]*Space and Atmospheric Sciences Division, Physical Research Laboratory, Navrangpura, Ahmedabad, 380009, India*
[2]*Department of Physics, Sardar Patel University, Vallabh Vidyanagar, 388120, India*

Measurement of O_2(0-1) and OH(6-2) nightglow emission intensities and their corresponding temperatures ($T(O_2)$ and T(OH)) which originates from 94 and 87 km altitudes are being carried out using an in-house built Near InfraRed Imaging Spectrograph (NIRIS) from Mount Abu (24.6^0 N, 72.8^0 E), in India, since January 2013. In general, it is seen that $T(O_2)$ is lower than T(OH) which is the normal behavior of the mesospheric temperature structure over low latitudes. However, on several occasions it was observed that $T(O_2)$ is greater than T(OH). These are atypical and were investgated in the context of mesospheric temperature inversions (MTIs). MTIs are the regions of enhanced temperatures above normal values of temperature and can have a thickness of several kilometres and can appear in MLT regions over low- and mid-latitudes at any time of the year. MTIs are mainly attributed to the energy deposition of upward propagating tides and gravity waves and chemical heat released *in-situ* by several exothermic reactions. The NIRIS derived temperatures over a long period are used to study the possible cause(s) for the occurrences of MTIs. Vertical propagation of wave is confirmed by investgating downward phase propagation at OH and O_2 emission altitudes. There are observations of existence of MTIs when such vertical propagations are observed. There are also several nights when MTIs are observed but vertical propagation is absent. Detailed analysis has been carried out to ascertain the cause for the observed MTIs. Based on this study it appears that chemical heating in the mesosphere could be a more probable cause in comparison to vertical propagation. In this paper these new findings on causes of MTIs over low-latitude will be discussed.

Subramanian Gurubaran : None Tammy Maart : None

On the relationship between the mesospheric tidal winds and counter electrojet in the Indian sector

Abstract ID : 870

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Subramanian Gurubaran ,gurubara@iigs.iigm.res.in ,(Professor) ,India ,Navi Mumbai ,Not Presenting[1]

1 - Indian Institute of Geomagnetism

Simultaneous observations of geomagnetic field variations and mesospheric winds by MF radar from Tirunelveli, a low latitude dip equatorial station, spanning over a period of 19 years (1993-2011) are utilized in this work to assess the role of mesospheric tidal winds in causing the day-to-day and long-period variabilities of equatorial electrojet. We decompose the ground magnetic field variations into natural orthogonal components using the Principal Component Analysis as adopted in an earlier work by the authors. Using the second principal component as a proxy for CEJ, we bring out certain peculiarities noticed between the diurnal and semidiurnal amplitudes of MLT winds and the occurrence of CEJ. The correlation between the tidal amplitudes and CEJ occurrence is seen to depend on season and solar activity. In this paper we present some highlights of this exercise carried out for the Indian sector.

Wave-4 structures in FORMOSAT/COSMIC low latitude ionospheric observations during low and high solar activity periods

Abstract ID : 969

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Amelia Onohara ,amelia.onohara@aeb.gov.br ,(Technologist) ,Brazil ,Brasilia ,Presenting[1]

Dr. Inez Batista ,inez.batista@inpe.br ,(Senior Researcher) ,Brazil ,Sao Jose dos Campos ,Not Presenting[2]

Dr. Paulo Batista ,paulo.batista@inpe.br ,(Senior Researcher) ,Brazil ,São José dos Campos ,Not Presenting[3]

1 - Brazilian Space Agency 2 - Instituto Nacional de Pesquisas Espaciais, Brazil 3 - National Institute for Space Research (INPE)

Ionospheric observations from FORMOSAT/COSMIC satellites were used to study the wave-4 longitudinal structure over low-latitude ionospheric regions during September equinoxes from 2007 to 2015. For this purpose NmF2, hmF2 and Ne parameters were used. Analyzing them, it was noticed that the four peaks pattern is a characteristic that can be seen during both low and high solar activity periods. Two dimensional Fourier spectral analysis was applied in order to obtain the amplitudes and phases of migrating and nonmigrating tides. Applying this analysis to Ne ionospheric parameter observed between 100 and 800 km, with 50 km altitude interval, it was noticed that the DE3 wave mode becomes more prominent in altitudes above 300 km. The same occurs with the wave-4 structure. This is an indicative that the DE3 wave propagates to the F-region altitudes through the dynamo mechanism. We found out that the combination of DE3, SPW4, diurnal, semidiurnal and terdiurnal migrating tides reproduces well the four peaks structures in the ionospheric parameters. Furthermore we found that at altitudes above the F-region peak, the reconstructed Ne maps are very well correlated with the observations.

Evidence of quasi-90 day oscillations in the thermosphere as revealed by GOCE measurements and MERRA/TIME-GCM

Abstract ID : 1523

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Federico Gasperini ,gasperini@usu.edu ,(Postdoctoral Research Fellow) ,United States ,Logan ,Presenting[1]

Prof. Maura E Hagan ,maura.hagan@usu.edu ,(None) ,United States , ,Not Presenting[1]

Prof. Jeffrey M Forbes ,forbes@colorado.edu ,(Professor) ,United States ,Boulder ,Not Presenting[3]

1 - Utah State University 2 - Utah State University 3 - University of Colorado

In the last decade evidence has demonstrated that terrestrial weather significantly impacts the ionosphere-thermosphere (IT). Periodic absorption of solar radiation in local time and longitude by tropospheric water vapor and stratospheric ozone as well as latent heat release in clouds generate a spatially- and temporally-evolving spectrum of global-scale atmospheric waves. A subset of these waves propagates vertically, evolving with height due to wave-mean flow, wave-wave, and wave-plasma interactions, and driving electric fields of tidal origin in the dynamo region. One of the largest waves that is known to greatly affect the IT is the diurnal eastward propagating wave with zonal wavenumber 3 (DE3). In this work, using neutral density and cross-wind measurements from the Gravity field and steady-state Ocean Circulation Explorer (GOCE) satellite, we present evidence of a new and persistent global-scale quasi-90 day oscillation in the thermosphere possibly connected to DE3 originating in the tropical troposphere. We investigate the origin and nature of this oscillation taking advantage of a high-resolution numerical simulation from the National Center for Atmospheric Research (NCAR) Thermosphere Ionosphere Mesosphere Electrodynamics General Circulation Model (TIME-GCM) with the lower boundary based on Modern Era Retrospective-Analysis for Research and Applications (MERRA) re-analysis data.

Poster Presentations

Joint Sessions

An Expendable Microstructure Profiler for Deep Ocean Measurements

Abstract ID : 16

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr Xiaodong Shang ,xdshang@scsio.ac.cn ,(None) ,South Africa ,None ,Presenting[1]

Dr. Hua Li ,lihua@jfe-advantech.co.jp ,(None) ,Japan ,Nishinomiya ,Not Presenting[2]

Mr Yongfeng Qi ,qiyongfeng2005@126.com ,(None) ,South Africa ,None ,Not Presenting[1]

Mr Guiying Chen ,gychen@scsio.ac.cn ,(None) ,South Africa ,None ,Not Presenting[1]

Mr Brett Prairie ,brett@rocklandscientific.com ,(None) ,South Africa ,None ,Not Presenting[5]

Prof. Xiaodong Shang ,yfqi@scsio.ac.cn ,(None) ,China ,Guangzhou ,Not Presenting[1]

Mr Changrong Liang ,103524079@qq.com ,(None) ,South Africa ,None ,Not Presenting[1]

Mr Rolf G. Lueck ,rolf@rocklandscientific.com ,(None) ,South Africa ,None ,Not Presenting[5]

1 - South China Sea Institute of Oceanology, Chinese Academy of Sciences 2 - Oceanographic Research Laboratory, JFE Advantech Co., Ltd. 3 - South China Sea Institute of Oceanology, Chinese Academy of Sciences 4 - South China Sea Institute of Oceanology, Chinese Academy of Sciences 5 - Rockland Scientific International Inc. 6 - South China Sea Institute of Oceanology, Chinese Academy of Sciences 7 - South China Sea Institute of Oceanology, Chinese Academy of Sciences 8 - Rockland Scientific International Inc.

Measurements of turbulence in the deep ocean, particularly close to the bottom, are extremely sparse due to the difficulty and operational risk of obtaining deep profiles near the seafloor. A newly developed expendable instrument-the VMP-X (Vertical Microstructure Profiler-Expendable)-carries two microstructure shear probes to measure the fluctuations of vertical shear into the dissipation range and can profile down to a depth of 6000 m. Data from nine VMP-X profiles in the western

Pacific Ocean near 11.6°N over rough topography display bottom-intensified turbulence with dissipation rates increasing by two factors of 10 to 4×10-9 W kg-1 within 200 m above the bottom. In contrast, over smooth topography in the southern South China Sea near 11°N, three profiles show that turbulence in the bottom boundary layer increases only slightly, with dissipation rates reaching 1×10-10 W kg-1. The eddy diffusivity over rough topography reached to 5×10-3 m2 s-1. The average diffusivity over all depths was 0.3×10-4 m2 s-1 and 0.9×10-4 m2 s-1 for the tests in the southern South China Sea and in the western Pacific Ocean, respectively, and these values are much larger than previous estimates of less than ≈0.1×10-4 m2 s-1 for the main thermocline.

Observations and drivers of turbulent dissipation and mixing over the Amundsen Sea continental shelf, Antarctica

Abstract ID : 158

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yvonne Firing ,yvonne.firing@noc.ac.uk ,(Researcher) ,United Kingdom ,Southampton ,Not Presenting[1]

Dr. Alberto Naveira Garabato ,acng@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Alexander Forryan ,a.forryan@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Paul Holland ,pahol@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. Povl Abrahamsen ,epab@bas.ac.uk ,(Physical Oceanographer) ,United Kingdom ,Cambridge ,Not Presenting[4]

Dr. Louise Biddle ,louise.biddle@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[6]

1 - National Oceanography Centre, UK 2 - University of Southampton 3 - University of Southampton 4 - British Antarctic Survey 5 - British Antarctic Survey 6 - University of East Anglia

Microstructure and finestructure observations are analysed to investigate the spatio-temporal distribution and drivers of turbulence and mixing in the Amundsen Sea Embayment, Antarctica. Microstructure observations collected in austral summer 2014 show low background levels of turbulent dissipation (10^-10 W/kg) over most of the continental shelf below the surface layer, with some elevated values near the shelfbreak and near the bottom, and greatly elevated values near the ice shelf front. Turbulent energy dissipation levels are correlated with internal wave-associated finestructure horizontal and vertical kinetic energy computed from co-located lowered acoustic Doppler current profiler profiles. Four two-year and two one-year moored ADCP records indicate that finestructure energy levels vary by up to an order of magnitude seasonally. The connection to surface winds and sea ice concentration is examined. Temperature variance dissipation from temperature microstructure exceeds the turbulent levels predicted from shear microstructure over much of the thermocline between Winter Water and Circumpolar Deep Water, where stratification is consistent with double-diffusive convection; contributors to the temperature variance budget are explored.

Variability of internal tides in the subpolar North Atlantic

Abstract ID : 385

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Janna Köhler ,jannak@uni-bremen.de ,(Postdoc) ,Germany ,Bremen ,Not Presenting[1]

Mr. Christian Mertens ,cmertens@uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Mrs. Maren Walter ,mwalter@physik.uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Mrs. Zhuhua Li ,zhuhua.li@mpimet.mpg.de ,(None) ,Germany , ,Not Presenting[4]

Prof. Monika Rhein ,mrhein@uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Mrs. Jin-Song von Storch ,jin-song.von.storch@mpimet.mpg.de ,(None) ,Germany , ,Not Presenting[4]

1 - University of Bremen 2 - University of Bremen 3 - University of Bremen 4 - Max Planck Institute for Meteorology 5 - University of Bremen 6 - Max Planck Institute for Meteorology

Low mode near inertial waves are important for the oceans energy balance because they contain a large fraction of the energy of the internal wave field, propagate basin wide and hence redistribute the energy available for mixing over large distances.
Internal tides are the main source for these low mode waves. Coherent internal tides can be discerned from satellite altimetry. However, satellites only deliver long term mean values and they do not work well in regions of strong flow variability, e.g. the North Atlantic. Whether there is no large scale distribution of tidal energy by internal tides in these regions, or whether it is merely not detected by remote sensing can only be answered with the aid of suitable in situ measurements.
Pressure inverted echo sounders (PIES) are instruments that are mounted on the seafloor and measure the bottom pressure as well as the travel time of sound in the overlying water column, and hence density variations. The combination of bottom pressure and travel time allows to extract the baroclinic contribution, i.e. the internal tide.
Here, we present preliminary results from time series recorded with several PIES along a satellite track on the western flank of the Mid Atlantic Ridge between 48°N and 52°N in the Atlantic between 2011 and 2016. The instruments show coherent tidal signals with a seasonal cycle. The question whether this variability is caused by variations in the generation of the tidal waves, or by changing propagation by varying flow of the North Atlantic Current is addressed using model output from the global high resolution STORMTIDE model.

Spatial Distribution of Diapycnal Mixing in the North Atlantic from Shipboard ADCPs

Abstract ID : 575

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Natalia Sukhikh ,natalia.sukhikh@uni-bremen.de ,(PhD student) ,Germany ,Bremen ,Presenting[1]

Dr. Tim Fischer ,tfischer@geomar.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Maren Walter ,maren.walter@uni-bremen.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Christian Mertens ,cmertens@uni-bremen.de ,(None) ,Germany , ,Not Presenting[4]

1 - IUP/MARUM, University of Bremen 2 - GEOMAR Helmholtz Centre for Ocean Research Kiel 3 - IUP/MARUM, University of Bremen 4 - University of Bremen

The North Atlantic is an important part of the global ocean circulation and plays a key role in climate change. Temperature and salinity variability, e.g. caused by Greenland ice sheets melting, affects the spatial distribution and intensity of water masses formation and circulation. Ocean mixing is one of the main factors in the vertical exchange of heat and freshwater, and influences many other processes, e.g. nutrient availability and sea ice formation. It is directly related to ocean-atmosphere-ice interactions, as it is affected by changes in wind forcing or stratification, and thus likely subject to change under different climate conditions. Since 2003, the IUP/MARUM of University of Bremen have carried out research cruises and obtained data from the North Atlantic. Datasets of sea currents (vessel mounted and lowered Acoustic Doppler Current Profiler, vmADCP and LADCP), temperature and salinity structure of water masses (Conductivity, Temperature, Depth, CTD) and hydrochemical parameters were collected. In this work, mixing connected only with the internal wave field is estimated using a shear-based spectral method. Parameters of ocean mixing in the upper ocean as diapycnal diffusivity Kp and dissipation rate ε are calculated from vm-ADCP data obtained during two research cruises: Maria S. Merian 53 (March-May, 2016) and Meteor 59/2 (July-August, 2003). The results describe the spatial distribution of mixing in the upper ocean layer (depths between 20-1620 meters, depending on instrument range). The two cruises cover the same transect with more than a decade apart, so it is possible to look into temporal as well as spatial variability.

Dispersal patterns in the North Sea, insights from a high resolution model

Abstract ID : 696

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. C. Gabriela Mayorga Adame ,gmaya@noc.ac.uk ,(Coastal Modeller (Postdoc)) ,United Kingdom ,Liverpool ,Presenting[1]

Dr. Jeff Polton ,jelt@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Jason Holt ,jholt@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Lea-Anne Henry ,L.Henry@ed.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. Alan Fox ,Alan.Fox@ed.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

1 - UK National Oceanography Centre 2 - National Oceanography Centre, UK 3 - UK National Oceanography Centre 4 - University of Edinburgh 5 - University of Edinburgh

Lagrangian particle tracking simulations are useful to elucidate the fate of materials transported by ocean currents (i.e. larvae, pollutants, debris, drifters), and can therefore be useful to study important process in coastal seas. Dispersal patterns should be improved by the new generation of high horizontal resolution (<2 km) ocean circulation models which provide an improved, more dynamic representation of the coastal ocean. We used the new high resolution Northwest European Shelf NEMO ocean circulation model and LTRANS, a particle tracking code, to study the effects of the increased resolution on the dispersion of Lagrangian particles in the North Sea. Particles were released at the locations of offshore oil and gas platforms in the North Sea and tracked for periods similar to the larval duration of benthic organisms that have colonized the subsea platforms. Dispersal patterns and spatio-temporal scales are identified for the summer (stratified) and winter (mixed) oceanographic regimes. The high resolution of the new NEMO model allows for fine scale detail of flow speed and variability. The small scale features (i.e. eddies and fronts) now represented in the model trap particles, decreasing their dispersal and increasing retention times in comparison to simulations done on a previous coarser resolution NEMO version (7 km AMM7). We isolated the effects of resolution from those due to different representations of the circulation in the different versions of the ocean circulation model by averaging the high resolution model velocity fields to the coarser (7 km) grid, and comparing the results of identical particle tracking experiments using these two flow fields. Our results provide a measure of the importance of high resolution flow fields when estimating transport of materials in an enclosed sea and provide a more realistic characterisation of dispersion in the North Sea.

Internal waves and mixing in the southeast Indian Ocean from EM-APEX floats

Abstract ID : 832

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Ajitha Cyriac ,ajitha.cyriac@utas.edu.au ,(PhD student) ,Australia ,Hobart ,Presenting[1]

Dr. Helen Phillips ,h.e.phillips@utas.edu.au ,(Senior Research Fellow) ,Australia ,Hobart ,Not Presenting[2]

Prof. Nathan Bindoff ,n.bindoff@utas.edu.au ,(None) ,Australia , ,Not Presenting[3]

Dr. Ming Feng ,Ming.Feng@csiro.au ,(None) ,Australia , ,Not Presenting[4]

1 - University of Tasmania 2 - University of Tasmania - IMAS 3 - Institute for Marine & Antarctic Studies, University of Tasmania 4 - CSIRO Australia

The shallow South Indian Countercurrent (SICC), composed of several branches, flows eastward across the southern Indian Ocean towards Australia and intersects with the Leeuwin Current system. Beneath the eastward flow is a subsurface westward flow. The southern branch of the SICC is concentrated around 25°S, a region with high Eddy Kinetic Energy. The breaking of internal waves and their interaction with mesoscale features such as eddies leads to turbulent mixing, which is important in driving the large-scale circulation. Because of the intermittent and patchy nature of these processes, it is difficult to observe them with the limited ship based measurements. We thus have little information on the size and distribution of mixing to understand the dynamics of the SICC and to inform ocean modelling efforts in this climatically important region for Australia. To measure these hard-to-observe processes, we deployed five Electromagnetic Autonomous Profiling Explorer (EM-APEX) floats between 25°S and 32°S along 105°E, where the southern branch of the SICC is concentrated. The EM-APEX floats measured ocean current speed and direction and watermass properties up to 1200m depths with extraordinarily high vertical (3m) and horizontal (2-3km) resolution, returning 8 profiles per day. The floats encountered with mesoscale eddies during their trajectory, which is evident from the velocity data and uplift (depression) of the density surfaces inside of cold-core (warm-core) eddies. The mirror imaging of velocity profiles that are half an inertial period apart shows the presence of inertial oscillations. The amplitude and phase of the near-inertial internal waves (NIWs) are calculated from the complex demodulation of velocity vectors. Near the sea surface, the large amplitudes (20-30cm/s) are often associated with strong wind events. At deeper levels, the NIWs have much lower amplitude except at the bottom of the eddy. The properties of these waves are analysed. Also the mixing caused by the breaking of these internal waves is estimated using a shear-strain parameterisation.

Observations of enhanced dissipation in an anticyclonic eddy impinging on a western boundary

Abstract ID : 1098

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Dafydd Evans ,dge105@soton.ac.uk ,(None) ,United Kingdom ,Southampton ,Not Presenting[1]

Dr. Eleanor Frajka-Williams ,e.frajka-williams@soton.ac.uk ,(Associate Professor) ,United Kingdom ,Southampton ,Not Presenting[2]

Dr. Alberto Naveira Garabato ,acng@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Kurt Polzin ,kpolzin@whoi.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Alex Forryan ,af1c10@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - None 2 - University of Southampton 3 - University of Southampton 4 - Woods Hole Oceanographic Institution 5 - University of Southampton

Mesoscale eddies disappear from altimetry at the western boundary of ocean basins. What role does local dissipation play in their disappearance?   Here, we present microstructure based estimates of dissipation in an anticyclonic eddy east of Abaco, Bahamas. The eddy drove an intensified along-slope flow. Two regions of elevated dissipation were identified suggesting differing mechanisms for the enhancement of local dissipation. The first occurred over a region of rough topography along the slope, where enhanced dissipation (up to 10^{-7} W kg^{-1}) occurred close to the seabed in a region of strong shear. ADCP velocities also revealed the generation of upward propagating internal waves with associated elevated dissipation (up to 10^{-8} W kg^{-1}) mid water column. The second occurred downstream of the first in a region of strong vertical and horizontal shear (e.g. the flow reduced from 1 ms^{-1} to 0.2 ms^{-1} over 50m depth), where the northeastward flow formed a jet as it separated from the topography, which steered to the north west. Elevated dissipation (up to 10^{-7} W kg^{-1}) occurred in the region of strong shear between the jet and the ambient water. To characterize the nature of this instability in the latter region, we calculate the potential vorticity using vertical profiles of temperature and salinity and ADCP measurements of velocity. These results demonstrate a rich interaction between mesoscale eddies and the complex topography along western boundaries that plays a key role in the cascade of energy from the mesoscale to the microscale.

Multifractal analysis of heat flux from ACEx project data

Abstract ID : 1444

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Neelakshi Joshi ,neelakshij@gmail.com ,(Doctoral Student) ,Brazil ,Sao Jose dos Campos ,Presenting[1]

Dr. Reinaldo Rosa ,rrrosa.inpe@gmail.com ,(Titular Researcher) ,Brazil ,São José dos Campos ,Not Presenting[2]

Dr. Luciano Pezzi ,luciano.pezzi@inpe.br ,(None) ,Brazil , ,Not Presenting[2]

Mr. R.B. Souza ,rbsouza@inpe.br ,(None) ,Brazil , ,Not Presenting[2]

Dr. Maurício Bolzan ,mauricio.bolzam@gmail.com ,(Professor) ,Brazil ,Jataí ,Not Presenting[5]

1 - Instituto Nacional de Pesquisas Espaciais (INPE) 2 - INPE 3 - INPE 4 - INPE 5 - Federal University of Jataí

The Multifractal Detrended Fluctuation Analysis(MFDFA) has been a proven ground for getting a better understanding of the scaling structure in turbulence phenomena. MFDFA reveals the richness of scaling and characterize the nature of the homogeneity and non-homogeneity in the underlying physical process driving the time series variability. Singularity spectra from MFDFA is used to analyze the heat flux from ACEx project data which provides high resolution sea surface temperature (SST) gradients. The presence of a nonhomogeneous turbulent energy cascade is characterized comparing such singularity spectrum parameters for the correspondent turbulent p-model. The possible causes of a non-homogeneous energy cascade for oceanic heat flow is discussed for the first time.

Constraining the role of the Southern Ocean in global climate: the ORCHESTRA programme

Abstract ID : 90

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Michael Meredith ,mmm@bas.ac.uk ,(Science Leader) ,United Kingdom ,Cambridge ,Not Presenting[1]

Mr Elaina Ford ,eakf@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr Margaret Yelland ,m.yelland@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Mr Lars Boehme ,lb284@st-andrews.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Mr Nina Fox ,ninx@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr George Nurser ,g.nurser@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Mr Alex Brearley ,jambre@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr Tim Smyth ,tjsm@pml.ac.uk ,(None) ,United Kingdom , ,Not Presenting[8]

Mr Anna Hogg ,a.e.hogg@leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[9]

Mr Andrew Meijers ,andmei@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr Elaine McDonagh ,elm@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Mr Melanie Leng ,mjl@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[12]

Mr Jo Beja ,joja@bodc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[13]

Mr Helene Hewitt ,helene.hewitt@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[14]

1 - British Antarctic Survey 2 - British Antarctic Survey 3 - National Oceanography Centre 4 - Sea Mammal Research Unit 5 - British Antarctic Survey 6 - National Oceanography Centre 7 - British Antarctic Survey 8 - Plymouth Marine Laboratory 9 - Centre for Polar Observation and Modelling 10 - British Antarctic Survey 11 - National Oceanography Centre 12 - British Geological Survey 13 - British Oceanographic Data Centre 14 - Met Office

Climate change is one of the most urgent issues facing humanity and life on Earth. The oceans are critically important in this context, and the Southern Ocean in particular: it has accounted for around half of all oceanic uptake of carbon, and more than three-quarters of the heat uptake. This central climatic role is a consequence of its unique pattern of circulation, and the physical and

biogeochemical processes that it hosts. Despite its profound importance, the Southern Ocean is also the least measured and arguably the least understood of the world's oceans: its remoteness and inhospitable nature have led to a dearth of sustained, strategic measurement programmes, and the small-scale and complexity of many of the key processes have precluded the desired advances in simulation. To address these issues, a new £10M programme funded by NERC has now commenced - 'Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports (ORCHESTRA)'. ORCHESTRA will span five years and use a combination of data collection, analyses, and computer simulations to radically improve our ability to measure, understand and predict the circulation of the Southern Ocean and its role in the global climate. It will make unique and important new measurements in the Southern Ocean using a range of techniques, including basin-wide ocean/carbon/tracer sections, as well as deployments of autonomous vehicles, meteorological aircraft, seal tagging and other innovative techniques for collecting data. It will also involve the development and use of advanced ocean and climate simulations, to improve our ability to predict climatic change in coming decades. This poster will outline the rationale, plans and status of the ORCHESTRA programme.

An evaluation of meteorological reanalysis products in the Amunsen Sea, West Antarctica.

Abstract ID : 110

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Richard Jones ,Richard.W.Jones@uea.ac.uk ,(PhD student) ,United Kingdom ,Norwich ,Presenting[1]

Prof. David Holland ,David.Holland@nyu.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Ben Webber ,B.Webber@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Andrew Orr ,anmcr@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. Matthew Lazzara ,mattl@ssec.wisc.edu ,(None) ,United States ,Madison ,Not Presenting[5]

Prof. Ian Renfrew ,i.renfrew@uea.ac.uk ,(Professor) ,United Kingdom ,Norwich ,Presenting[1]

1 - University of East Anglia 2 - New York University 3 - University of East Anglia 4 - British Antarctic Survey 5 - University of Wisconsin-Madison 6 - University of East Anglia

The glaciers within the Amundsen Sea Embayment (ASE), West Antarctica, are amongst the most rapidly retreating in Antarctica. Meteorological reanalysis products are widely used to help understand and simulate the processes causing this retreat. Here we provide an evaluation against observations of four of the latest global reanalysis products within the ASE region - the ECMWF Interim Re-analysis (ERA-I), Japanese 55-year Reanalysis (JRA-55), Climate Forecast System Reanalysis (CFSR) and Modern Era Retrospective-Analysis for Research and Applications (MERRA). The observations comprise data from four automatic weather stations (AWS), three research-vessel cruises and a new set of 38 radiosondes all within the period 2009-2014. All four reanalyses produce 2 m temperature fields that are colder than AWS observations, with the biases varying from approximately -1.8° C (ERA-I) to -6.8° C (MERRA). Over the Amundsen Sea, spatially averaged summertime biases compared to research vessel observations are between -0.4° C (JRA-55) and -2.1° C (MERRA) with notably larger cold biases close to the continent (up to -6° C) in all reanalyses. All four reanalyses underestimate near surface wind speed at the AWS sites with high wind speeds (>15 m s-1) linked to orographic and katabatic flows poorly represented. They also tend to exhibit slight dry biases and relatively large root-mean-square errors (RMSE) in specific humidity. A comparison to the radiosonde soundings shows that close to the Antarctic continent the cold, dry bias at the surface extends into the lower troposphere; here ERA-I and CFSR reanalyses provide the most accurate profiles. The reanalyses generally contain larger temperature and humidity biases, (and RMSE) when a temperature inversion is observed; and contain larger wind speed biases (~2 to 3 m s-1) when a low-level jet is observed.

Deep temperature variability and the Antarctic Circumpolar Current fronts in Drake Passage

Abstract ID : 157

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yvonne Firing ,yvonne.firing@noc.ac.uk ,(Researcher) ,United Kingdom ,Southampton ,Presenting[1]

Mr Elaine McDonagh ,elm@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Damien Desbruyères ,dades@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Ms. Oana Dragomir ,ocd1n16@soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. Brian King ,bak@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - National Oceanography Centre, UK 2 - National Oceanography Centre 3 - National Oceanography Centre 4 - University of Southampton 5 - National Oceanography Centre

Observations made on >20 occupations between 1993 and 2016 of GO-SHIP line SR1b in eastern Drake Passage show substantial variability in temperature deeper than 2000 dbar. Using a neutral density framework to decompose the temperature variability into isopycnal displacement (heave) and isopycnal property change components shows that approximately 95% of the year-to-year variance in deep temperature is due to heave. Changes on isopycnals make a small contribution to year-to-year variability but contribute a significant trend of -0.0014+/-0.0006 ºC per year, largest for neutral density >28.1, south of the Polar Front (PF). The heave component is depth-coherent and attributable to either vertical or horizontal motions of neutral density surfaces, which trend upward and northward around the PF, downward for the densest levels in the southern section, and downward and southward in the Subantarctic Front and Southern Antarctic Circumpolar Current Front (SACCF). A proxy for the locations of the Antarctic Circumpolar Current (ACC) fronts based on upper-ocean baroclinic velocity is constructed from the repeat hydrographic data and has a strong relationship with deep ocean heat content, explaining 76% of deep temperature variance. Nearly as much (73%) can be explained by the same frontal position proxy based on satellite altimeter-derived surface velocities. The position of the PF plays the strongest role in this relationship between ACC fronts and deep temperature variability in Drake Passage, although much of the temperature variability in the southern half of the section can be explained by the position of the SACCF. Despite good performance at reproducing the year-to-year variance, the frontal position proxy does not reproduce the total or heave-driven trend with the same constant of proportionality. Possible changes in the links among temperature fronts, geostrophic velocity jets, and streamfunction contours on this section are investigated.

Changing of ice drift patterns in the Barents Sea during last 15 years

Abstract ID : 204

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Nataliya Marchenko ,natalym@unis.no ,(Research Assosiate) ,Norway ,Longyearbyen ,Not Presenting[1]

1 - The University Centre in Svalbard

The knowledge of sea ice movement in the whole Arctic and its various parts is very important both in practical and pure scientific sense. Forecast of sea ice behavior, retreating and advancing of ice edge, probability of approaching of icebergs to offshore construction is important for sustainable development

We took into consideration the Barents Sea, as dynamically evolving region where sea ice can create the problems for growing industrial activities and analyzed ice drift in 2001-2016, covering cold period, rapid warming and ice shrinking time. This is the place of Polar front, where Atlantic waters meet with Arctic waters. The interaction of these two different flows creates great variability in currents and, accordingly, in the sea ice drift patterns. But information about ice movement is insufficient.
Several institutions and agencies provide so called "Sea ice products", showing mean ice motion vector, derived from passive microwave sensors, visible and infrared sensors, and other sources. Unfortunately, they are not so good in marginal zone as Barents Sea.
After comparison with our own drifting buoys movement we analyze IFREMER data massive as more adequate for our purposes and region. Using drift vector data we reconstructed the trajectories of ice movement in different part of the Barents Sea in last 15 years in ArcGIS software.

In the presentation we will show changing of ice drift pattern during the season and through the years, illustrating the processes accompanying of sea ice reducing.
The possibilities of forecast will be discussed.

Antarctic Bottom Water formation and deep convection events in ocean reanalysis products

Abstract ID : 370

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Wilton Aguiar ,aguiar.wilton@gmail.com ,(PhD Student) ,Brazil ,Rio Grande ,Presenting[1]

Mr. Mauricio Mata ,mauricio.m.mata@gmail.com ,(None) ,Brazil , ,Presenting[1]

Mr. Rodrigo Kerr ,kerr.rodrigo@gmail.com ,(None) ,Brazil , ,Not Presenting[1]

1 - FURG 2 - FURG 3 - FURG

Antarctic Bottom Water (AABW) formation due to deep convection under open ocean polynyas is a frequent source of error in non-assimilatory Ocean General Circulation Models. However, the Weddell Sea Polynya opening in the Estimating the Circulation and Climate of the Ocean Phase II (ECCO2) ocean reanalysis points to possible deep convection events in other state-of-art products. Using neutral density definitions for Southern Ocean water masses and maps of sea ice concentration and thickness, we evaluate how three state-of-art ocean reanalysis form AABW in their simulations. The products used in this study are the ECCO2, Southern Ocean State Estimate (SoSE) Version 2 and My Ocean University Reading (UR025.4). We found that both ECCO2 and SoSE formed AABW through deep convection under oceanic polynyas as a result from the upward heat transport from Warm Deep Water in the Weddell Sea, and consequent heat exchange with sea ice. The appearance of spurious polynyas in ECCO2 and SoSE suggests that the assimilation scheme of sea ice concentration could not hinder large oceanic polynya openings. The UR025.4 product created AABW through the interaction of Upper Circumpolar Deep Water with sea ice near the shelf break in the Indian Ocean sector, a mechanism similar to the one that occurs in the real Southern Ocean. Although the more accurate AABW formation in UR025.4 is an important progress on the representation of Southern Ocean and its processes in reanalysis products, the associated spurious sea ice thickness simulated near the Antarctic Peninsula shows that there is still need for substantial improvements to represent reliably the AABW formation in those classes of models.

Change in Arctic Ocean freshwater content in response to a step change in wind forcing

Abstract ID : 371

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Helen Johnson ,helen.johnson@earth.ox.ac.uk ,(Associate Professor) ,United Kingdom ,Oxford ,Not Presenting[1]

Ms. Emma Beer ,emb17@hotmail.co.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Camille Lique ,camille.lique@ifremer.fr ,(None) ,France , ,Not Presenting[3]

Dr. Yavor Kostov ,ykostov@gmail.com ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Oxford 2 - None 3 - IFREMER 4 - University of Oxford

We investigate how freshwater storage in the Arctic Ocean responds to a change in atmospheric forcing, by examining the relationship between freshwater storage and sea-level pressure (SLP) in an unperturbed control simulation of the high-resolution coupled climate model, HiGEM. Multiple lagged regression is used to extract the response of integrated freshwater content to a hypothetical step increase in the Arctic Oscillation and other principle components of SLP. The results demonstrate that the freshwater content responds on a decadal timescale, consistent with our expectation that eddies set the timescale on which the Arctic Ocean adjusts to changes in surface forcing. The relationship between freshwater and sea-level pressure is then exploited in an attempt to predict the variability in freshwater content under greenhouse gas forcing applied to the same model.

Evaluation of high-resolution MetUM and AMPS forecasts of near-surface meteorological variables over Larsen C ice shelf and northern Antarctic Peninsula

Abstract ID : 379

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Andrew Orr ,anmcr@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Michiel van den Broeke ,M.R.vandenBroeke@uu.nl ,(None) ,Netherlands , ,Not Presenting[2]

Mr John King ,jcki@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. Amelie Kirchgaessner ,acrki@bas.ac.uk ,(Atmospheric Scientist) ,United Kingdom ,Cambridge ,Not Presenting[1]

Dr. Mark Weeks ,mark.weeks@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[5]

Dr. Konrad Steffen ,Konrad.steffen@wsl.ch ,(None) ,Switzerland , ,Not Presenting[6]

Mr Andy Elvidge ,a.elvidge@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[7]

Dr. Peter Kuipers Munneke ,P.KuipersMunneke@uu.nl ,(None) ,Netherlands , ,Not Presenting[2]

Dr. Alan Gadian ,alan@env.leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[9]

1 - British Antarctic Survey 2 - University of Utrecht 3 - BAS 4 - British Antarctic Survey 5 - UK Met Office 6 - Swiss Federal Institute for Forest, Snow and Landscape Research WSL 7 - UEA 8 - University of Utrecht 9 - University of Leeds

High-resolution weather forecasts are an important tool for understanding the detailed patterns of surface melt on the Larsen C ice shelf (LCIS), Antarctic Peninsula. We investigate the skill of UK Met Office Unified Model (MetUM) and Antarctic Mesoscale Prediction System (AMPS) forecasts with horizontal grid spacing of 4-5 km for a 1 month period during January-February 2011 by comparing near-surface model output to automatic weather station measurements at 5 sites on the LCIS and 3 on the northern Antarctic Peninsula. Forecasts for the range 12-24 h showed a fairly homogeneous performance over the LCIS. The 2 m temperature simulated by AMPS has a correlation with observations of 0.5-0.6 and a systematic cold bias of around -1 degrees centigrade. By comparison, the MetUM had a higher correlation and was less negatively biased. The simulated surface pressure has a correlation of 0.99 and small biases in both models. AMPS yielded better results than the MetUM for 10 m wind speed, being able to capture particularly well synoptically-driven high wind speeds which the MetUM systematically underestimated. Both models struggle to simulate the 10 m

wind direction when the wind conditions are highly variable. The simulation of specific humidity by both models was poor. Both models showed a general reduction in performance over the northern Antarctic Peninsula compared to the LCIS. Extending the analysis to consider the 12-36 h forecast range demonstrated a relatively weak dependence of model skill to the length of the forecast. The study focuses particularly on the representation of foehn wind events, which are an important contributor to surface melt over the LCIS, by examining additional 1 km scale forecasts using the MetUM. Finally, to diagnose how various physical processes contribute to the simulated 2 m temperature, the contributions to the local tendencies are examined.

Surface Melting on the Greenland Ice Sheet: Recent Drivers, Future Scenarios

Abstract ID : 539

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. David Reusch ,david.reusch@nmt.edu ,(Research Associate Professor) ,United States ,Socorro ,Not Presenting[1]

1 - None

Melting on the surface of the Greenland ice sheet has been changing dramatically as global air temperatures have increased in recent decades. Examples include melt extent frequently exceeding the 1981-2010 median through much of the melt season, including the ice-sheet-wide event of 2012, and the onset of intermittent melt moving to earlier in the year.
We investigate recent and future drivers of surface melting using the regional forecast model Polar WRF with different driving datasets. Polar WRF provides higher resolution regional modeling (here 15 km) and improved, polar-centric model physics. We first developed a Polar WRF-based 30-year (1986-2015) summer (JJA) reference climatology with the ERA-Interim reanalysis (ERAI). The 30-member CESM1.0-CAM5-BGC Large Ensemble (LENS) was then used for recent (1996-2005) and future (RCP 8.5, 2071-2080) WRF runs. Recent simulations were skill-tested against ERAI and AWS observations with results informing future interpretations. For example, LENS tends to overpredict both maximum (above-freezing) and minimum daily average surface temperatures compared to the GC-Net Swiss Camp AWS.
Intramodel uncertainty was also examined via ensemble variability in LENS daily data. For 1981-2000, spatially averaged climatological July temperature anomalies over a Greenland ice-sheet/ocean domain are mostly between +/- 0.2 °C, relative to the ensemble average. The spatial average hides larger local anomalies of up to +/- 2 °C. The ensemble average itself is ~2 °C cooler than ERAI.
Self-organizing maps (SOMs) extend our standard diagnostics and climatologies by providing a concise, objective summary of model variability as a set of generalized patterns. For LENS, the SOM patterns summarize the variability of multiple realizations of climate: changes in pattern frequency by ensemble member show the influence of initial conditions. For example, analysis of pattern frequency yields interquartile ranges of 2-4% for individual patterns across the ensemble. In climate terms, this tells us about climate state variability through the range of the ensemble, a potentially significant source of melt-prediction uncertainty.

Transit navigation through Northern Sea Route from satellite data and CMIP5 simulations

Abstract ID : 602

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Igor Mokhov ,mokhov@ifaran.ru ,(Director) ,Russia ,Moscow ,Presenting[1]

Dr. Vyacheslav Khon ,khon@ifaran.ru ,(None) ,Russia , ,Not Presenting[1]

Dr. Vladimir Semenov ,vasemenov@mail.ru ,(None) ,Russia , ,Not Presenting[1]

1 - A.M.Obukhov Institute of Atmospheric Physics Russian Academy of Sciences 2 - A.M.Obukhov Institute of Atmospheric Physics Russian Academy of Sciences 3 - A.M.Obukhov Institute of Atmospheric Physics Russian Academy of Sciences

Rapid Arctic sea ice decline over the last few decades opens new perspectives for Arctic marine navigation. Further warming in the Arctic will promote the Northern Sea Route (NSR) as an alternative to the conventional Suez or Panama Canal routes for intercontinental shipping. Here we use both satellite data and CMIP5 ensemble of climate models to estimate the NSR transit window allowing intercontinental navigation between Atlantic and Pacific regions. To this end, we introduce a novel approach to calculate start and end dates of the navigation season along the NSR. We show that modern climate models are able to reproduce the mean time of the NSR transit window and its trend over the last few decades. The selected models demonstrate that the rate of increase of the NSR navigation season will slow down over the next few decades with the RCP4.5 scenario. By the end of the 21st century ensemble-mean estimates show an increase of the NSR transit window by about 4 and 6.5 months according to RCP4.5 and 8.5, respectively. Estimated trends for the end date of the navigation season are found to be stronger compared to those for the start date.

A connection between seasonal biases in phytoplankton and Antarctic sea-ice in CMIP5 models

Abstract ID : 611

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Mark Hague ,markhg77@gmail.com ,(PhD Candidate) ,South Africa ,Cape Town ,Not Presenting[1]

Prof. Marcello Vichi ,marcello.vichi@uct.ac.za ,(Director of the Marine Research Institute) ,South Africa ,Cape Town ,Not Presenting[2]

1 - Dept. of Oceanography, University of Cape Town 2 - Department of Oceanography and Institute of Marine Research, University of Cape Town

While much attention has been paid in recent years to unrealistic Antarctic sea-ice representations in CMIP5 models, little has been said about similar problems with phytoplankton growth simulation in the region. In particular, many authors have discussed possible reasons why the recent overall increase in Antarctic sea-ice volume has not been captured by CMIP models, but not what implications misrepresentations of seasonal sea-ice may have on phytoplankton phenology. Since large blooms are often observed (in both satellite and CMIP5 data) at the retreating ice-edge or marginal ice zone (MIZ), it is expected that biases in modeled sea-ice will generate a response in the biota, although the exact nature of this response is currently unclear. Apart from exposing gaps in our knowledge, it is also likely that these misrepresentations will have implications for climate change projections, making it essential that we understand their source. The study to be presented provides a detailed analysis of the connection between seasonal phytoplankton growth and sea-ice distribution using CMIP5 historical runs from 11 models, with comparisons to satellite and other observational products. The analysis suggests that biases in the sea-ice distribution could contribute significantly to phenology biases, primarily through modifying the vertical structure of the water column. One proposed mechanism involves the accelerated spring warming rate observed in many models, leading to early stratification and favourable light and nutrient conditions prior to when such conditions are observed. Furthermore, many of the models exhibit a southward sea-ice extent bias of 3 to 4 degrees (averaged over the year), which may help explain why a phenology more typical of the subtropics is observed in these regions. The study also seeks to include the affects of the large scale wind and ocean circulation, which we know play a role in the mixing regime, the formation of water masses and the sea-ice distribution in the MIZ. In summary, this study provides a conceptual framework upon which hypotheses can be formulated and further modeling activities undertaken.

The Seasonal Cycle of CO2 in the Southern Ocean: Diagnosing Anomalies in CMIP5 Earth Systems Models

Abstract ID : 620

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Precious Mongwe ,npmongwe@gmail.com ,(None) ,South Africa , ,Not Presenting[1]

Prof. Marcello Vichi ,marcello.vichi@uct.ac.za ,(Director of the Marine Research Institute) ,South Africa ,Cape Town ,Presenting[2]

Dr. Pedro Monteiro ,pmonteir@csir.co.za ,(None) ,South Africa , ,Not Presenting[3]

1 - Southern Ocean Carbon-Climate Observatory (SOCCO), CSIR and Deaprtment of Oceanography, University of Cape Town, Cape Town, South Africa 2 - Department of Oceanography and Institute of Marine Research, University of Cape Town 3 - 1Southern Ocean Carbon-Climate Observatory (SOCCO), CSIR, and Department of Oceanography University of Cape Town, Cape Town, South Africa

The Southern Ocean forms a key component of global carbon budget: taking up about a third (1.0±0.5 PgC yr^{-1}) of the total global oceanic annual uptake of anthropogenic CO_2 and accounting for most of the uncertainty in the global ocean CO_2 fluxes. Recent synthesis studies showed that although ocean biogeochemical models agree on the mean annual flux of CO_2 in the Southern Ocean, they disagree on both amplitude and phasing of the seasonal cycle and compare poorly to observations. In this study, we used a diagnostic analysis based on the representation of the seasonal cycle of CO_2 air-sea fluxes (FCO_2) on 10 CMIP5 earth system models. Our approach shows how an understanding of the seasonal variability of drivers of CO_2 at a seasonal scale helps explain the anomalies between observations and CMIP5 models. In this study, we show that the model - observations FCO_2 seasonal cycle anomalies are due to differences in the magnitude of the seasonal cycle of dominant drivers of pCO_2 i.e. thermal and physical-biogeochemical drivers. We found that 6 of the 10 CMIP5 models overestimate the role of solubility (temperature driven) during autumn, which delays the impact of winter sub-surface DIC entrainment to surface pCO_2 and thus causing a divergence from observations FCO_2. We found that 3 of the 10 overestimate the physical - biogeochemical driver on pCO_2 due to overestimation of the net CO_2 biological uptake. We found that convective CO_2 winter entrainment, as well as the impact of summer biological CO_2 uptake, have a compound effect on the amplitude of the seasonal cycle of DIC and hence FCO_2.

The role of the interaction of storms and fronts in driving intraseasonal variability of primary production in the Southern Ocean

Abstract ID : 706

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sarah Nicholson ,snicholson@csir.co.za ,(None) , , ,Not Presenting[1]

Dr. Marina Levy ,marina@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[2]

Dr. Pedro Monteiro ,pmonteir@csir.co.za ,(None) ,South Africa , ,Not Presenting[3]

Dr. Julien Jouanno ,julien.jouanno@legos.obs-mip.fr ,(None) ,France , ,Not Presenting[4]

Dr. Xavier Capet ,xclod@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[2]

Dr. Sebastiaan Swart ,sebastiaan.swart@marine.gu.se ,(None) ,Sweden , ,Not Presenting[6]

1 - CSIR 2 - LOCEAN-IPSL 3 - 1Southern Ocean Carbon-Climate Observatory (SOCCO), CSIR, and Department of Oceanography University of Cape Town, Cape Town, South Africa 4 - LEGOS 5 - LOCEAN-IPSL 6 - University of Gothenburg

The Southern Ocean is one of the stormiest places on earth; here strong mid-latitude storms frequently traverse large distances of this ocean. Their interaction with underlying meso to submesoscale dynamics has the potential to strongly impact the upper-ocean environment where phytoplankton live, yet exactly how remains unclear. Using a reentering zonal channel model representing an open ocean section of the Southern Ocean with mesoscale to sub-mesoscale turbulence and idealized storm forcing, we have shown how the interactions of these mechanisms may drive enhanced intraseasonal variability in primary production. These storms resulted in the generation of strong vertical mixing and post-storm wakes of increased vertical velocities associated with inertial wave activity lasting for more than two weeks. We show how this enhances the upward supply fluxes (advective and diffusive) of dissolved iron raising primary production by up to 20% from the background values during a storm event. What has emerged is an efficient coupled mechanism of vertical diffusion and advection allowing for the redistribution of surface and subsurface iron supplies during and between storm events.

Thermodynamic transformations of the first year and multiyear ice ridges

Abstract ID : 1041

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Aleksey Marchenko ,Aleksey.Marchenko@unis.no ,(Professor) ,Norway ,Longyearbyen ,Not Presenting[1]

1 - UNIS

Sea ice ridges are formed due to the compression of sea ice in places of floes contact. They consist of a set of ice blocks submerged into the water or pushed out at the surface of surrounding level ice. Ridged ice occupies significant portions of ice covered areas in the Arctic. Their vertical sizes can reach 20-30 m that is much greater the thickness of multiyear ice. Ice ridges store significant amount of ice and give an input in fresh water balance in the Arctic. Field studies performed on the first year ice show that ice ridges consist of the consolidated layer and unfrozen ice rubble located below the consolidated layer. The consolidated layer has physical characteristics (salinity and strength properties) similar to level ice. Submerged ice blocks occupy from 60% to 80% of total volume of the rubble. Cavities between submerged ice blocks are filled by sea water or sea water brine. Field studies performed on multiyear ice show that multiyear ice ridges frequently are completely consolidated. Thermodynamic consolidation of ice rubble occurs due the water freezing between submerged ice blocks. Two physical mechanisms of the consolidation are considered in the present work. The first mechanism is associated with the influence of the atmospheric cooling. The second mechanism is associated with ice rubble melting from below due to the influence of oceanic heat flux. The melt water is fresher the sea water and has higher freezing point. Therefore it replaces the sea water inside the rubble and freezes gradually under the influence of cold flux from surrounded ice blocks. The first physical mechanism explains that the thickness of the consolidated layer is greater the thickness of level ice formed in the same weather conditions not more than in two times and doesn't give an explanation of the formation of completely consolidated ice ridges. This mechanism is most important for structural transformation of the first year ice ridges. The second mechanism becomes important over relatively long time of about several years when the oceanic heat flux is below 10 W/m^2. This mechanism explains the formation of completely consolidated multiyear ice ridges. Consolidated ice ridges can form also when they drift into warm water region where ice rabble melts faster and provides high influx of the fresh water inside the rubble. The last effect is important for the regions where offshore development in the Barents Sea is planned. In the present work new mathematical model and numerical simulations describing the formation of completely consolidated ice ridges are discussed.

Mesoscale mixing of the Denmark Strait Overflow in the Irminger Basin

Abstract ID : 1043

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Inga Koszalka ,ikoszalka@geomar.de ,(None) ,Germany , ,Not Presenting[1]

Prof. Thomas Haine ,thomas.haine@jhu.edu ,(Convener) ,United States ,Baltimore ,Presenting[2]

Dr. Marcello Magaldi ,marcello.magaldi@sp.ismar.cnr.it ,(None) ,Italy , ,Not Presenting[3]

1 - GEOMAR 2 - Johns Hopkins University 3 - CNR ISMAR

The Denmark Strait Overflow (DSO) is a major export route for dense waters from the Nordic Seas forming the lower limb of the Atlantic Meridional Overturning Circulation, an important element of the climate system. Mixing processes along the DSO pathway influence its volume transport and properties contributing to the variability of the deep overturning circulation. They are poorly sampled by observations, however, which hinders development of a proper DSO representation in global circulation models. We employ a high resolution regional ocean model of the Irminger Basin to quantify impact of the mesoscale flows on DSO mixing focusing on geographical localization and the time-modulation of water property changes. The model reproduces the observed bulk warming of the DSO plume 100-200 km downstream of the Denmark Strait sill. It also reveals that mesoscale variability of the overflow ('DSO-eddies', of 20- 30 km extent and a time scale of 2-5 day) modulates water property changes and turbulent mixing, diagnosed with the vertical shear of horizontal velocity and the eddy heat flux divergence. The space-time localization of the DSO mixing and warming and the role of coherent mesoscale structures should be explored by turbulence measurements and factored into the coarse circulation models.

Observations of Submesoscale Instabilities and Frontal Structure in Drake Passage

Abstract ID : 1149

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Giuliana Viglione ,gviglion@caltech.edu ,(Graduate Student, Environmental Science and Engineering) ,United States ,Pasadena ,Not Presenting[1]

Prof. Andrew Thompson ,andrewt@caltech.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Janet Sprintall ,jsprintall@ucsd.edu ,(Research Oceanographer) ,United States ,La Jolla ,Not Presenting[3]

Dr. Mar Flexas ,marf@caltech.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Sebastiaan Swart ,sebastiaan.swart@marine.gu.se ,(None) ,Sweden , ,Not Presenting[5]

1 - Caltech 2 - California Institute of Technology 3 - Scripps Institution of Oceanography 4 - Caltech 5 - University of Gothenburg

Submesoscale motions may produce vertical velocities in the upper ocean that can either re-stratify the mixed layer or penetrate the strong, persistent buoyancy gradients found at the base of the mixed layer. Submesoscale motions in the Antarctic Circumpolar Current (ACC) remain largely uncharacterized due to a lack of observations, and simulated flows at these scales remain unvalidated. The ChinStrAP (Changes in Stratification at the Antarctic Peninsula) field campaign consisted of two four-month deployments of two gliders in Drake Passage. From December to April (2014-15), the gliders sampled on either side of Shackleton Fracture Zone (SFZ), a major bathymetric feature of the region, collecting over 2800 hydrographic profiles. These are used to examine the density structure and estimate potential vorticity (PV) in the region. The balanced Richardson angle (the ratio of the vertical to lateral buoyancy gradients) is used to classify submesoscale instabilities; comparison with a 1/48° resolution GCM is used to validate this approach. Significant differences in the lateral buoyancy gradients and mixed layer depths up- and down-stream of SFZ suggest dissimilar dynamics between the two regions. Intermittent instances of symmetric instability are identified downstream of SFZ throughout the summer. We propose that the differences are due enhanced variability downstream of the SFZ due to topographic steering upstream of the SFZ and the injection of Weddell Sea waters downstream of the SFZ. From May to September (2016) the gliders sampled in parallel, with a separation of ~15 km, from southern Drake Passage across the Polar Front. Multiple meridional sections reveal a series of submesoscale fronts across Drake Passage that had previously not been resolved. The sampling strategy permits reconstruction of a the three-dimensional (balanced) Ertel PV at scales of ~15 km. Deeper mixed layers in the winter season

suggest a higher proclivity for submesoscale instabilities upstream of the SFZ than observed in the summer months. The results emphasize the significant role that submesoscale motions play in modulating the near-surface stratification and frontal structure at a key location for the ventilation of deep density classes.

The impact of the meridional gradient in surface forcing on upper ocean submesoscale processes and mixing in the Southern Ocean

Abstract ID : 1297

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sebastiaan Swart ,sebastiaan.swart@marine.gu.se ,(None) ,Sweden , ,Not Presenting[1]

Mr. Marcel du Plessis ,marceldpl10@gmail.com ,(None) , , ,Not Presenting[2]

Dr. Sandy Thomalla ,sandy.thomalla@gmail.com ,(None) ,South Africa , ,Not Presenting[3]

Dr. Pedro Monteiro ,pmonteir@csir.co.za ,(None) ,South Africa , ,Not Presenting[4]

1 - University of Gothenburg 2 - UCT 3 - CSIR 4 - 1Southern Ocean Carbon-Climate Observatory (SOCCO), CSIR, and Department of Oceanography University of Cape Town, Cape Town, South Africa

The vast expanse of the Southern Ocean can be separated meridionally into various frontal regimes with an extreme north-south gradient in oceanographic properties and atmospheric conditions. These frontal zones exhibit distinctive seasonal cycles of mixed layer dynamics and associated phytoplankton biomass that may be dependent on the underlying physical drivers. These unique responses have direct implications on air-sea and biogeochemical processes. The region provides a prime test-bed to better understand the sensitivity of upper ocean dynamics to varying space and time scales of forcing. We look to identify the role of submesoscale processes on mixed layer dynamics and how they are impacted by various surface forcing. We characterise the stratification and dynamics of the mixed layer through the presence and interaction of fine-scale, submesoscale features and atmospheric forcing, that exert turbulent effects and heat flux variations, on the surface ocean. A series of multi-month glider deployments, at different latitudinal extents of the Southern Ocean, provides high-resolution measurements of upper ocean physical and biogeochemical fields. Ancillary satellite reanalysis wind and heat flux products, together with simulations of a 1-D mixing model, provide the basis by which to test the relationship between the submesoscale field and surface forcing and their impacts on upper ocean stratification. The glider bio-optics observations allows us to assess the impact of these mixed-layer processes on phytoplankton biomass.

Variability in the marine environment at the Sub- Antarctic Prince Edward Islands

Abstract ID : 1322

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. sarah asdar ,sarah.asdar@gmail.com ,(PhD Candidate) ,South Africa ,cape town ,Not Presenting[1]

Dr. Julie Deshayes ,julie_deshayes@mac.com ,(None) ,France , ,Not Presenting[2]

Prof. Isabelle Ansorge ,Isabelle.Ansorge@uct.ac.za ,(Head of Department) ,South Africa ,None ,Not Presenting[3]

Prof. Pierrick Penven ,pierrick.penven@ird.fr ,(None) ,France , ,Not Presenting[4]

1 - UCT/LOPS 2 - LOCEAN/CNRS 3 - UCT 4 - IRD

The sub-Antarctic Prince Edward Islands (PEIs) (47°S,38°E) are classified as isolated, hostile, impoverished regions, in which the terrestrial and marine ecosystems are relatively simple and extremely sensitive to perturbations. Their location between the Sub-Antarctic Front (SAF) and the Antarctic Polar Front (APF), bordering the Antarctic Circumpolar Current (ACC) provides an ideal natural laboratory for studying how organisms, ecological processes and ecosystems respond to a changing climate in the Southern Ocean. Recent studies have proposed that climate changes reported at the PEI may correspond in time to a southward shift of the ACC and in particular of the SAF. This southward migration in the geographic position of major ocean fronts is likely to coincide with dramatic changes in the distribution of species and total productivity of this region. However, there are other sources of variability in the hydrodynamic conditions around PEI : upstream of the islands, a region of high eddy kinetic activity produces mesoscale features that directly irrigate the PEIs and may impact their marine environment. In order to understand better this mechanism of variabilty, we develop a high-resolution (1/12°) two-way nested simulation of the ocean circulation around PEI. A comparison between the model results and observations available at the islands shows that the nested model reproduces quite well the mesoscale signatures.

Identifying glacial meltwater and upper ocean processes using noble gases in the Amundsen Sea

Abstract ID : 1338

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Louise Biddle ,louise.biddle@marine.gu.se ,(Postdoctoral Researcher) ,Sweden ,Gothenburg ,Not Presenting[1]

Dr. Brice Loose ,bloose@uri.edu ,(None) ,United States , ,Not Presenting[2]

Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[3]

1 - University of Gothenburg 2 - University of Rhode Island 3 - University of East Anglia

Pine Island Ice Shelf, in the Amundsen Sea, is losing mass due to warm ocean water penetrating beneath the ice shelf and causing basal melt. Tracing this warm deep water and the resulting glacial meltwater it produces can help identify changes in melt rate, feedbacks onto the circulation across the continental shelf, and the regions most affected by the increased input of this freshwater. Here, optimum multi-parameter analysis is used to deduce glacial meltwater fractions from water mass characteristics (standard hydrographic observations, noble gases and oxygen isotopes), collected during a ship-based campaign in the eastern Amundsen Sea in February-March 2014. Noble gases (neon, argon, krypton and xenon) and oxygen isotopes are used to trace the meteoric (precipitation and glacial melt) water found in seawater. A comparison of the results from water mass analysis using hydrographic observations (temperature, salinity, dissolved oxygen) with analysis using strictly noble gases reveals trade offs in each suite of tracers. The presence of glacial meltwater is shown to erode the hydrographic WW properties, resulting in differences between the water mass analyses of up to 4 per mil glacial meltwater content. This is accounted for by simulating a "pure" WW endpoint, and remaining disparities between the analyses reflect how upper ocean processes can affect individual tracers through sea ice formation/melt, biological productivity and air-sea gas exchange. The corrected glacial meltwater content values show a persistent signature in the upper 400 m of the water column across all of the sample locations (up to 500 km from Pine Island Ice Shelf), with increased concentration towards the west along the coastline.

Upper ocean processes in the Southern Ocean marginal ice zone during the sea ice melt season

Abstract ID : 1340

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Louise Biddle ,louise.biddle@marine.gu.se ,(Postdoctoral Researcher) ,Sweden ,Gothenburg ,Not Presenting[1]

Dr. Sebastiaan Swart ,sebastiaan.swart@marine.gu.se ,(None) ,Sweden , ,Not Presenting[1]

Prof. Anna Wåhlin ,anna.wahlin@marine.gu.se ,(None) ,Sweden , ,Not Presenting[1]

1 - University of Gothenburg 2 - University of Gothenburg 3 - University of Gothenburg

The linkages between atmosphere, sea ice and ocean can have a large influence on the heat and carbon storage of the Southern Ocean. To understand the impacts of future climatic variability on this storage, it is vital to consider the connectivity between these elements. The mixed layer acts as a gateway to long-term storage provided by deep-water formation around the coasts of Antarctica, so how this layer acquires and loses climate tracers is important to understand. The evolution of the mixed layer is largely driven by air-sea, freshwater and momentum fluxes, as well as ocean-ice interaction. However, the relative importance of each of these forcing mechanisms, and their associated climate sensitivity, is largely unknown due to the dearth of observations in the subpolar regions. As the marginal ice zone travels towards the Antarctic continent, the melting of sea ice can initiate mixing through the buoyancy changes that are caused, and will also result in the removal of the 'cap' of sea ice limiting air-sea exchange. Over the Antarctic continental shelf edge this can have implications for cross-shelf transfer of heat, freshwater and nutrients. This research focuses on the upper ocean mixing following the period of spring-summer sea ice melt by analyzing existing datasets, such as seal tag hydrographic observations and satellite data. By synergizing these datasets, the major drivers of important upper ocean processes are identified, and the use of simple ocean models will be used to complement observational data; separating out the importance of individual ocean processes.

Observing the polynya and ocean under sea ice around Antarctica

Abstract ID : 1361

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Yutian Jiao ,jiaoyutian@ouc.edu.cn ,(Senior Engineer) ,China ,Qingdao ,Presenting[1]

Prof. Jiuxin Shi ,shijiuxin@ouc.edu.cn ,(None) ,China , ,Not Presenting[1]

1 - Ocean University of China 2 - Ocean University of China

Sea ice not only influences the dynamic and thermodynamic processes of the polar ocean but also creates barriers on observing the ice-covered ocean. There are few platform and equipment suitable for observing the ocean under sea ice. Several techniques of observation in polynya and ice-covered ocean have been developed and applied in the Chinese Antarctic Research Expedition in recent decade. XCTD (eXpendable Conductivity Temperature Depth profiler) probes were launched from helicopter suspending above a polynya to get the temperature and salinity profile in the polynya. Programmed winch was mounted on fast ice to drive a CTD throng an ice hole to measure the hydrographic feature of the sea water under ice. A breaking-connector was used on mooring in order to save the lower part of mooring when its upper part was towed by an iceberg. Data collected by above methods helped us to understand the real process in sea ice-ocean interactions.

Modelling the mixed layer in the Bay of Bengal during the Indian summer monsoon

Abstract ID : 510

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Simon Peatman ,s.peatman@reading.ac.uk ,(NCAS Research Scientist) ,United Kingdom ,Reading ,Not Presenting[1]

Dr. Ben Webber ,B.Webber@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Prof. Adrian Matthews ,a.j.matthews@uea.ac.uk ,(Professor of Meteorology) ,United Kingdom ,Norwich ,Not Presenting[2]

Dr. K Vijaykumar ,kvkumar@nio.org ,(None) ,India , ,Not Presenting[4]

Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[5]

Dr. Nicholas Klingaman ,nicholas.klingaman@ncas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[6]

1 - NCAS Climate, University of Reading 2 - University of East Anglia 3 - University of East Anglia 4 - National Institute of Oceanography, Goa 5 - Indian Institute of Science 6 - NCAS, University of Reading

The BoBBLE (Bay of Bengal Boundary Layer Experiment) project exists to investigate the impact of air-sea interactions and ocean dynamics in the Bay of Bengal (BoB) on intra-seasonal variability in the Indian summer monsoon. The BoB is one of the key moisture sources for monsoon rain and features northward-propagating bands of convection associated with the monsoon onset and active-break cycle. Furthermore, a shallow, strongly stratified mixed layer allows the sea surface temperature to respond rapidly to surface fluxes, with subsequent feedbacks onto atmospheric convection. However, there are many key physical processes which are poorly understood. The BoB is a region of large horizontal gradients in sea surface temperature and salinity, but how they are maintained and what impact they have on precipitation is a matter of ongoing research. The diurnal cycle is also known to be of importance as it generates a strongly stratified shallow surface warm layer on days of strong insolation, which warms the SST before mixing down to deeper water overnight. However, it is not known how this process and its feedback onto convection vary throughout the BoB. Chlorophyll concentration is also known to vary spatially and seasonally in the BoB, but both the cause of this and the impact on monsoon precipitation is not fully known. A single-column one-dimensional mixed layer ocean model, using the KPP parametrization, is forced by surface fluxes measured during the BoBBLE field campaign in the summer of 2016. The model output is validated against further field campaign observations from sea gliders, CTD (conductivity, temperature and depth) sensors and ADCPs (acoustic Doppler current profilers). It is shown that the model is able to reproduce signals observed in the field campaign data, for example a warming of ~0.5C in SST over a seven-day period

at 8N, 89E during a monsoon break phase when clear skies resulted in a large downwelling short-wave flux at the surface. Through a series of mechanism denial experiments we investigate the effect on upper ocean stratification of the diurnal cycle, advection and light absorption by chlorophyll.

The effect of chlorophyll variability on Bay of Bengal surface temperature as observed during the 2016 BoBBLE campaign

Abstract ID : 515

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Jack Giddings ,J.Giddings@uea.ac.uk ,(PhD student) ,United Kingdom ,Norwich ,Not Presenting[1]

Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[2]

Prof. Adrian Matthews ,a.j.matthews@uea.ac.uk ,(Professor of Meteorology) ,United Kingdom ,Norwich ,Not Presenting[3]

Dr. Manoj Joshi ,m.joshi@uea.ac.uk ,(Senior Lecturer) ,United Kingdom ,Norwich ,Not Presenting[3]

Dr. Nicholas Klingaman ,nicholas.klingaman@ncas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[5]

Dr. Simon Peatman ,s.peatman@reading.ac.uk ,(NCAS Research Scientist) ,United Kingdom ,Reading ,Not Presenting[6]

Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[3]

1 - School of Environmental Science, UEA 2 - Indian Institute of Science 3 - University of East Anglia 4 - University of East Anglia 5 - NCAS, University of Reading 6 - NCAS Climate, University of Reading 7 - University of East Anglia

The Indian Ocean is one of the warmest bodies of water on the globe, providing an essential source of moisture and heat for the South Asian monsoon system. The tight coupling of sea and air plays a vital role in regulating both regional and global climate on intra-seasonal and inter-annual timescales. Prolonged exposure to solar radiation during the summer months results in intense heating of the Indian Ocean surface as light is attenuated and absorbed through the water column. Chlorophyll blooms provide additional light absorption in the upper ocean, a factor previously shown to have a significant impact on sea surface temperature in the Arabian Sea and thus on regional climate. As part of the joint Indian-UK Bay of Bengal Boundary Layer Experiment (BoBBLE), ocean gliders were deployed during June - July 2016. One of these was equipped with chlorophyll fluorescence, photosynthetically active radiation (PAR) and optical backscatter sensors. The glider provides data from 1000 m depth up to within the top metre, where it is challenging to obtain direct measurements. The PAR profiles of the upper water column are presented and discussed in the context of light absorption by water and the biological constituents that influence the rate of light attenuation with depth. We determine the transmission of light through the water column by fitting double exponential functions to each PAR profile, representing the transmission of red and blue wavelengths, and find scale depths of 0.5 m and 17 m respectively. The aim of this study is to improve numerical simulations of ocean mixed layer heating and hence climate across this region. Applying the glider-derived light transmission to the 1-Dimensional coupled KPP model (part of the NEMO model) improves the depth

and distribution of heating at the ocean surface, modifying sea surface temperatures that will ultimately influence surface fluxes into the planetary boundary layer. Future work will include how this may impact on monsoon rainfall forecasts.

Modeling Larval Connectivity of Coral Reef Organisms in the Kenyan-Tanzanian Region

Abstract ID : 683

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. C. Gabriela Mayorga Adame ,gmaya@noc.ac.uk ,(Coastal Modeller (Postdoc)) ,United Kingdom ,Liverpool ,Not Presenting[1]

Dr. Hal Batchelder ,hbatch@pices.int ,(None) ,United States , ,Not Presenting[2]

Prof. Yvette Spitz ,yvette@coas.oregonstate.edu ,(Professor/ Scientists) ,United States ,Corvallis ,Not Presenting[3]

1 - UK National Oceanography Centre 2 - North Pacific Marine Science Organization 3 - Oregon State University

Most coral reef organisms have a bipartite life-cycle; being site attached as adults but having pelagic larval stages that allow them to disperse to other reefs. Connectivity among coral reef patches is critical to the survival of local populations of reef organisms, and requires movement across gaps that are not suitable habitat for recruitment. Knowledge of population connectivity among individual reef habitats within a broader geographic region of coral reefs has been identified as key to developing efficient spatial management strategies to protect marine ecosystems. The study of larval connectivity of marine organisms is a complex multidisciplinary challenge that is difficult to address by direct observation alone. An approach that couples ocean circulation models with individual based models (IBMs) of larvae with different degrees of life-history complexity has been used to assess connectivity patterns in several coral reef regions (e.g., the Great Barrier Reef and the Caribbean). We applied the IBM particle tracking approach to the Kenyan-Tanzanian region, which exhibits strong seasonality in the alongshore currents due to the influence of the monsoon. A 3-dimensional ocean circulation model with 2 km horizontal resolution was coupled to IBMs that track virtual larvae released from each of 661 reef habitats, associated with 15 distinct regions. Given that reefs provide homes to numerous species with diverse life-histories, several scenarios were modeled to examine the variety of dispersal and connectivity patterns possible. We examined the effects of short (<12 days) and long (>50 days) pelagic larval durations (PLD), differences in swimming abilities (implemented as reef perception distances), and active depth keeping in reef connectivity, as well as the effect of temperature dependent PLD. Short PLD virtual larvae (typical of corals) were passively advected only. Long PLD virtual larvae included an idealized ontogenetic vertical migration behavior characteristic of larval fish. The influence of interannual environmental variations was assessed for two contrasting years. Less than 0.3% of the virtual coral larvae relesead successfully settled, within region settlement was 0.38%, substantially greater than inter-region settlement (ca. 0.2%). Settlement of virtual coral reef fish larvae was >20% overall, with increased cross-region recruitment.

Salinity intrusions in the Bay of Bengal from a highly resolved Argo float array

Abstract ID : 739

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Alejandra Sanchez-Franks ,alsf@noc.ac.uk ,(None) ,United Kingdom ,Southampton ,Not Presenting[1]

Dr. Brian King ,bak@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Prof. Adrian Matthews ,a.j.matthews@uea.ac.uk ,(Professor of Meteorology) ,United Kingdom ,Norwich ,Not Presenting[3]

Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[4]

Dr. Ben Webber ,B.Webber@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[3]

Dr. Dariusz Baranowski ,darek.baranowski@gmail.com ,(None) ,Poland ,Warsaw ,Not Presenting[7]

Dr. Bastien Queste ,b.queste@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. V. Vijith ,vijithvnair@gmail.com ,(Assistant Professor) ,India ,Kochi ,Not Presenting[9]

Dr. Jenson George ,jensonvgeorge@gmail.com ,(Post Doctoral Fellow) ,India ,Bangalore ,Not Presenting[4]

Miss. V Thushara ,thushara@caos.iisc.ernet.in ,(None) ,India , ,Not Presenting[11]

Dr. Elizabeth Kent ,eck@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - National Oceanography Centre, Southampton, UK 2 - National Oceanography Centre 3 - University of East Anglia 4 - Indian Institute of Science 5 - University of East Anglia 6 - University of East Anglia 7 - Institute of Geophysics, Faculty of Physics, University of Warsaw, Warsaw, Poland 8 - University of East Anglia 9 - School of Marine Sciences, Cochin University of Science and Technology, Kochi, India 10 - Indian Institute of Science 11 - Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore, India 12 - National Oceanography Centre, Southampton, UK

An optimal interpolation (OI) method is used to construct gridded time series of temperature and salinity with daily resolution in the Bay of Bengal. The data incorporated into the OI gridded time series includes measurements from 7 Argo floats with enhanced near-surface resolution, 5

underwater gliders, and a ship-borne CTD deployed during the Bay of Bengal Boundary Layer Experiment (BoBBLE) field campaign, which took place summer 2016 in the Bay of Bengal. The OI also uses data from the international Argo float program.

The OI gridded time series shows the evolution of the salinity and temperature variability in the surface (top 500 m) layer of the southern Bay of Bengal. Salinity profiles indicate the observed salinity maxima are likely salinity intrusions advected from the Arabian Sea via the Southwest Monsoon Current. These results suggest that during the summer monsoon, the heat and freshwater budgets are not locally driven. Elevated salinity is also observed in the uppermost (top 50 m) surface layer, generally corresponding in time to the salinity intrusions at depth. The elevated surface salinity events have a duration of 2-3 days and occur every few weeks (and do not appear to be restricted to the southwest monsoon). The combination of datasets from the BoBBLE field campaign has provided an important ocean observing system that will be will be critical in determining seasonal and interannual heat and freshwater variability in the Bay of Bengal.

Connectivity between the Somali Current and Arabian Sea interior

Abstract ID : 830

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Pierre L'Hégaret ,pierre.lhegaret@outlook.fr ,(None) ,United States ,Miami ,Not Presenting[1]

Prof. Lisa Beal ,lbeal@rsmas.miami.edu ,(Professor of Ocean Sciences) ,United States ,Miami ,Not Presenting[2]

Dr. Shane Elipot ,selipot@rsmas.miami.edu ,(Associate Scientist) ,United States ,Miami ,Not Presenting[2]

1 - None 2 - Rosenstiel School of Marine and Atmospheric Science at the University of Miami 3 - Rosenstiel School of Marine and Atmospheric Science at the University of Miami

We use real and synthetic drifters in the Arabian Sea and tropical Indian Ocean to reveal the evolving connectivity of the Somali Current with the ocean interior on a monthly time scale. The Indian monsoon drives a seasonal reversal of the circulation in this region, such that an Eulerian approach can create artefacts of currents and their connectivity through temporal averaging. Hence, we simulate hundreds of thousands of synthetic drifters in both an absolute velocity field (from drifters) and in a geostrophic velocity field (from satellite measurements), in order to create statistical robustness, longer trajectories, and a separation of the Ekman and geostrophic components of the flow. Most significantly, we find a lack of connectivity between the Somali Current and the northeastern Arabian Sea throughout the year, with impacts on the sea surface temperature, and hence the stritification and monsoon strength. In agreement with previous observations, we find that the Somali Current splits into coastal and offshore components. We are able to further show the differences between the geostrophic and Ekman flows in both the simulated and observed drifters. Geostrophy sustains a year-round circulation south of the equator and a coastal connectivity in boreal summer between the Somali Current and the Great Whirl, its northern extension. However, driven by the monsoon reversal, the wind-induced circulation injects seasonal variability into the geostrophic balance. The gyre south of the equator stops from late summer to fall, and its northern branch moves southward in winter and overshoots north of the equator in spring. Moreover, in summer, drifters captured in the Great Whirl are pushed southward into the equatorial current, towards the Bay of Bengal. Thereby, these regimes, sustained by either Ekman or geostrophy, imply different near-surface and sub-surface circulations. Furthermore, from April to September, the Somali Current advects water masses with temperature warming up over 29°C towards the equator and freshening down to 26.5°C into the Great Whirl.

Climate Change Adaptation and Geospatial Technology at Kavaratti Island - Lakshadweep Islands, India

Abstract ID : 840

Conflict Declaration : There is no conflict of interest of anyway in the content and study related to the abstract submitted herewith.

Content Motivation : This study is carried out in the islands located in the submarine ridge, central Indian Ocean.

Additional Information : This abstract is a part of the ongoing interdisciplinary research network project entitled "Vulnerability Assessment and Development of Adaptation Strategies for Climate Change Impact with Special Reference to Coasts and Island Ecosystems of India (VACCIN)" funded by Ministry of Science and Technology, Govt. of India.

Dr. J Sundaresan Pillai ,csirvaccin2015@gmail.com ,(Head Climate Change Informatics) ,India ,New Delhi ,Not Presenting[1]

Mr. Mutum Ibomcha Singh ,mutum.singh1@gmail.com ,(None) ,India , ,Not Presenting[1]

Mr. Arghadyuti Banerjee ,arghadyutibanerjee@gmail.com ,(None) ,India , ,Not Presenting[1]

Mr. N S Sreekanth ,nssreekanth@gmail.com ,(None) ,India , ,Not Presenting[4]

1 - CSIR-NISCAIR 2 - CSIR-NISCAIR 3 - CSIR-NISCAIR 4 - Centre for Development of Advanced Computing (C-DAC)

Lakshadweep Islands are tiny Islands (area 32 sq.km) scattered over Arabian Sea 8^0 and 13^0 N latitude and 71^0 and 74^0 E longitude. It is located north to south on a contiguous submarine ridge in the central Indian Ocean. Kavaratti Island is one of the inhabited islands of Lakshadweep archipelago. During the last many decades all the systems viz, biological and physical in all continents and Oceans had recorded signals of unusual warming. Climate Change due to global warming followed by accelerated sea level rise will have profound impact on these tiny Islands. The limited land available in Lakshadweep islands is to be properly planned for adaptation to compact the accelerated sea level rise, inundation of limited land, natural resources and ecosystem in total. Geospatial Technology (GST) in association with Information and Communication technology (ICT) is applied at Kavaratti Island as a part of the ongoing network project "Vulnerability Assessment and Development of Adaptation Strategies for Climate change Impact with special reference to Coasts and island ecosystem India (VACCIN)". Task of adaptation inclusive development and spatial challenge at Kavaratti Island is examined through above perspectives. Height of the island from regions of specific points (total 3875 locations) houses, other establishments, water sources etc. were surveyed using DGPS (Differential Global Position System). During survey it is recorded that maximum height of Kavaratti Island is 7.629 M from mean Sea level and minimum height is 1.49 M. As a part of the adaptation inclusive developmental programs for Kavaratti Island with data intensive approach of fourth paradigam, detailed survey on water source , sanitation, health information, livelihood data, economic and demographic details, information and communication technology, climate change knowledge & perspectives and entrepreneurships were collected from all the permanent residents of

Kavaratti Island. Application of this data for spatial planning is dedicated and designed through a web based platform. ICT along with Geospatial Technology (GST) is developed for entrepreneurship and heritage industry as an adaptive measure for Kavaratti Island.

Eddies control oxygen availability and denitrifying potential in the north west Arabian Sea.

Abstract ID : 1157

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Bastien Queste ,b.queste@uea.ac.uk ,(None) ,United Kingdom , ,Presenting[1]

Dr. Clement Vic ,c.vic@soton.ac.uk ,(Post-doctoral researcher) ,United Kingdom ,Southampton ,Presenting[2]

Dr. Sergey Pionktovski ,spion@squ.edu.om ,(None) ,Oman , ,Not Presenting[3]

Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[1]

1 - University of East Anglia 2 - University of Southampton 3 - Sultan Qaboos University 4 - University of East Anglia

Ocean oxygen concentrations regulate chemical and biological processes, with subtle thresholds leading to shifts in ecosystem functioning; limited deoxygenation and small changes in oxygen distribution can lead to dramatic shifts in ecosystem functioning as systems flip from one oxic state to another. Mixing of an oxygenated source within an oxygen minimum zone (OMZ) defines the chemical and biological state of water masses transported. Here we show, using a combination of glider observations and a 2km nested ROMS model, that local "peddies" govern the mixing of Persian Gulf water in the Gulf of Oman and define the extent of the suboxic zone as it travels along the Gulf of Oman and into the Arabian Sea. The glider observations show drastic deoxygenation of the now persistently suboxic Gulf of Oman OMZ (from 6 µM to < 2µM in 50 years). The seasonal variability in eddy energy in the numerical model is found to set the oxygen concentration of export watermasses. In summer, this causes a four-fold reduction in denitrifying potential along 26.5 σ (the core of the PGW). We conclude that highly dynamic marginal regions such as the Gulf of Oman play a critical and underestimated role in defining vertical habitat space, regional denitrification budgets and ventilation across the western Indian Ocean.

Biogeochemistry of carbon dioxide system, oxygen and nitrogen in the Southern Bay of Bengal: Findings from Bay of Bengal Boundary Layer Experiment (BoBBLE)

Abstract ID : 1249

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Amit Sarkar ,amitsarkar81@gmail.com ,(None) ,India , ,Not Presenting[1]

1 - ESSO-National Centre for Antarctic and Ocean Research, Goa, India.

We have investigated the cycling of carbon, oxygen and nitrogen in the southern Bay of Bengal (BoB) during the BoBBLE field campaign during the summer monsoon of 2016. In this region, the effect of fresh water input is much lower compared to the northern BoB but it is influenced by the strong summer monsoon current (SMC) that carries high salinity water from the Arabian Sea into the BoB. Observations were carried out along east-west transect along 8^{o}N comprising of 6 stations and a 10-day quasi-time series observation at a fixed station (8^{o}N, 89^{o}E). The measured pH ranged from 8.071 to 8.168 whereas total alkalinity (TA) varied between 2172 and 2295 µmol kg^{-1}. Atmospheric CO_2 ranged between 386 and 409 µatm with higher concentrations at the western stations; these stations also exhibited high pCO_2 with a range of 467-554 µatm. The low surface pH, in tandem with low TA and high pCO_2 suggest upwelled waters presumably associated with the SMC. Overall, higher pCO_2 was observed at all stations, compared to the atmospheric mixing ratios, suggesting this region as a possible source of CO_2 to the atmosphere during summer. The dissolved oxygen (DO) at the surface ranged between 199-212 µM with relatively higher values at the eastern stations. At 3 western stations, low DO (~7µM) levels and occurrence of secondary NO_2^- maxima (>1µM) in mid-depths (100-150m) were experienced. At these depths we also observed that significant N_2O concentrations coincided with NO_3^- draw-down. This suggests that the oxygen deficient water in southern BoB has the potential to host bio-geochemical activities those contribute to the oceanic fixed Nitrogen loss.

MetOp-A IASI Decadal Observation and Monitoring of Global Surface Thermodynamic Parameters

Abstract ID : 226

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Daniel Zhou ,daniel.k.zhou@nasa.gov ,(Physical Scientist) ,United States ,Hampton ,Not Presenting[1]

Dr. Allen Larar ,allen.m.larar@nasa.gov ,(None) ,United States , ,Not Presenting[1]

Dr. Xu Liu ,Xu.Liu-1@nasa.gov ,(None) , , ,Not Presenting[3]

1 - NASA LaRC 2 - NASA LaRC 3 - NASA Langley Research Center

Presented here are global surface thermodynamic parameters, such as land surface IR emissivity, volumetric soil moisture (VSM), and skin temperature (denoted as Ts), retrieved from the Infrared Atmospheric Sounding Interferometer (IASI) measurements over the past decade.
Monthly-mean spatially-gridded climatology datasets are generated to demonstrate emissivity and VSM spatial variation as well as their seasonal-cycle and inter-annual variability. The VSM estimated from IR measurements (denoted as IR-VSM) is compared with that routinely retrieved from microwave multi-sensor measurements (denoted as MW-VSM). Positive agreement is shown to exist between IR- and MW-VSM.
The relationship between IR-VSM and Ts, as well as the skin temperature diurnal difference (denoted as DTs), are examined using Ts retrieved from the same measurements of IASI. We are able to draw the conclusion that both Ts and DTs follow an inverse relationship with VSM.
IASI global Ts indicates global surface warming in the past decade. IASI global Ts anomalies are compared with NASA GISS global surface air temperature (denoted as Ta) anomalies. Despite the physical difference between surface Ts and Ta, both indicate global surface warming during the past decade.

Observing the Earth's Atmosphere and Surface using Satellite-based Hyperspectral Observation

Abstract ID : 241

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Xu Liu ,Xu.Liu-1@nasa.gov ,(None) , , ,Not Presenting[1]

Dr. Xu Liu ,Xu.Liu-1@nasa.gov ,(None) , , ,Not Presenting[1]

Dr. Daniel Zhou ,daniel.k.zhou@nasa.gov ,(Physical Scientist) ,United States ,Hampton ,Not Presenting[3]

1 - NASA Langley Research Center 2 - NASA Langley Research Center 3 - NASA LaRC

Satellite-based hyperspectral observations provide high information content for the Earth's atmospheric and surface properties; however, in order to analyze hyperspectral data efficiently, fast and accurate radiative transfer model is needed. We have developed a Principal Component-based radiative transfer model (PCRTM) which can simulate radiative transfer in the cloudy atmosphere from far IR to visible and UV spectral regions quickly and accurately. Multi-scattering of multiple layers of clouds/aerosols is included in the model. The computation speed is 3 to 4 orders of magnitude faster than the medium speed correlated-k option MODTRAN5 and LBLRTM. The PCRTM calculated radiance spectra agree with the Modtran and LBLRTM within 0.02%. We will demonstrate the application of the PCRTM forward model for atmospheric and surface property inversions and for climate observation studies.

Coastal Altimeter and Scatterometer Fields

Abstract ID : 325

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. P. Ted Strub ,tstrub@coas.oregonstate.edu ,(Professor, Emeritus) ,United States ,Corvallis ,Presenting[1]

Dr. Corinne James ,corinne@coas.oregonstate.edu ,(None) ,United States , ,Not Presenting[1]

Mr. Craig Risien ,crisien@coas.oregonstate.edu ,(Senior Faculty Research Assistant) ,United States ,Corvallis ,Presenting[1]

1 - Oregon State University 2 - Oregon State University 3 - Oregon State University

During the past decade, there have been several efforts to improve the fields retrieved from active radar satellite sensors in regions of the coastal ocean, where land reflections and other signals create difficulties for standard retrieval techniques. Here we consider fields of sea surface height (SSH) from altimeters and surface winds from scatterometers in two regions: off the west coasts of both the U.S. and South Africa. One approach is to combine offshore satellite data with nearshore *in situ* data, as in the blend of altimeter and tide gauge SSH data presented here (see also the presentation by C. Risien). This blend improves the alongshore geostrophic currents derived from the SSH fields. The other approach is to minimize or correct for reflections of the radar signals from land. Winds from QuikSCAT have been reprocessed to account for land reflections using two methods: either eliminating retrievals with a fraction of land in the footprint above a thresh-hold; or attempting to estimate and subtract the reflected land energy from the received signal. Wind fields using these methods will be presented. For SSH data, several European projects are also using methods to reduce the effects of reflections in altimeter data and examples of these will be presented for the two target regions. Off the US west coast, comparison to the available *in situ* data help to evaluate the wind and geostrophic velocities, derived from the blended SSH data. One purpose of the presentation is to inform the community about these methods and data sets and to invite their evaluation in a greater number of coastal regions in the global ocean.

Studies of Land Cover Changes and their Simulated Impacts on Climate with the CG-LTDR Remote Sensing Datasets

Abstract ID : 628

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Xueli SHI ,shixlncc2011@hotmail.com ,(None) ,China ,Beijing ,Presenting[1]

Dr. Yanwu ZHANG ,zhangyw@cma.gov.cn ,(None) ,China , ,Not Presenting[1]

Mr. Huijuan HE ,1350887165@qq.com ,(None) ,China , ,Not Presenting[3]

Dr. Wenyan ZHOU ,zhouwy@cma.gov.cn ,(None) ,China , ,Not Presenting[1]

1 - National Climate Center 2 - National Climate Center 3 - 2. Shaanxi Remote Sensing Infromation Center for Agriculture 4 - National Climate Center

Various high-resolution remote sensing datasets have provided essential databases for land cover (LC) changes detection at different scales, as well as the climate effects investigations.
In this paper, the global CG-LTDR datasets has firstly been used to analyze the LC changes in China during 1990-2010 after the validation and comparisons with other references remote sensing datasets. The results show that the CG-LTDR had a comparable and even higher classification precision. The LC types in China had dramatically (smoothly) changed during 1990-2000 (2000-2010) in China, which is related to the implementation of national policy and economic development. The increase of woodland area was the most significant mainly due to the land use transformation from crop to tree in the Southeastern China, and grassland into woodland in part of the Southwest and Northeast China. Because of the deforestation and cropland expansion, the coverage of woodland was decreased in some of the Northeast and Northwest China regions. The bareland locating at the Northwest China, shows an increasing trend due to the degradation of grassland.
The multi-time LC datasets was also applied into the climate model of Beijing Climate Center (BCC_AGCM) after making necessary land cover type re-classification and up-scaling, to investigate the LC changes impacts on climate. Results has shown that the revised LC datasets had certain impacts on the model performances of both atmosphere and land surface variables, especially the temperature.
Key Words: CG-LTDR datasets, Land cover, precision evaluation, BCC_AGCM simulation, climate

The spatial distribution of rainfall associated with tropical cyclones that making landfall over China

Abstract ID : 782

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Shoujuan Shu ,sjshu@zju.edu.cn ,(Associate professor) ,China ,Hangzhou ,Presenting[1]

Dr. Xibin Feng ,294118210@qq.com ,(None) ,China , ,Not Presenting[2]

1 - Zhejiang University 2 - Nanjing University

The spatial distribution of rainfall associated with tropical cyclone (TC) that making landfall over China are examined by using ten years of data from the Tropical Rainfall Measurement Mission satellite's Precipitation Radar (TRMM PR) in this study. The rainfall area, magnitude as well as the location of heavy rainfall are analyzed from 24 h prior to landfall to 24 h after landfall of TCs. Results show that prior to landfall, the rainfall area of weak TCs is less than that for strong TCs. However, the rainfall distribution characteristics are different with different TC intensity. The symmetric heavy rainfall that distributes around centers of strong TC changes to asymmetric pattern with heavy rainfall locating in the downshear quadrants of weak TC circulation, suggesting a resistance impact the strong TC exerts to the environmental vertical wind shear. After landfall, the medium rainfall covers symmetrically about four hundred kilometers from centers for weak TCs. While for strong TCs, the medium rainfall decreases largely and heavy rainfall dominates over the downshear quadrant within two hundred kilometers from TC centers.

Analyses further show that the TC rainfall area is significant positively with the mid-level environmental relative humidity. A possible mechanism for the impact of dry air intrusion on the rainfall of landfalling TCs is also presented in this work. The stronger a TC is, more dry air the TC engulfs. Along with TC landfall, large amounts of dry air intrudes and encircles the TC circulation. As a result of eyewall contraction and associated enhancement of eyewall convection, TC rainfall is eventually strengthened.

Investigation the relationship between Sea Surface Fluxes for Tropical Cyclone Intensity Evolution

Abstract ID : 1038

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Chian-Yi Liu ,cyliu@csrsr.ncu.edu.tw ,(Associate Professor) ,Taiwan ,Taoyuan ,Not Presenting[1]

Mr. You-Cheng Lai ,e832041@gmail.com ,(None) ,Taiwan , ,Not Presenting[2]

Mr. Shen-Cha Hsu ,weiny1992@gmail.com ,(None) ,Taiwan , ,Not Presenting[2]

1 - National Central University, TAIWAN 2 - National Central University 3 - National Central University

The genesis and intensification of tropical cyclone(TC) are usually occurring in the ocean where is lacking those traditional observations like surface in-situ data or radiosounde for upper atmosphere. Therefore, satellite data plays a critical role in the purpose of simulation and/or forecast of TC in these stages, and the further investigation of the evolution and intensity intensification. According to the earlier studies, part of the energy for TC intensification is associated with the planetary boundary processes, which might be through the air-sea interaction like latent heat flux and sensible heat flux. Furthermore, sea surface wind could be an important role between sea and air when gradient is presented. Therefore, sea surface wind data from the Advanced Scatterometer (ASCAT) which is aboard on ESA Metop-A satellite are used to address this issue in this study through the data assimilation technique and the use of regional Weather Research and Forecasting (WRF) model. The main focus is placed on the investigation of the impacts from sea surface wind, sensible heat flux, and latent heat flux for the TC forecast. The discussion on the relative importance of those above fluxes during the TC intensification stage.

This study is divided into two parts: data assimilation experiment and sensitivity experiment. Typhoon Nuri (2008) in the northwestern Pacific Ocean is chosen to elaborate those fluxes and roles as described. In first part of experiment, the best forecast skill is from the use of ASCAT and traditional observation data sets, by examination of the TC's intensity and track forecasts. This is due to the ASCAT data can improve the structure of surface wind in the initial time.

Development of geophysical products from the new generation of Korean geostationary meteorological satellite Geo-KOMPSAT-2A

Abstract ID : 1349

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Sung-Rae Chung ,csr@korea.kr ,(Senior Researcher) ,South Korea ,Jincheon ,Not Presenting[1]

Prof. Dong-Bin Shin ,dbshin@yonsei.ac.kr ,(None) ,South Korea , ,Not Presenting[2]

Dr. Seon-Kyun Baek ,frogsun@korea.kr ,(None) ,South Korea , ,Not Presenting[1]

Dr. Gyung-Soo Han ,kyung-soo.han@pknu.ac.kr ,(None) ,South Korea , ,Not Presenting[4]

Prof. Myoung-Hwan Ahn ,terryahn65@gmail.com ,(None) ,South Korea ,Seoul ,Not Presenting[5]

Prof. Won-Chan Jung ,wcjung@etri.re.kr ,(None) ,South Korea , ,Not Presenting[6]

1 - Korea Meteorological Administration 2 - Yonsei University 3 - Korea Meteorological Administration 4 - Pukyong National University 5 - Ewha Womans U. 6 - Electronics and Telecommunications Research Institute

Korea Meteorological Administration (KMA) has developed second geostationary meteorological satellite, Geo-KOMPSAT-2A (GK-2A) since 2013. It is scheduled for a launch in May 2018. GK-2A will have a new generation of geostationary imager, Advanced Meteorological Imager (AMI) like Himawari-8/9 and GOES-R satellites. GK-2A/AMI will provide huge observational data through 16 channels with high spatial and temporal resolution to observe the Earth's weather, climate and environment. In order to implement these applications, KMA is developing fifty-two geophysical products in cooperation with Korean Electronics and Telecommunications Research Institute (ETRI) and domestic academia. These geophysical products are categorized as scene analysis/surface information, cloud/rainfall, radiation/aerosol and atmosphere/aviation information according to their characteristics and applications. We are now in the provisional validation stage of the products to evaluate their performances and utilizations for satellite data users as well as in-depth review the science and concepts for the products. In this paper, the status of the development of GK-2A's geophysical products and related activities are presented.

Modulation of Bjerknes feedback on the decadal variations in ENSO predictability

Abstract ID : 123

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Xiang-Hui Fang ,fangxh@fudan.edu.cn ,(Postdoctor) ,China ,Shanghai ,Presenting[1]

Prof. Jin-Yi Yu ,jyy@uci.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Fei Zheng ,zhengfei@mail.iap.ac.cn ,(None) ,China , ,Not Presenting[3]

1 - Fudan university 2 - Department of Earth System Science, University of California, Irvine, CA, USA
3 - Institute of Atmospheric Sciences, Chinese Academy of Sciences

Clear decadal variations exist in the predictability of the El Niño-Southern Oscillation (ENSO), with the most recent decade having the lowest ENSO predictability in the past six decades. It has been suggested that the amplitude, period and sustainability of ENSO are determined by the ocean-atmosphere coupling strength in the tropical Pacific. Physically, this coupling strength can be largely interpreted as the strength of the so-called Bjerknes feedback (BF), which describes the sensitivity of the atmospheric response to ocean forcing and vice versa. In fact, the strength of the BF has been used as a criterion to measure the instability of the coupled ENSO mode in both observations as well as model simulations. Here we demonstrate that decadal variations in BF intensity are largely a result of the sensitivity of the zonal winds to the zonal sea level pressure (SLP) gradient in the equatorial Pacific. Furthermore, the results show that during low ENSO predictability decades, zonal wind anomalies over the equatorial Pacific are more linked to SLP variations in the off-equatorial Pacific, which can then transfer this information into surface temperature and precipitation fields through the BF, suggesting a weakening in the ocean-atmosphere coupling in the tropical Pacific. This result indicates that more attention should be paid to off-equatorial processes in the prediction of ENSO.

The effect of regional climate change on ecological conditions and feeding of Persian sturgeon (Acipenser persicus) in coastal zone of Caspian Sea (Iranian water)

Abstract ID : 139

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Kourosh HaddadiMoghaddam ,khkhmoghadam@gmail.com ,(International sturgeon research institute,Rasht, Guilan, Iran ,P.O.Box:41635-3464) ,Iran ,Rasht ,Not Presenting[1]

1 - None

Ecosystems in the Caspian Sea region have been heavily modified by anthropogenic activities, mainly as a result of changes in the water flow and degradation of the water quality in the ecosystems. Changes in the climate change have influenced regional economies, particularly obvious in the impacts on fish stocks. The bulk of the remaining stocks of the world sturgeon resources is located here and provides another unique feature of the Caspian Sea where 80-90% of the world Caviar is produced. Natural feeding and prey selection of *A.persicu* (Bordin,1987*) s studied in southern part of Caspian Sea, Iran. Persi*an sturgeon caught under 10m depth using bottom trawl net by research vessel during from 2013 to 2015 in east, central and west of southern parts of coastal zone of Caspian Sea. During 136 trawling in the aimed seasons,108 un matured Persian sturgeon 1 to 2 years old ranging from 25 to 34 cm(total length) and 48 to 294 g (body weight) captured. Examination of stomach contents, revealed food spectrum composed of benthic belonging to crustaceans ,polychaeta and bony fishes. Investigation on stomach contents of sturgeon *Acipenser persicus* caught under 10m depth in 2006 to 2007 surveys showed that there is significant difference in the consumed food. Polychaeta is the primary consumed food and crustacean is the secondary one. Our results showed that, the climate change had not effect in food chain and ecological conditions of sturgeon

Key words: Sturgeon, Climate change , Ecology, Caspian Sea

Interannual variability of spring intraseasonal variability and Mei-Yu onset

Abstract ID : 657

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Yonghong Yao ,yyh@nju.edu.cn ,(Associated Professor) ,China ,Nanjing ,Presenting[1]

Dr. Hai Lin ,Hai.lin@ec.ca ,(None) ,Canada , ,Not Presenting[2]

Mr. Qigang Wu ,qigangwu@nju.edu.cn ,(None) ,China , ,Not Presenting[3]

1 - School of the Atomospheric Sciences, Nanjing University, China 2 - Enviornment Canada 3 - School of the Atomospheric Sciences

The Mei-yu onset over the middle-lower reaches of Yangtze River Basin from mid-June to Mid-July in China is associated with the transition of weather regimes with the evolution of the East Asia summer monsoon, and the Mei-Yu onset date is closely related to the amount of rainfall and the rainy season length as well as its intensity. In this study, we find that the Mei-Yu onset date is significantly associated with the strength of the intraseasonal oscillation (ISO) over the East Asia and the western Pacific (EAWNP) region in spring, and that a strong (weak) EAWNP ISO during the spring season leads to an early (late) onset of Mei-yu over the middle-lower reaches of Yangtze River Basin. The seasonal march of the rain belt in China matches well with the 8 phases of the EAWNP ISO referring to the convective center.

An examination of the precursory signals associated with early onsets of Mei-yu reveals that, during strong spring EAWNP ISO years, the abnormal sea surface temperature (SST) is presented as a conventional ENSO pattern from January to July. With the ENSO pattern, the negative SST anomalies in eastern Indian Ocean and the South China Sea in May lead to the early onset of the South China Sea monsoon?indicating the early Meiyuonset subsequently. Corresponding to the weak spring EAWNP ISO years, the abnormal SST pattern changes from CP-ENSO pattern to EP-ENSO pattern in May, and the positive SST anomalies appear in both eastern Indian Ocean and the South China Sea, and cause the late onset of the South China Sea monsoon suggesting the late onset of Meiyu too.

A statistical forecast model is established using the intensity of spring EAWNP ISO, CP-ENSO and EP-ENSO indices to assess the predictability of the onset dates of Mei-yu. Since all these predictors can be readily monitored in real time, this empirical model provides a real-time forecast tool to predict the Meiyu onset.

Initial condition perturbations on different scales in a large ensemble climate system model experiment and the associated multi-decadal regional-scale climate change response

Abstract ID : 881

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Willem Conradie ,stefaan@csag.uct.ac.za ,(PhD student) ,South Africa ,Cape Town ,Not Presenting[1]

Dr. Joseph Daron ,joseph.daron@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Mr. Babatunde Abiodun ,babiodun@csag.uct.ac.za ,(Senior Lecturer) ,South Africa ,Cape Town ,Not Presenting[3]

Dr. Tristan Hauser ,thauser@csag.uct.ac.za ,(None) ,Canada , ,Not Presenting[3]

1 - Climate System Analysis Group, University of Cape Town 2 - Met office 3 - CSAG, UCT 4 - CSAG, UCT

Large initial condition (IC) ensembles are gaining ground as a means of investigating different scales of uncertainty-including a large irreducible component-and the role of internal variability in climate system model projections (e.g. Swart and Fyfe, 2016; Hawkins et al., 2015). Here we consider three transient forcing ensembles of the IC ensemble experiment described in Conradie (2015) and Conradie et al. (2016). Each ensemble has 50 members, and is run for 60 years with RCP8.5 forcing. The change in decadal mean temperature in each ensemble member is assessed from the first to the sixth (?T_1) and from the second to the sixth (?T_2) decade. Irreducible uncertainty is responsible for the spread among ensemble members in ?T_1 being a factor of two or larger in the mid- to high-latitudes of both hemispheres. Whereas most regions show statistically indistinguishable differences in the distribution of ?T_2 between ensembles, the influence of differences in initial ocean state between ensembles is often detectable in the distributions of ?T_1 . Centennial-scale differences in the year that ensembles are branched off the control run is shown to alter the multi-decadal scale temperature change over some domains, although this is likely due to the influence of nonlinear model drift. These findings have important implications for interpretation of climate change projections and the design of climate model experiments.

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A midwinter minimum in Atlantic storm track intensity in years of strong jet

Abstract ID : 882

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Hilla Afargan-Gerstman ,hilla.a@gmail.com ,(Phd student at the Weizmann Institute of Science) ,Israel ,Rehovot ,Presenting[1]

Dr. Yohai Kaspi ,yohai.kaspi@weizmann.ac.il ,(None) ,Israel , ,Presenting[2]

1 - None 2 - Weizmann Institute of Science

We investigate the seasonal cycle of the Atlantic storm track and the occurrence of a midwinter minimum of eddy activity over the North Atlantic. Observations show that eddy kinetic energy over the Atlantic is reduced during winter relative to fall and spring, despite the stronger jet stream and enhanced baroclinicity, similarly to the well-known Pacific midwinter minimum. The reduction over the Atlantic is smaller and persists for a shorter period, yet it is statistically significant. To explore the potential role of the jet stream in driving this seasonal cycle, we present an analysis of years of strongest jet versus years of weakest jet over the Atlantic and Pacific basins. We find that when the wintertime jet is stronger, the midwinter suppression of eddy activity is more pronounced, as was found in observations of the Pacific storm track. We also explore the impact of the jet position on the Atlantic storm track seasonal cycle and the response to ENSO and NAO, and show the connection of the midwinter minimum to these modes of variability.

Effects of Surface Orography and Land–Sea Contrast on the Madden–Julian Oscillation in the Maritime Continent: A Numerical Study Using ECHAM5-SIT

Abstract ID : 1210

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Wan-Ling Tseng ,wtseng@gate.sinica.edu.tw ,(Postdoc) ,Taiwan ,Taipei ,Presenting[1]

Dr. Huang-Hsiung Hsu ,hhhsu@gate.sinica.edu.tw ,(Research Fellow Research Center for Environmental Changes) ,Taiwan ,Taipei ,Not Presenting[1]

Prof. Noel Keenlyside ,noel.keenlyside@gfi.uib.no ,(None) ,Norway ,None ,Not Presenting[3]

Prof. Chiung-Wen June Chang ,c.june.chang@gmail.com ,(None) ,Taiwan , ,Not Presenting[4]

Prof. Ben-Jei Tsuang ,btsuang@gmail.com ,(None) ,Taiwan , ,Not Presenting[5]

Dr. Chia-Ying Tu ,cytu@gate.sinica.edu.tw ,(None) ,Taiwan , ,Not Presenting[1]

Mr. Li-Chiang Jiang ,lcjiang@gate.sinica.edu.tw ,(None) ,Taiwan , ,Not Presenting[1]

1 - Academia Sinica 2 - Academia Sinica 3 - Geophysical Institute, University of Bergen, Norway 4 - Chinese Cultural University 5 - National Chung-Hsing University 6 - Academia Sinica 7 - Academia Sinica

This study uses a newly-developed atmospheric general circulation model, ECHAM5 coupled with the Snow-Ice-Thermocline model (ECHAM5-SIT), which realistically simulated the major characteristics of the Madden-Julian Oscillation (MJO), to examine the effects of orography and land-sea contrast on the MJO in the Maritime Continent (MC) during boreal winter. Three experiments are conducted with realistic topography, without orography, and with oceans only in the MC region to evaluate the relative effects of orography and land-sea contrast. Orography and land-sea contrast has the following effects on the MJO in the MC: 1) a larger amplitude, 2) a smaller zonal scale, 3) more realistic periodicity and stronger eastward-propagating signals, 4) a stronger southward detour during the eastward propagation, 5) a distorted coupled Kelvin-Rossby wave structure, and 6) larger low-level moisture convergence. Theoretical and empirical studies have mainly investigated the MJO in an aqua planet framework, which likely provides fundamental but oversimplified views. Detailed exploration of the effects of the mountainous and islands in the MC should lead to a clearer understanding and more accurate forecast of the MJO.

Future change of wintertime North Pacific blocking frequency and intensity in CMIP5 models

Abstract ID : 1247

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Joong-Bae Ahn ,jbahn@pusan.ac.kr ,(Professor) ,South Korea ,Busan ,Presenting[1]

Dr. Doo-Young Lee ,doo.young@bsc.es ,(None) ,Spain , ,Not Presenting[2]

1 - Pusan National University, South Korea 2 - Earth Sciences Department, Barcelona Supercomputing Center

The current status and future changes in the frequency and intensity of climatological blocking activity over the North Pacific region are investigated using historical and two Representative Concentration Pathway (RCP4.5 and 8.5) simulations in the coupled climate models from phase 5 of the Coupled Model Inter-comparison Project (CMIP5) for boreal winters (December-February) over a 30-year period. The future change in the Pacific blocking frequency and intensity are examined in terms of the projected meridional thickness gradient, Hadley circulation changes, and changes in the probability distribution of categorized blocking strength. The five CMIP5 models that show better performance in reproducing climatological blocking events in the historical simulations for the Pacific region are selected for the analyses of the projected blocking activities. The climatological winter Pacific blocking frequencies of most of the individual models and model mean values show a tendency to decrease under global warming conditions. The trend is closely linked with the strong upper level westerly wind, resulting in less meandering air flow, consistent with the enhanced meridional temperature gradients at mid-latitude in the future climate. The decreased frequency in climatological atmospheric blocking over the Pacific under warming may also be influenced by the strengthening of the north-south temperature gradients due to the poleward extension of Hadley circulation in the subtropics. The climatology of the Pacific blocking intensity in boreal winter also tends to decrease slightly due to a future reduction in the number of strong blocking events.

Acknowledgement
This work was funded by the Korea Meteorological Administration Research and Development Program under grant KMIPA 2015-2081.

Winter climate changes of East Asian winter monsoon under RCP scenarios

Abstract ID : 1248

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Joong-Bae Ahn ,jbahn@pusan.ac.kr ,(Professor) ,South Korea ,Busan ,Presenting[1]

Dr. Ja-Young Hong ,hongja0627@gmail.com ,(None) ,South Korea , ,Not Presenting[2]

Prof. Jong-Ghap Jhun ,jgjhun@snu.ac.kr ,(None) ,South Korea , ,Not Presenting[3]

1 - Pusan National University, South Korea 2 - Division of Polar Climate Change, Korea Polar Research Institute 3 - School of Earth and Environmental Sciences, Seoul National University

The changes in the climatology and variability of the East Asian winter monsoon (EAWM) for the late 21st century (2070-2099) under the RCP 4.5 and 8.5 scenarios are projected in terms of EAWM indices (EAWMIs). Nine of twenty-three climate models participating Coupled Model Intercomparison Project phase 5 (CMIP5) are selected based on capability for boreal winter climatology and the interannual variability and a multi-model ensemble is applied to the nine model data.. The ensemble CMIP5 is capable of reproducing the overall features of the EAWM in spite of some biases in the region. The negative correlations between the EAWMIs and boreal winter temperature and 3-5 years of the major interannual variation observed in this region are well simulated. The regressed fields of sea level pressure, surface air temperature, 500-hPa geopotential height, and 300-hPa zonal wind are well established with pattern correlations above 0.83 between CMIP5 and observation data. The differences between RCPs and Historical indicate strong warming, which increases with latitude, ranging from 1 to 5 °C under RCP4.5 and from 3 to 7 °C under RCP8.5 in the East Asian region. The anomalous southerly winds generally become stronger, implying weaker EAWMs in both scenarios. The future projections reveal that the interannual variability of the indices will be maintained with an intensity similar to that of the present. The correlation between monsoon indices and Arctic Oscillation increases over time. On the other hand, the correlation between monsoon indices and North Atlantic Oscillation decreases

Acknowledgement
This work was funded by the Korea Meteorological Administration Research and Development Program under grant KMIPA 2015-2081.

Precipitation variability in the Serengeti during the 20th century

Abstract ID : 492

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Josephine Mahony ,josephine.mahony@wolfson.ox.ac.uk ,(DPhil Student) ,United Kingdom ,Oxford ,Not Presenting[1]

1 - University of Oxford

The Serengeti-Mara ecosystem covers 30 000 km^2 and spans the Tanzania-Kenya border. The rainfall regime here is dominated by the seasonal passage of the inter-tropical convergence zone. However, a strong rainfall gradient is present across the park, with the north-west receiving three times more annual precipitation than the southeast. This is due to moisture from Lake Victoria generating precipitation in the north-western portion of the park, while the southeast lies in the rain-shadow of Ngorogoro Crater. The wildlife in the park is strongly affected by the precipitation patterns, and the rainfall gradient is one of the key driving forces of the annual migration of 1.5 million wildebeest. The focus of this study is to analyse how precipitation patterns in this region have varied and changed over the past century. This allows a better understanding of the changes that the region has already experienced, and provides a baseline dataset for regional climate model evaluation. Thus it provides the foundation for work that could enable a better understanding of how precipitation in the region may change in the future. The study uses data from a network of raingauges that were set up in the early 20th century. The first gauge was set up in 1902 and the number of gauges grew until a peak in the 1960s and 1970s, with three complete 30 year time series running from 1921-1950, 8 from 1931-1960 and 26 from 1961-1990. Though this data has been used extensively in ecological studies, little work from a climate science perspective has been carried out on the dataset. This study presents the calculated baseline climatologies for different time periods, using both the new raingauge dataset and existing gridded precipitation datasets. The impacts of large scale climate oscillations (including the El Niño Southern Oscillation and the Indian Ocean Dipole) on regional precipitation are evaluated using composite analysis. The results of trend analysis which test for the existence of long term changes in the regional precipitation are also presented.

Constraining Congo Basin rainfall in the CMIP5 ensemble: a process-based assessment

Abstract ID : 496

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Amy Creese ,amy.creese@keble.ox.ac.uk ,(PhD student) ,United Kingdom ,Oxford ,Presenting[1]

Prof. Richard Washington ,richard.washington@ouce.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - University of Oxford 2 - Oxford University

Despite its significance in the global and regional climate, the Congo Basin continues to receive limited scientific attention compared to other regions of Africa. This is partly a result of an extreme paucity of observational data in the region. In consequence, global coupled models (GCMS), the most common tool for assessing future climate change, are critically under-evaluated. To address the scarcity of research in this region, this study utilises process-based assessments to evaluate numerical model products. Traditional methods of model evaluation are made difficult by a lack of observational data, and as a result, GCMs from different modelling groups simulate vastly differing climatologies for the Congo region. Climatological mean rainfall varies between models by up to a factor 5 in some months, and the location and intensity of rainfall differs starkly. Process-based assessments aim to determine the credibility of model climatologies based on processes that are either better constrained or better understood in numerical models. This study compares Congo rainfall climatologies across a suite of models from the Coupled Model Intercomparison Project (CMIP5). Moisture flux convergence emerges as a quantity that can help differentiate across the spectrum of models, and as a largely dynamical field rather than a parameterised one, is better constrained than rainfall. Significant relationships are found between moisture convergence at low-levels (850hPa and 700hPa) and rainfall, and between moisture flux into the basin at low-levels and rainfall. This has led to a consideration of local and regional features which may influence these fluxes in different models in particular seasons; DJF rainfall is related to flow at 850hPa from the north and east ($r=0.82$ and $r=0.87$ respectively), and SON rainfall is related to westerly flow throughout the lower troposphere ($r=0.60$ at 700hPa). Sea surface temperature biases in the tropical Atlantic are established as a key differentiating factor between wet and dry models in the west of the Congo basin in SON. The existence of robust SST datasets means we are confident in the magnitude of these biases, and we can therefore begin to determine which models produce more credible Congo climatologies based on this relationship.

Improvements in the precipitation distribution of West Africa with a convection-permitting simulation at climate scales

Abstract ID : 700

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Segolene Berthou ,segolene.berthou@metoffice.gov.uk ,(Scientist) ,United Kingdom ,EXETER ,Not Presenting[1]

1 - None

10-year present day and future climate simulations over the whole of Africa with a convection-permitting regional model are being run at the Met Office. The 4.5km regional model (CP4A) is forced at its boundaries with a 25km global model (N512) with present-day AMIP forcing and future climate RCP8.5 forcing. The first 5 years of present-day CP4A show a large improvement in the mean West African monsoon with a reduction in the dry bias compared to the global N512 model. It also shows a better precipitation distribution with more short duration strong rainfall events. It is in good agreement with observations at the 25km scale. It further shows a better timing of the afternoon convection peak compared to N512 and a better representation of wet and dry spells.
There are remaining biases in the model, including an underestimation of the number of wet days by 10-30 %, an underestimation of rainfall at night/morning and too much rainfall over orography. However, these results make us confident that this model will give improved information on locally-driven future changes of the West-African monsoon that the current global models fail to represent.

Distillation of contrasting projections for informing city scale adaptation in Africa

Abstract ID : 872

Conflict Declaration : None

Content Motivation : Arguably the leading challenge in the development of actionable climate projections, is the resolution of contrasts and contradictions from multiple sources of data which reflect a mix or error, bias, skill, and natural variability.

Additional Information : None

Prof. Bruce Hewitson ,hewitson@csag.uct.ac.za ,(Director, CSAG) ,South Africa ,Cape Town ,Not Presenting[1]

Dr. Piotr Wolski ,wolski@csag.uct.ac.za ,(None) ,South Africa , ,Not Presenting[2]

Dr. Christopher Lennard ,lennard@csag.uct.ac.za ,(None) ,South Africa , ,Not Presenting[2]

Dr. Christopher Jack ,cjack@csag.uct.ac.za ,(None) ,South Africa , ,Not Presenting[2]

1 - University of Cape Town 2 - CSAG, University of Cape Town 3 - CSAG, University of Cape Town 4 - CSAG, University of Cape Town

The FRACTAL consortium (www.fractal.org.za) of the Future Climate For Africa (FCFA) programme focuses on climate projections for urban-scale decision making in Africa. At such spatial scales a critical challenge is the contrasting and contradicting indications that emerge from multi-model, multi-method, and multi-resolution ensemble data of GCMs, RCMs, statistical downscaling, and the incomplete observational history. The approach uses the concept of distillation, that is, to distil defensible messages relevant to the decision-scale from data that is a mix of error, bias, and natural variability alongside the signals of interest. The project is developing a framework that considers (a) what constitutes information in the context of climate change and decision needs, and (b) analytical methods to allow the construction of key messages relevant to information needed by the decision makers, and to take account of the variable skill of different models and the uncertainty from natural variability of the climate system.
The analysis is predicated on four information sources: a probabilistic history represented by an incomplete observational record; GCM projections of changes in atmospheric processes at multiple scales, GCM projections of local surface variables, and downscaling from RCMs and from empirical-statistical techniques. For the GCM data the CMIP archive is the primary source, while the RCM and statistical downscaling is from the CORDEX programme. The method uses the representation of changes in key atmospheric processes as the lens to filter and distill the data from the multi-model multi-method ensembles. With input from the urban decision makers these results are processed into forms that are relevant to the risk management decisions, and represented as both narrative and quantitative products for further co-assessment with the recipients. The outcomes focus as much on

what is not possible to project about the future climate, as it does on what is robust about the projections.
The use of climate processes as the initial discriminator of signal from noise shows significant value in identifying where there is data credibility, versus where a source is fundamentally undermined by critical spatial or temporal error in representing climate features of importance to the region.

Modelling changes in the West African Monsoon (2000 to 2100)

Abstract ID : 1044

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Peter Cook ,p.a.cook@reading.ac.uk ,(Research Scientist) ,United Kingdom ,Reading ,Presenting[1]

Prof. Anne Verhoef ,a.verhoef@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Emily C.L. Black ,e.c.l.black@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - University of Reading, UK 2 - University of Reading, UK 3 - University of Reading

The vulnerability of many people in West Africa to hydrological hazard means that it is crucial to understand how the monsoon will change in the future. We are using a Met Office Unified Model (GA3) ensemble of ~25km horizontal resolution, atmosphere-only model runs to investigate change in the West African monsoon under a high emissions scenario. Our study examines the changes in the amount of rain and its intensity, in the spatial distribution and timing of the monsoon, and in the land surface water balance. It is projected that rainfall will increase and become more intense, the monsoon will shift northwards and occur later in the year, and evapo-transpiration will be reduced, while runoff and soil moisture will increase.

Development of Precise Precipitation Data for Assessing the Potential Impacts of Climate Change for Middle East and Africa

Abstract ID : 1484

Conflict Declaration : None

Content Motivation : None

Additional Information : Hirosaki University

Dr. Akiyo Yatagai ,yatagai@hirosaki-u.ac.jp ,(Associate Professor) ,Japan ,Hirosaki ,Presenting[1]

Dr. Vinay Kumar ,neelubijnori@gmail.com ,(None) ,United States , ,Not Presenting[2]

Prof. T.N. Krishnamurti ,tnk@io.met.fsu.edu ,(None) ,United States , ,Not Presenting[3]

1 - None 2 - Texas A&M University 3 - Florida State University

A multimodel superensemble developed by the Florida State University with APHRODITE precipitation produced the best monsoon forecast (Yatagai et al., 2013). With using a similar superensemble scheme, APHRODITE data and updated CMIP models, we examined winter precipitation forecasts over the Middle East. The principal results are as follows: 1) Seasonal (winter) forecasts of Middle East precipitation were considerably improved by use of APHRODITE rain gauge-based data. We could represent the Fertile Crescent pattern. These forecasts are much superior to those from the best model of the suite and ensemble mean. 2) Use of a statistical downscaling and synthetic superensemble method for multimodel forecasts of seasonal climate significantly improved precipitation prediction at higher resolution. However, trends are not well reproduced by this method (Yatagai et al., 2017).

Rain-gauge based products are essential for assessing water availability and regional impact assessment. Hence, APHRODITE-type activity to create such datasets in collaboration with local experts are essential. We have created a gridded precipitation data of Zambia after getting rain-gauge data. We welcome any kinds of cooperation to diagnose future impact of climate changes in Africa.

Space Weather Prediction Through the Observation and Modeling of Coronal Magnetism

Abstract ID : 317

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Sarah Gibson ,sgibson@ucar.edu ,(Senior Scientist/Section Head) ,United States ,Boulder ,Presenting[1]

Dr. Yuhong Fan ,yfan@ucar.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Edward DeLuca ,edeluca@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Steven Tomczyk ,tomczyk@ucar.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Svetlan Tassev ,svetlan.tassev@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Giuliana de Toma ,detoma@ucar.edu ,(None) ,United States , ,Not Presenting[6]

Dr. Steven Tomczyk ,tomczyk@ucar.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Kevin Dalmasse ,dalmasse@ucar.edu ,(None) ,United States , ,Not Presenting[8]

Dr. Antonia Savcheva ,asavcheva@cfa.harvard.edu ,(Astrophysicist) ,United States ,Cambridge ,Not Presenting[3]

Dr. Nishu Karna ,nishu.karna@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Doug Nychka ,nychka@ucar.edu ,(None) ,United States , ,Not Presenting[11]

Mr. Nathaniel Mathews ,nathaniel.mathews@colorado.edu ,(None) ,United States , ,Not Presenting[12]

Dr. Natasha Flyer ,flyer@ucar.edu ,(None) ,United States , ,Not Presenting[11]

1 - NCAR/HAO 2 - NCAR/HAO 3 - Center for Astrophysics/Harvard University 4 - NCAR/HAO 5 - Center for Astrophysics/Harvard University 6 - HAO/NCAR 7 - NCAR/HAO 8 - NCAR 9 - Center for Astrophysics/Harvard University 10 - Center for Astrophysics/Harvard University 11 - NCAR/CISL 12 - University of Colorado 13 - NCAR/CISL

Magnetic fields in the sun's outer atmosphere - the corona - control both solar wind acceleration and the dynamics of solar eruptions. We present progress to date on the Data-Optimized Coronal Field Model (DOCFM) project. The goal of this project is to develop a new methodology for assimilating coronal magnetic diagnostic data into magnetohydrodynamic (MHD) models in order to establish not only the magnetic structure of the source region of coronal mass ejections, but also the global field into which it erupts. In particular, we report on 1) new observational diagnostics using coronal linear

polarization measurements that detect magnetic nulls and super-radial expansion of magnetic flux tubes; 2) the construction of observing system simulation experiment (OSSEs) for testing methodology; 3) a Radial-basis-function Optimization Approximation Method (ROAM) for obtaining orders-of-magnitude increases in speed vs a full grid search of parameter space; and 4) the application of ROAM to a parameterized flux-rope insertion model in order to diagnose the 3D coronal magnetic field from synthetic coronal polarization observations generated for an OSSE.

Storm time ion composition variations in the near earth plasma sheet using space borne measurements

Abstract ID : 847

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. megha pandya ,megha.pandya14@gmail.com ,(Senior Research Fellow) ,India ,Mumbai ,Not Presenting[1]

Prof. B. Veenadhari ,bveena@iigs.iigm.res.in ,(None) ,India , ,Not Presenting[2]

Dr. Sandeep Kumar ,sandeepk.iig@gmail.com ,(Research Associate) ,India ,Navi Mumbai ,Not Presenting[3]

Mr Geoffrey Reeves ,geoff@reevesresearch.org ,(None) ,United States , ,Not Presenting[4]

Dr. Masahito Nose ,nose@kugi.kyoto-u.ac.jp ,(None) ,Japan ,Kyoto ,Not Presenting[5]

1 - None 2 - Indian Institute of Geomagnetism (IIG) 3 - Indian Institute of Geomagnetism 4 - Los Alamos National Laboratory 5 - World Data Center for Geomagnetism, Kyoto, Kyoto University

Streaming solar wind particles and ionospheric O^+ ions play an important role in the global dynamics of the Earth's magnetosphere. The major particle source for the plasma sheet ions is solar wind and ionosphere. The ion composition of the near-Earth plasma sheet changes with the geomagnetic conditions. The solar wind ions contributes the most to the plasma sheet population during geomagnetically quiet conditions while, ionosphere contributes exclusively during the geomagnetic storm conditions. Its ion composition change during different interplanetary conditions is compared using energetic particle flux data obtained from Geotail spacecraft and Van Allen probes. Intense and moderate geomagnetic storms from solar cycle 23 and 24 with ion composition variations in the near-Earth plasma sheet are compared. Intense geomagnetic storms shows higher O^+/H^+ and He^+/H^+ energy density ratio than the moderate ones while there is a strong geomagnetic storm dependence on singly charged heavy O^+ ions. The energy density of H^+, O^+ and He^+ ions also depends on the magnitude and duration of southward IMF Bz and solar wind dynamic pressure. The ion composition changes in plasma sheet are comparable to the ring current region, as reported in previous studies indicating transport of ionospheric ions from plasma sheet to the ring current region through mass dependent acceleration by convection electric field. Some of the results regarding the intense and moderate events for solar cycle 23 and 24 will be discussed in the meeting.

A Model Study on the Role of Ocean-Atmosphere Coupling for the 11-Year Solar Signal in the Troposphere

Abstract ID : 363

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Anne Kubin ,kubin@tropos.de ,(Postdoctoral Researcher) ,Germany ,Leipzig ,Not Presenting[1]

Dr. Janna Abalichin ,janna.abalichin@met.fu-berlin.de ,(None) ,Germany , ,Not Presenting[2]

Prof. Ulrike Langematz ,ulrike.langematz@met.fu-berlin.de ,(None) ,Germany , ,Not Presenting[2]

1 - None 2 - Freie Universitaet Berlin 3 - Freie Universitaet Berlin

The 11-year solar cycle is known to influence the stratospheric circulation and even tropospheric conditions on a hemispheric and seasonal scale. However, large uncertainties exist with respect to the top-down influence of radiative-chemical interactions as well as bottom-up ocean-atmosphere interactions for the tropospheric signal.

Here, effects of the 11-year solar cycle on the tropospheric climate are studied by analyzing integrations of the chemistry climate model EMAC that has been coupled to the MPIOM ocean model. A series of experiments has been tailored to investigate the role of atmosphere-ocean coupling for the formation of the near-surface response to the 11-year solar irradiance variability. The focus is on the north Atlantic region in the northern winter season. The model output is analyzed with a multiple linear regression technique.

It is found that there is a tendency towards a positive phase of the North-Atlantic Oscillation (NAO) at maxima of the Sunspot cycle. The signal is enhanced when the atmosphere-ocean interaction is suppressed by prescribed sea surface temperatures. Additional sensitivity simulations with either the sea surface temperatures or the middle atmosphere being free from 11-year solar influence reveal a key role for the stratospheric forcing in shaping the tropospheric response in the North Atlantic-European region. The robustness of the signals is tested by varying the length of the analyzed time series as well as by varying the set of basis functions used in the regression. The NAO response shows substantial variation of magnitude and even sign when subsets of the analysis period are examined.

Revised historical solar forcing using updated model and proxy data

Abstract ID : 621

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Tatiana Egorova ,t.egorova@pmodwrc.ch ,(Scientist) ,Switzerland ,Davos Dorf ,Not Presenting[1]

Dr. Alexandr I. Shapiro ,shapiroa@mps.mpg.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Eugene Rozanov ,e.rozanov@pmodwrc.ch ,(None) ,Switzerland , ,Presenting[1]

Dr. Ilya Usoskin ,ilya.usoskin@oulu.fi ,(None) ,Finland , ,Not Presenting[4]

Dr. Jürg Beer ,Juerg.Beer@eawag.ch ,(None) ,Switzerland , ,Not Presenting[5]

Prof. Thomas Peter ,thomas.peter@env.ethz.ch ,(None) ,Switzerland , ,Not Presenting[6]

Prof. Werner Schmutz ,werner.schmutz@pmodwrc.ch ,(Director) ,Switzerland ,Davos Dorf ,Not Presenting[1]

1 - PMOD/WRC 2 - MPS 3 - PMOD/WRC 4 - University of Oulu 5 - EAWAG 6 - ETH 7 - PMOD/WRC

There is no consensus on the amplitude of the historical solar forcing. This work aims at the development of more reliable reconstruction of solar irradiance variability on decadal to millennial time scales. We calculate the spectral solar irradiance (SSI) as the weighted sum of the contributions from sunspots umbra/penumbra, faculae and quiet Sun. We introduce activity belts for the calculation of sunspots/facula contributions and new solar structure model for the quietest Sun state. We assume that the solar irradiance from the quiet Sun is varying in time proportionally to a secular (22-year smoothed) variations of the solar modulation potential. The new reconstruction of TSI and SSI covering the period 6000 BCE - 2015 CE is presented. The model simulates well the solar irradiance variability during the satellite era. The TSI change between the Maunder and recent minima is ranged between 3.7 and 4.5 W/m2 depending on the applied solar modulation potential.

Quasi-two-day wave variability in the Southern MLT low latitude during austral summer and winter

Abstract ID : 1056

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Luciana R. Araujo ,lucianarodriggues@uol.com.br ,(None) ,Brazil , ,Not Presenting[1]

Prof. Lourivaldo Mota Lima ,lourivaldo_mota@yahoo.com.br ,(Professor) ,Brazil ,Campina Grande-PB ,Not Presenting[1]

Dr. Paulo Batista ,paulo.batista@inpe.br ,(Senior Researcher) ,Brazil ,São José dos Campos ,Not Presenting[3]

1 - UEPB 2 - UEPB 3 - National Institute for Space Research (INPE)

In the present investigation, the mesosphere/lower thermosphere winds at Cachoeira Paulista (22.7° S, 45.0° W) obtained by meteor radar have been used to investigate the variability of the quasi-two-day wave (QTDW) at a low latitude in the Southern Hemisphere during austral summer and winter. The observations include data obtained during time intervals from December 1999 to July 2006, from September 2007 to October 2008 and from December 2013 to March 2016. The QTDW amplitudes for meridional component show a weak correlation with 15-45 hPa QBO winds, during summer. For winter, the best positive correlations have occurred for QTDW and 25 hPa QBO winds, mainly for altitudes above 90 km. A good concordance between the behaviour of the summer QTDW amplitudes for meridional component and F10.7 index have been observed, with the exception of 2001 and 2002 when the QTDW amplitude were weak and 2006 when the QTDW amplitude was very strong. When we do not consider these summers, there are good correlations between QTDW amplitudes at 81-93 km altitude range for meridional component and F10.7 index, in which the best correlations ($r = 0.78$ to 0.95, significant to $\alpha=0.025$) occur when F10.7 index for November and December are used.

IAPSO

Coastal Current Pattern Analysis On The Shelf Edge Zone In The Sea Of Enshu With VHF Ocean Radar Measurements

Abstract ID : 46

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Shin'ichi Sakai ,s-sakai@criepi.denken.or.jp ,(Senior Research Scientist) ,Japan ,Chiba ,Not Presenting[1]

Mr Fumihiro Uehara ,Uehara.Fumihiro@chuden.co.jp ,(None) ,South Africa , ,Not Presenting[2]

Mr Yoshihito Tanaka ,Tanaka.Yoshihito@chuden.co.jp ,(None) ,South Africa , ,Not Presenting[2]

Mr Yasuo Niida ,niida@criepi.denken.or.jp ,(None) ,South Africa , ,Not Presenting[1]

1 - CRIEPI 2 - Chubu Electric Power Co., Inc. 3 - Chubu Electric Power Co., Inc. 4 - CRIEPI

The sea of Enshu in the middle south of Japan is facing the Pacific with the continental shelf extending about 10 km off the coast where unsteady current flow is dominant and then it is difficult to survey the current features by the conventional observing methods such as ships and buoys technically and costly. The purpose of this study is to investigate the surface current characteristics mainly by using ocean radar data in the sea of Enshu. Current observation was conducted with two VHF ocean radars through a year every 5 minutes in the area extending about 20km off the coast including shelf edge. Precision of surface currents detected by ocean radars was evaluated in comparison with the GPS-drifting buoy experiments in two days in the offshore area. As the result of the particle-tracking simulation the particle trajectories by using the ocean radar current velocities coincided well with those by using the drifting buoy current velocities within the discrepancy of 500 m apart. The daily surface current patterns were classified in a 4 x 4 map by the SOM (Self-organizing Maps) analysis. The first and the second dominant patterns are the westerly current and the southeasterly current with an average speed of about 20 cm/s respectively. The third and the fourth patterns are the weak easterly current and the weak northwesterly current less than 10 cm/s. The total relative frequency of occurrence of the above four representative patterns is about 42 %. By adapting the SOM analysis to the reanalysis daily wind data, it was certified that winds predominantly contribute to generate surface current patterns in the area. The current shear pattern in the offshore direction was also investigated by the SOM based on the near-shore current-meter data 1 km off the

coast and the offshore ocean radar data. It was found that the near-shore currents totally tend to behave discontinuously as to offshore currents. In case of the first dominant pattern, the offshore current flows west-northwesterly with the speed over 20 cm/s, whereas the near-shore current is too weak with an average speed of 2 cm/s.

Acoustic remote sensing: 5 MHz backscattering response by phytoplankton in waters off the southeast Argentinian coast.

Abstract ID : 56

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Igor Prario ,iprario@fi.uba.ar ,(Member of Underwater Sound Division - DIIV-UNIDEF) ,Argentina ,Buenos Aires ,Not Presenting[1]

Mr Mariano Cinquini ,marianocinquini@gmail.com ,(None) ,United States , ,Not Presenting[1]

Mrs. Silvia Blanc ,silblanc@yahoo.com ,(Head of the Underwater Sound Division of the Argentinian Navy Research Office.) ,Argentina ,Vicente López ,Not Presenting[1]

Mr Patricio Bos ,pbos@fi.uba.ar ,(None) ,Argentina , ,Not Presenting[1]

Mr Analia Tolivia ,analiatolivia@gmail.com ,(None) ,United States , ,Not Presenting[1]

1 - Argentinian Navy Research Office (DIIV) UNIDEF (National Council of Scientific and Technical Research - Ministry of Defence) 2 - Argentinian Navy Research Office (DIIV) UNIDEF (National Council of Scientific and Technical Research - Ministry of Defence) 3 - Argentinian Navy Research Office (DIIV) UNIDEF (National Council of Scientific and Technical Research - Ministry of Defence) 4 - Argentinian Navy Research Office (DIIV) UNIDEF (National Council of Scientific and Technical Research - Ministry of Defence) 5 - Argentinian Navy Research Office (DIIV) UNIDEF (National Council of Scientific and Technical Research - Ministry of Defence)

Acoustics is considered an important tool for remote sensing of the marine environment. Its application realm spans over a wide spectrum of signal frequencies (from less than 1 Hz to 10 MHz) with its consequent very different fields of interest for scientific research purposes. The present work is motivated by the fact that phytoplankton is generally the most important primary producer in the aquatic systems. Therefore, it plays an undoubtedly relevant role in the oceanic ecosystem. A long-term research programme to investigate the acoustic response of phytoplankton has been developed. Its aim is to use the remote sensing capability of high-frequency acoustic scattering techniques as a tool for contributing to phytoplankton biomass' estimation and harmful algae blooms detection. It includes insonification of single-species algae aqueous culture media during laboratory experiments as well as examination of nearly real-time acoustic responses of seawater samples collected with a vertical trawl phytoplankton net or Niskin bottles. Recently, acoustic measurements in waters off the southeast Argentinian coast were conducted at thirteen CTD stations within the San Jorge Gulf. Seawater samples were insonified with a 5 MHz narrowband transducer driven by a pulse-receiver system. Analysis, signal processing, simulation and modelling of the scattered signals have been carried out in order to correlate measured backscattered power with scatterers' type and

concentrations. For that purpose, optical observation, taxonomic classification, sample cells counting were also accomplished. Unmasking of undesirable acoustic responses from spurious scattering was performed through ad-hoc signal processing techniques. The power backscattered by the at-sea samples from the whole water column collected with the phytoplankton net showed an increment of about 20 dB - 25 dB referred to surface samples at the stations with high fluorescence values. A detailed analysis of the time dependence of the backscattered signals is fulfilled. Measurements of backscattered power, generated by the insonified collected seawater samples are compared with simulations using theoretical models.

Stabilisation of hydrographic profiles

Abstract ID : 62

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Paul Barker ,paul.barker@unsw.edu.au ,(Physical Oceanographer) ,Australia ,Kensington ,Not Presenting[1]

Dr. Trevor McDougall ,Trevor.McDougall@unsw.edu.au ,(None) ,Australia ,None ,Not Presenting[1]

1 - UNSW 2 - UNSW

Both observed and averaged oceanographic data often contain regions with density inversions. We present two methods of stabilising a water column. The first method is intended for use with observed data, and it minimally adjusts Absolute Salinity while leaving the values of in situ temperature unchanged. The second method adjusts the values of both Absolute Salinity and Conservative Temperature, and these adjustments are made in such a way as to cause the least possible damage to the water-mass structure of the vertical cast.

The geomorphological and environmental aspects of Shiab Al-Kabeer, a coral patch in the Red Sea of Saudi Arabia

Abstract ID : 256

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Ali Basaham ,abasaham@kau.edu.sa ,(None) ,Saudi Arabia , ,Not Presenting[1]

Mr. Abdulnasser Al Qutub ,Qutub.As@sgs.org.sa ,(Head of the Centre for Marine Geology) ,Saudi Arabia ,Jeddah ,Presenting[2]

1 - King Abdulaziz University 2 - Saudi Geological Survey

A unique feature referred to as a shoal called Shiab Al-Kabeer or Abu Tair sits almost in the middle of the Red Sea of Saudi Arabia. The shoal is almost completely made-up corals with over 90 % of calcium carbonate matter. The shoal undergoes various degree of stress either by human activities or natural causes. The dynamics of the area is controlled by varying water currents generated by wind and tidal cycles. The shoal is inhabited by fauna and flora exclusive to the Red Sea. Pristine and uncontaminated water helps in keeping the sub-environment of the shoal healthy, although minor irreversible process might be a concern. Sediment input to the area is mostly of carbonate origin largely contributed by the corals with subordinate wind-blown quartz from the adjacent deserts, and terrigenous material from various sources, including wadi Al-Kura, a seasonal stream that once actively fed Sharm Obhur before the head of the sharm was raised to contain the flood discharge. The veneer is rich in biogenic material in the form of mollusc, forams, and abundant coral debris are relatively coarser and darker in colour and poorly sorted with little fine sediment, and if present, are in minor amounts and calcareous in nature. This is related to weak currents where the environment is relatively stagnant, but coarse debris are contributed by human activities and fine sediment by further breaking down by parrotfish. The staining of the sediments is not as severe as compared to other areas, and is be restricted in terms of the distribution pattern. Various remotely controlled technologies show different geomorphological features, whereas ground-truthing shows the activities that currently plays an important role in sediment movement especially in the sub-environments of the shoal. The sediment veneer shows that coarse sediment dominate the shoal mostly of biogenic origin. Since the current research is the only detailed work, a more comprehensive strategy to understand the shoal and its inhabitants has been recommended to keep the environment pristine that would enhance the scientific knowledge we lack from the sub-environments of the Red Sea.

Processes responsible for the sediment distribution pattern in the Khuraybah lagoon, eastern Red Sea, Saudi Arabia

Abstract ID : 339

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. SALEM ALNOMANI ,nomani.sm@sgs.org.sa ,(Marine Geologist) ,Saudi Arabia ,Jeddah ,Not Presenting[1]

Mr. Ali AlTharowi ,Tharowi.AA@sgs.org.sa ,(None) ,Saudi Arabia , ,Not Presenting[2]

Mr. Mustafa Khorsheed ,Khorsheed.MM@sgs.org.sa ,(None) ,Saudi Arabia , ,Not Presenting[2]

Dr. Najeeb Rasul ,najeeb_rasul@hotmail.com ,(None) ,Canada , ,Not Presenting[2]

1 - Saudi Geological Survey (SGS) 2 - SAUDI GEOLOGICAL SURVEY 3 - SAUDI GEOLOGICAL SURVEY 4 - SAUDI GEOLOGICAL SURVEY

Al-Khuraybah lagoon is one of the largest and deepest lagoons along the north-east Red Sea coast of Saudi Arabia. It is separated from the Red Sea by many convoluted shoals and coral reefs, and the entrance to the lagoon from the open sea is restricted to a couple narrow channels that cut the shoals The lagoon was fed by several wadis (seasonal streams) in the past, although some are now dormant. Wadi Aynunah is one of the major wadis that supply the lagoon with eroded material from the mountains; this wadi is now populated making the input of terrigenous material to the lagoon negligible. The lagoon is veneered with mud to muddy sand of both terrigenous and biogenic origin. The abundant mud in the central deeper part of the lagoon is mostly terrigenous, whereas carbonate is contributed by churning of the seabed sediment by trawling, making the carbonate material even fine. The re-suspended sediment stays within the lagoon since there is no major outlet to the open sea, and sediment input from the wadis to force sediment out of the lagoon is almost completely absent, whereas in sheltered areas, terrigenous mud and sand are present. Relatively well-sorted terrigenous materials, and wind-blown sand is common along the beach. Heavy minerals dominate the inter-tidal zone and consist mainly biotite, magnetite and ilmenite, giving the sand a black appearance. During flooding the water from the Red Sea reaches the lagoon by over-spilling; this exchange of water makes the lagoon less saline. However, movement of sediment is restricted because of the numerous shoals. The beach is covered by algal mats, especially where the influence of Wadi Aynunah was once significant and organic debris together with seagrass was transported to the lagoon. At present, trawling activity has stopped and therefore the bed is not as imbalance as before. Human activity like salt extraction and boating activity is still common but the environmental stress has minimized recently. The input of fresh water to the lagoon is restricted because of farming practices along the shores and construction in the path of the wadi. This might have an impact on the lagoon but the current-status is healthy.

variability of the patagonian shelf circulation

Abstract ID : 571

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. vincent combes ,vcombes@coas.oregonstate.edu ,(Research Associate) ,United States ,Corvallis ,Not Presenting[1]

Prof. Ricardo Matano ,rmatano@coas.oregonstate.edu ,(None) ,United States , ,Not Presenting[1]

1 - Oregon State University 2 - Oregon State University

Observational studies have already established the general mean circulation and hydrographic characteristics of the Patagonian shelf waters using data from in situ observation, altimetry and more recently from the Aquarius satellite sea surface salinity, but the paucity of those data in time or below the surface leave us with an incomplete picture of the shelf circulation and of its variability. Using process-oriented modeling experiments, we describe the variability of the shelf circulation and its interaction with the adjacent large-scale ocean currents. The model indicates that the southern shelf interannual circulation is mainly wind-driven with the influence of the Malvinas Current variability on the cross-shelf transport variability, while the central shelf circulation is modulated by local wind variability, southern shelf transport variability and by the Brazil/Malvinas Confluence latitude variability. The understanding of the shelf circulation variability has high biological and economical importance as the Patagonian region is a class I marine ecosystem, associated with a robust spring/summer bloom of chlorophyll at the shelf break. We will therefore also present the solution of a coupled biophysical model experiment to better describe the different sources and the fate of the main limiting factor: iron.

Monitoring the Terra Nova Bay polynya by MODIS ice surface temperature imagery during winter 2010 and 2011

Abstract ID : 646

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Giannetta Fusco ,giannetta.fusco@uniparthenope.it ,(None) ,Italy ,Napoli ,Not Presenting[1]

Miss. Manuela Sansiviero ,manuela.sansiviero@uniparthenope.it ,(None) ,Italy , ,Not Presenting[2]

Dr. Giuseppe Aulicino ,giuseppe.aulicino@uniparthenope.it ,(None) ,Italy , ,Not Presenting[1]

Dr. Stephan Paul ,stephan.paul@awi.de ,(None) ,Germany , ,Not Presenting[4]

Prof. Giorgio Budillon ,giorgio.budillon@uniparthenope.it ,(None) ,Italy , ,Not Presenting[1]

1 - University of Naples "Parthenope", Italy 2 - University of Naples 'Parthenope' 3 - University of Naples "Parthenope", Italy 4 - AWI 5 - University of Naples "Parthenope", Italy

Polynyas occur in remote, mostly inaccessible, places of the Arctic and Antarctic. Hence, remote sensing is essential for monitoring their dynamics. On regional scales, passive microwave (PM) radiometers provide useful information about their extent because they are available on a daily basis and do not depend on daylight and penetrate perfectly through clouds. Nonetheless, the coarse resolution of PM radiometers does not allow an accurate discrimination of open water and thin ice from thick ice. Synthetic radar aperture (SAR) sensors provide a better spatial resolution (up to few tents of meters) but present a lower data acquisition frequency. Despite their sensitivity to the presence of clouds, thermal infrared (TIR) Moderate Resolution Imaging Spectroradiometers (MODIS) operate at large swath widths providing high spatial resolution images (typically 1 Km) several times per day. Many studies already demonstrated their usefulness for the retrieval of polynyas size and thin ice thickness.
In this study, we deal with MODIS observation of a frequently occurring coastal polynya in the Terra Nova Bay (TNB), located in the western Ross Sea (Antarctica). We examine the TNB polynya evolution during the freezing seasons (April to October) 2010 and 2011 using a new methodology that combines a sequence of MODIS swath-based scenes (level-1b products). Not-informative cloudy scenes have been completely discarded from our analyses Clear-sky and fog-contaminated scenes have been analysed in order to extract the polynya area, thus having a revisit time of few hours in absence of thick clouds.
Results have been validated through the comparison with a huge set of ENVISAT ASAR images. The good agreement with high resolution ASAR information demonstrated the potential of this tool for the continuous monitoring of the polynya extent. A comparison with TNB polynya extent estimations retrieved by other MODIS and PM based tools has also been carried out for freezing season 2010

and 2011, and differences discussed. Finally, wind speeds and directions measured by automatic weather stations located along the TNB coast, have been used to identify katabatic events to be compared with the polynya dynamics during the study period.

The Antarctic Circumpolar Wave: Its presence and Interdecadal Changes during the last 142 years

Abstract ID : 677

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yuri Cotroneo ,yuri.cotroneo@uniparthenope.it ,(Post Doc Research Fellow) ,Italy ,Napoli ,Not Presenting[1]

Dr. Dario Cerrone ,dario.cerrone@uniparthenope.it ,(None) ,Italy , ,Not Presenting[1]

Prof. Giannetta Fusco ,giannetta.fusco@uniparthenope.it ,(None) ,Italy ,Napoli ,Not Presenting[1]

Prof. Ian Simmonds ,simmonds@unimelb.edu.au ,(None) ,Australia , ,Not Presenting[4]

Prof. Giorgio Budillon ,giorgio.budillon@uniparthenope.it ,(None) ,Italy , ,Not Presenting[1]

1 - University of Naples "Parthenope", Italy 2 - University of Naples "Parthenope", Italy 3 - University of Naples "Parthenope", Italy 4 - School of Earth Sciences, The University of Melbourne, Victoria, Australia 5 - University of Naples "Parthenope", Italy

The Southern Ocean (SO) is the region of the world ocean bordering on Antarctica over which significant exchanges between the atmosphere, the ocean and the sea ice take place. Here, the strong and nearly unhindered eastward flow of the Antarctic Circumpolar Current plays an important role in mean global climate as it transmits climate anomalies around the hemisphere. Features of interannual variability have been observed to propagate eastward around the SO with the circumpolar flow in the form of a system of coupled anomalies, known as the Antarctic Circumpolar Wave (ACW). In the present study, the 142-year series of the 20th Century Reanalysis Version 2 dataset (850hPa geopotential height, sea level pressure, sea surface temperature, surface meridional wind, surface air temperature) spanning from 1871-2012 is used to investigate the presence and variability of ACWs. This examination shows, for the first time, the presence of the ACW before the mid-1950s and interdecadal changes in its characteristics. Modifications in the strength and speed of the circumpolar wave are shown to be linked with large-scale climate changes. Complex Empirical Orthogonal Function analyses confirm that the ACW becomes apparent when the tropical El Niño-Southern Oscillation (ENSO) signal gives rise to the Pacific-South American (PSA) pattern, and is a consequence of the constructive combination of the PSA and the subantarctic Zonal Wavenumber-3. Correlation analyses are also performed to quantify the role played by ENSO teleconnections for the appearance of the ACW, and the impact on the presence of ACWs of three super El-Niño events is investigated.

The Toroidal Magnetic Field Generated in the Earth's Global Oceans

Abstract ID : 861

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jakub Velímský ,velimsky@karel.troja.mff.cuni.cz ,(Assistant Professor) ,Czech Republic ,Prague ,Presenting[1]

Mr. Libor Šachl ,sachl@karel.troja.mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

Prof. Zden?k Martinec ,zm@karel.troja.mff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[1]

1 - Charles University, Prague 2 - Charles University, Prague 3 - Charles University, Prague

The toroidal component of the magnetic field in the Earth's oceans is generated by the interaction of the large-scale ocean currents with the main magnetic field. It doesn't propagate into the insulating atmosphere, and therefore it is not directly observable at the sea-surface or at satellite altitudes. We use a recently developed Large Scale Ocean Model for Geophysics (LSOMG) to calculate the three-dimensional ocean current system driven by wind and buoyancy forcing. The global circulation models are in turn used to predict the induced magnetic field in the Earth's oceans, taking into account the three-dimensional variations of ocean electrical conductivity. A time-domain, spherical-harmonic approach is used to solve the electromagnetic induction equation, providing a natural separation of the magnetic field into its toroidal and poloidal components. We aim to estimate the realistic amplitudes of the toroidal magnetic field, to find the ocean flow patterns that are necessary to generate it, and to study the effect of poloidal-toroidal coupling, allowing for indirect observations of the toroidal field through its poloidal counterpart.

Dynamics of Malvinas Current at 41°S from CASSIS project: analysis and comparison with historical data

Abstract ID : 925

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Guillermina F. Paniagua ,guillermina.paniagua@cima.fcen.uba.ar ,(Ph D student) ,Argentina ,Ciudad Autónoma de Buenos Aires ,Presenting[1]

Dr. Christine Provost ,cp@locean-ipsl.upmc.fr ,(None) ,France , ,Not Presenting[2]

Mr. Camila Artana ,cartlod@locean-ipsl.upmc.fr ,(None) ,Argentina , ,Not Presenting[3]

Mr Alberto Piola ,apiola@hidro.gov.ar ,(None) ,Argentina , ,Not Presenting[4]

Dr. Ramiro Ferrari ,ramiro.ferrari@cima.fcen.uba.ar ,(None) ,Argentina , ,Not Presenting[5]

Miss. Loreley Lago ,loreleylago@gmail.com ,(None) ,Argentina , ,Not Presenting[6]

Dr. Martin Saraceno ,saraceno@cima.fcen.uba.ar ,(Researcher) ,Argentina ,Buenos Aires ,Presenting[1]

1 - CONICET-UBA 2 - CNRS 3 - LOCEAN UMR 7159, France 4 - Univ. Buenos Aires 5 - CONICET 6 - CONICET-INIDEP 7 - CONICET-UBA

The present study is based on the analysis of a new in situ data set collected along the northern transect of the CASSIS (Southwest Atlantic Currents Satellite In-Situ) project (see Saraceno et al.) at five sites across the limit of the continental shelf and shelf break off Argentina around 41°S between December 2014 and November 2015. Moorings were deployed under Jason track #26: at the continental shelf an oceanographic buoy measured currents, temperature, salinity and meteorological variables; at the shelf break four moorings (A4, M1, M2 and M3) measured currents, temperature and salinity. A4 is located at the sea-bottom and M1, M2 and M3 are tall-moorings. A4, M1 and M2 recorded continuously for 337 days while the oceanographic buoy and M3 recorded data for less than 42 days. Depth-integrated time-averaged currents at A4, M1 and M2 show a dominant NE component, well aligned with the isobaths; mean values are of 24.5, 23.2 and 16 cm s^{-1}, respectively. Very different scenarios are observed in 2014-2015: almost half of the time the mean current direction is inverted. During those periods the cross shelf-break velocity component were higher than in others periods. Gridded altimetry and SST satellite data show that the largest inversions observed in the current meter measurements are related to eddies and mesoscale structures that intercept the Malvinas current at that latitude. Comparison with data obtained from mooring deployments at the same location during 1993-1994 (Vivier et al) and 2001-2003 (Spadone et al.) and the satellite altimetry record (1993-2015) shows that it is the first time that such inversions last for so long. Mean

values and variance ellipses for the 2014-2015 time period are comparable with those obtained from previous periods.

An observing system for multidisciplinary purposes

Abstract ID : 1011

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Elena TEL ,elena.tel@ieo.es ,(Researcher) ,Spain ,Madrid ,Presenting[1]

Dr. Rosa BALBIN ,rosa.balbin@ba.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Mrs. M Carmen GARCIA-MARTINEZ ,mcarmen.garcia@ma.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Cesar GONZALEZ-POLA ,cesar.pola@gi.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Alicia LAVIN ,alicia.lavin@st.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Mr. Joaquin MOLINERO ,joaquin.mol@md.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Mrs. Carmen RODRIGUEZ ,carmen@st.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Manuel RUIZ-VILLARREAL ,manuel.ruiz@co.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Ricardo SANCHEZ-LEAL ,rleal@cd.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Manuel VARGAS ,manolo.vargas@ma.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Pedro VELEZ-BELCHI ,pedro.velez@ca.ieo.es ,(None) ,Spain , ,Not Presenting[1]

1 - Instituto Espanol de Oceanografia (IEO) 2 - Instituto Espanol de Oceanografia (IEO) 3 - Instituto Espanol de Oceanografia (IEO) 4 - Instituto Espanol de Oceanografia (IEO) 5 - Instituto Espanol de Oceanografia (IEO) 6 - Instituto Espanol de Oceanografia (IEO) 7 - Instituto Espanol de Oceanografia (IEO) 8 - Instituto Espanol de Oceanografia (IEO) 9 - Instituto Espanol de Oceanografia (IEO) 10 - Instituto Espanol de Oceanografia (IEO) 11 - Instituto Espanol de Oceanografia (IEO)

The Instituto Espanol de Oceanografia Observing System (IEOOS) systematically monitors the national waters from coastal to open ocean to give responses to ocean research initiatives, official agencies requirements and social and industrial demands. Different IEO supported programs include a tide gauge network since 1943 for long-term sea level studies, a ship-based monitoring sections network for hydrography, biogeochemistry and plankton along the Iberian shelf as well as two deep water sections, one in the N-NW of Iberian Peninsula and one in Canary Islands, and permanent moorings. This monitoring network provides information about the regional circulation at all levels, transports and hydrographical variability and also permits to explore their relationship with biological variables or contributing to the global change monitoring.

The whole system is completed by the autonomous underway monitoring performed by the IEO research fleet. All vessels are equipped with thermosalinometers, vessel-mounted Acoustic Doppler Current Profilers and automatic meteorological stations. There is also an open-waters ocean-meteorological buoy in the Bay of Biscay and forecasting models in the N-NW Iberian Peninsula in support to the intense ecosystem and fisheries activities in the area. Besides, the IEO supports international initiatives as ARGO profiles program.
The success of this integrated observing system provides quality controlled data used, among others, to explore the circulation patterns and perform classical scientific research, but also to give responses to European initiatives as European Marine Observation and Data Network (EMODNET) or the Marine Strategy Framework Directive (MSFD) that demand periodical evaluations of the marine environment.

Measuring spatio - temporal variability of chemical seawater parameters around the Spanish coasts.

Abstract ID : 1013

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Elena TEL ,elena.tel@ieo.es ,(Researcher) ,Spain ,Madrid ,Not Presenting[1]

Dr. Marta ALVAREZ ,marta.alvarez@co.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Antonio BODE ,antonio.bode@md.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Ms. Agueda CABRERO ,agueda.cabrero@vi.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Ms. Irene CHAMARRO ,irene.chamarro@md.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Mrs. M Carmen GARCIA-MARTINEZ ,mcarmen.garcia@ma.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Mrs. Carmen RODRIGUEZ ,carmen@st.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Pedro VELEZ-BELCHI ,pedro.velez@ca.ieo.es ,(None) ,Spain , ,Not Presenting[1]

Ms. Amaia VILORIA ,amaia.viloria@st.ieo.es ,(None) ,Spain , ,Not Presenting[1]

1 - Instituto Espanol de Oceanografia (IEO) 2 - Instituto Espanol de Oceanografia (IEO) 3 - Instituto Espanol de Oceanografia (IEO) 4 - Instituto Espanol de Oceanografia (IEO) 5 - Instituto Espanol de Oceanografia (IEO) 6 - Instituto Espanol de Oceanografia (IEO) 7 - Instituto Espanol de Oceanografia (IEO) 8 - Instituto Espanol de Oceanografia (IEO) 9 - Instituto Espanol de Oceanografia (IEO)

The hydrographic standard sections, supported by various projects of the Instituto Espanol de Oceanografia Observing System (IEOOS) since the beginning of the 90's, include the collection of discrete sea water samples in Spanish waters. Samples are analyzed in the laboratory in order to determinate dissolved O_2 and nutrient as well as chlorophyll concentrations. The main objectives of these IEOOS coastal monitoring projects (Radiales, RadMed, Stoca), and deep water ones (RadPRof, RaProCan) is the measurement of the ocean variability at different time scales, from seasonal to interannual ones, and to investigate their dynamics.
An important effort to recover, homogenize and validate the whole sets has been performed to fulfill the requirements of international initiatives, such as the European Marine Observation and Data Network (EMODNET) and the Marine Strategy Directive Framework (MSDF). The permanent activity of the IEO datacenter assesses the accessibility and reuse of these data, giving them added value. Averaged vertical profiles and statistical values are a useful tool for modelers and to validate future 'in situ' and model data and to assess environmental changes. The resulting time series at different

depths allow for a better knowledge of the chemical variability in coastal and oceanic waters in relation to oceanographic features and associated ecosystem responses. In the northern shelf, sampled in a monthly basis, time series show the seasonal variability of nutrients, the increase due to the mixing caused by autumn-winter winds and the consequent run out when the stratification begins in spring, as well as, the detection of extreme events on nutrient concentration.

Results from the Antarctic CircUmpolar Current dynamics Analysis (ACCUA) project

Abstract ID : 1105

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Pierpaolo Falco ,pierpaolo.falco@uniparthenope.it ,(None) ,Italy ,Naples ,Not Presenting[1]

Dr. Bruno Buongiorno Nardelli ,bruno.buongiornonardelli@cnr.it ,(None) ,Italy , ,Not Presenting[2]

Dr. Yuri Cotroneo ,yuri.cotroneo@uniparthenope.it ,(Post Doc Research Fellow) ,Italy ,Napoli ,Not Presenting[3]

Dr. Paola de Ruggieroy de Ruggiero ,paola.deruggiero@uniparthenope.it ,(None) ,Italy , ,Not Presenting[4]

Dr. Daniele Iudicone ,diudicone@gmail.com ,(None) ,Italy , ,Not Presenting[5]

Prof. Stefano Pierini ,stefano.pierini@uniparthenope.it ,(None) ,Italy , ,Not Presenting[6]

Prof. Giancarlo Spezie ,giancarlo.spezie@uniparthenope.it ,(None) ,Italy , ,Not Presenting[4]

Prof. Enrico Zambianchi ,enrico.zambianchi@uniparthenope.it ,(None) ,Italy , ,Not Presenting[4]

1 - University of Naples Parthenope and CoNISMa 2 - Istituto Ambiente marino costiero - Consiglio Nazionale delle Ricerche 3 - University of Naples "Parthenope", Italy 4 - University Parthenope of Naples and CoNISMa 5 - Stazione Zoologica A. Dohrn 6 - University of Naples, Parthenope 7 - University Parthenope of Naples and CoNISMa 8 - University Parthenope of Naples and CoNISMa

The ACCUA project (funded in the framework of the Italian Antarctic Research Programme, PNRA) was aimed at analyzing and interpreting oceanographic data gathered in previous PNRA Antarctic expeditions through a combination of innovative data analysis methods (based on in situ observations and satellite data) and the use of an ocean circulation model of a wide sector of the Southern Ocean. The main achieved results are:
- the identification of the ACC frontal variability from in situ and satellite altimeter data;
- the observation-based reconstruction of the temperature and salinity fields and associated estimates of the upper mixed layer depth in the Southern Ocean;
- the reconstruction of the 3D circulation along the New Zealand - Antarctica transect;
- the identification and analysis of the intrinsic component of the ACC variability based on numerical simulations with stationary forcing;
- the analysis of the mesoscale dynamics and its impact on the large scale circulation.
In this presentation these results are summarized and their interrelationships are discussed.

Evidence of glacial melt water input in the Western Ross Sea (Antarctica) water masses

Abstract ID : 1135

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Paola Rivaro ,paola.rivaro@unige.it ,(Associate Professor) ,Italy ,GENOVA ,Not Presenting[1]

Dr. Francisco Ardini ,ardini@chimica.unige.it ,(None) ,Italy , ,Not Presenting[1]

Dr. Pasquale Castagno ,pasquale.castagno@gmail.com ,(None) ,Italy , ,Not Presenting[3]

Dr. Massimo Destefano ,massimo.destefano@uniparthenope.it ,(None) ,Italy , ,Not Presenting[4]

Prof. Pierpaolo Falco ,pierpaolo.falco@uniparthenope.it ,(None) ,Italy ,Naples ,Not Presenting[5]

1 - University of Genoa 2 - University of Genoa 3 - Parthenope University of Neaples 4 - Parthenope university of Neaples 5 - University of Naples Parthenope and CoNISMa

Ice shelves are believed to control the glacial stability and the Antarctic Ice Sheet balance, thus their melting is a critical issue. One of the recognized drivers of the ice shelf melting is the intrusion of the warm Circumpolar Deep Water (CDW) onto the Antarctic continental shelves. is. In the Ross Sea, the CDW intrudes onto the shelf preferably in the western sector, where the local glaciers are potentially exposed to this warm intrusion. Moreover, the water masses of the Ross Sea experienced significant changes in the thermohaline characteristics, which could affect as well the ice shelf melting rates. The evaluation of the glacial melt water inputs in the western Ross Sea is one of the goals of CELEBeR (CDW Effects on glaciaL mElting and on Bulk of Fe in the Western Ross sea) project.To this purpose, CELEBeR carried out ship measurements during a cruise in the austral summer 2016-17, as part of the Italian National Program of Research in Antarctica (PNRA - Programma Nazionale di Ricerca in Antartide).Physical and chemical properties (dissolved oxygen, $H_2{}^{18}O/H_2{}^{16}O$ ratio, nutrients) data were collected in 33 stations sampled in Terra Nova Bay polynya and near the Drygalski, Aviator and Mariner glaciers. In particular, the relative abundance of ^{16}O and ^{18}O isotopes allowed us to distinguish glacial from sea ice melting at the surface and to evaluate basal melting. Moreover the vertical profile of current field were obtained by means of a Lowered Acoustic Doppler Current Profiler (LADCP) system which was deployed together with the CTD.Sources of water with temperature below the surface freezing point have been detected in the intermediate layers of the water column close to the Terra Nova Bay coast and in the area bounded by Aviator and Mariner glaciers.Preliminary results suggest the significant role of the local water masses in controlling the floating glaciers by governing the basal melting processes.

Global Ocean circulation derived from the Argo-based Model for Investigation of the Global Ocean (AMIGO)

Abstract ID : 1244

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Konstantin Lebedev ,klebedev@ocean.ru ,(Scientist) ,Russia ,Moscow ,Presenting[1]

Mrs. Maria Kurnosova ,kurnosova_maria@mail.ru ,(None) ,Russia , ,Not Presenting[1]

1 - Shirshov Institute of Oceanology 2 - Shirshov Institute of Oceanology

Starting from 2005, measurements with the Argo floats have been performed over the majority of the World Ocean. Currently, 4000 Argo floats autonomously profile the upper 2000-m water column of the ocean from Antarctica to Spitsbergen increasing World Ocean temperature and salinity databases by 12000 profiles per month. This makes it possible to solve problems on reconstructing and monitoring the ocean state on an almost real-time basis, study the ocean dynamics, obtain reasonable estimates of the climatic state of the ocean in the last decade and estimate existing intraclimatic trends. We present the newly developed Argo-Based Model for Investigation of the Global Ocean (AMIGO), which consists of a block for variational interpolation of the profiles of drifting Argo floats to a regular grid and a block for model hydrodynamic adjustment of variationally interpolated fields. Such a method makes it possible to obtain a full set of oceanographic characteristics - temperature, salinity, density , and current velocity - using irregularly located Argo measurements (the principle of the variational interpolation technique entails minimization of the misfit between the interpolated fields defined on the regular grid and irregularly distributed data; hence the optimal solution passes as close to the data as possible). The simulations were performed for the entire globe limited in the north by 85.5° N using 1° grid spacing in both longitude and latitude. At the depths exceeding 2000 m, in which Argo data are lacking, the temperature and salinity data were taken from the WOA-09 database. The constant temperature and salinity values from the Argo data for the corresponding month (year, season) derived using the variational technique described above were specified as the boundary conditions at the ocean surface. The constant wind stress in the corresponding month (year, season) was specified from the ECMWF ERA-Interim reanalysis data. The calculations cover the 12-year period from 2005 to 2016, the temporal resolution is one month. The AMIGO database enjoys free public access on the Internet at: http://argo.ocean.ru/. The results are presented as monthly, seasonal, and annual data and climatological mean fields. The work was supported by the Russian Science Foundation (project 14-50-00095).

Biases in the upper ocean in the northern Indian Ocean simulated by CMIP5 models

Abstract ID : 1250

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Chan Joo Jang ,cjjang@kiost.ac.kr ,(Principal Research Scientist) ,South Korea ,Ansan ,Not Presenting[1]

Dr. Cheol-Ho Kim ,chkim@kiost.ac.kr ,(None) ,South Korea , ,Not Presenting[1]

Mr. Minwoo Kim ,minwoo@kiost.ac.kr ,(None) ,South Korea , ,Not Presenting[1]

Dr. Ho-Jeong Shin ,hjshin@kiost.ac.kr ,(None) ,South Korea , ,Not Presenting[1]

1 - KIOST 2 - KIOST 3 - KIOST 4 - KIOST

Through its recent fifth assessment report, IPCC (Intergovernmental Panel on Climate Change) provides up-to-date scientific knowledge and socio-economic aspects of global climate change, mostly based on observational data and CMIP5 (Coupled Model Intercomparison Project Phase 5) global models. This study evaluates the upper ocean processes in the Indian Ocean in the Northern Hemisphere simulated by 19 CMIP5 models by comparing their historical run simulation with observed climatology. We found that, although significant progresses have been achieved through CMIP projects, there are still considerable common biases in simulation of the upper ocean in the northern Indian Ocean. For example, most of the analyzed CMIP5 models tend to have a cold bias in the sea surface temperature (SST), a fresh bias in the sea surface salinity, and a deep bias in the winter mixed layer depth (MLD). More importantly, the cold SST bias and deep bias in the winter MLD seem to be related with a strong wind bias, suggesting importance of proper wind representation for realistic upper ocean simulation in the northern Indian Ocean.

Water mass transport in the Vema fracture zone of the Mid-Atlantic ridge

Abstract ID : 1287

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Ilya Drigo ,ilya.drigo@gmail.com ,(Student) ,Russia ,Moscow ,Presenting[1]

Mr. Alexander Demidov ,tuda@mail.ru ,(None) ,Russia , ,Not Presenting[1]

1 - Lomonosov Moscow State University 2 - Lomonosov Moscow State University

Research on a square polygon composed of 25 oceanographic stations in the Vema fracture zone of the Mid-Atlantic Ridge was carried out during the 22nd cruise of R/V "Akademik Ioffe" in 2006. LADCP currents measurements were performed on each station. Such detailed current measurements were performed for the first time in this region.
In this study the transport of water mass inside the polygon is assessed. The LADCP data is compared with geostrophic flows velocities and transport, which are calculated according to different equations of state using the CTD data. AVISO ADT data and higher layers of LADCP data were used for the correction of geostrophic velocities to absolute velocities.
Results of geostrophic velocities calculations weakly correlate with direct measurements data. We believe that this big difference in results occurs due to near-bottom triangles and ageostrophic factors. Ageostrophic factors (aliasing, internal waves, wind-driven and tidal currents) could lead to errors of geostrophic currents estimations, especially in the top and near-bottom layers.
According to the balance method of water transport, the balance is observed mostly in the intermediate layers. In the top and in the bottom layers, water transport mostly does not match the balance.
Thus, calculation of the correction to geostrophic currents estimation would improve accuracy in geostrophic currents and water mass transport calculation.

Key Region for the Interannual Variability of Western Pacific Warm Pool in Reanalyses and CMIP5 Multi-models

Abstract ID : 1339

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Fan Jia ,jiafan@qdio.ac.cn ,(RESEARCH ASSOCIATE) ,China ,QINGDAO ,Presenting[1]

Prof. Dunxin Hu ,dxhu@qdio.ac.cn ,(None) ,China , ,Not Presenting[1]

1 - Institute of Oceanology, Chinese Academy of Sciences 2 - Institute of Oceanology, Chinese Academy of Sciences

The Western Pacific Warm Pool (WPWP) plays an important role in the global climate through modulating deep convections and ENSO. Due to its huge area and water mass, it is difficult to obtain real-time and three-dimensional data that can be used to timely infer the impact of WPWP on climate. Based on four reanalysis datasets, here we find that at interannual time scales, the SST index in a V-shaped region over the central Pacific (V-SST) could explain about half of the variance of WPWP heat content and almost all of the variance of WPWP east-west migrations. A mixed layer heat budget shows that the anomalous advections of background temperature by anomalous zonal and vertical currents dominate in the interannual variability of the V-SST. We apply this V-shaped region to 31 CMIP5 CGCMs' outputs and find a significant linear relationship between the interannual variability of V-SST and WPWP heat content across models. That is, a model with larger interannual variance and amplitude in V-SST tend to simulate larger of those in WPWP heat content as well. Since SST is much easier to observe, our study provides an effective index to represent and evaluate the interannual variability of WPWP. Meanwhile, a better simulation of SST and surface currents in the V-shaped region may help to improve model performance in simulating the interannual variability of WPWP heat content.

Role of mollusks in the sediment balance of accumulative beaches of Anapa Bay bar (the Black Sea)

Abstract ID : 92

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Alisa Kosyan ,kosalisa@yandex.ru ,(scientific researcher) ,Russia ,Moscow ,Not Presenting[1]

1 - Southern Branch of P.P. Shirshov Institute of Oceanology

Accumulative beaches of the Azov and Black Seas of the Krasnodar region (Russia) are unique nature landscapes, possessing great esthetic, historical and recreational value, as well as essential significance for the economy of the region. The stability of these beaches is determined by balance and dynamics of sediments. Biogenic sediments (carbonates) are provided by populations of coastal shelly mollusks. In some sites, the share of biogenic carbonates reaches 90%. The purpose of this project was to study the role of shell-bearing mollusks in lithodynamic balance of accumulative sea beaches of the Krasnodar region. We studied near shore benthic communities of Anapa Bay Bar near Anapa city and Blagoveschenskaya village.

The venus clam *Chamelea gallina,* inhabiting the depth range of 2-10 m, proved the major source of restoring the carbonates of biogenic origin (average biomass at 2-10 m depth - 186.6 g/m2). The next species was the bivalve *Donax trunculus* (129.9 g/m2 at 2-10 m depth). Gastropods *Rapana venosa* had an order less number and biomass than bivalves (18.9 g/m2 at 6-10 m). The number and biomass of other molluscan species were negligibly low. Calculation shows, that the annual income of the carbonates of biogenic origin on the studied 11 km long site will reach 2234.19 ton near Blagoveschenskaja and 5670.5 ton near Anapa city, which means on the average 3952.3 ton or 2485.8 m3. Taking into account that removal of fine sand into the deep parts of the sea is about 50000 m3 per year, restoring of the beaches by means of shelly material amounts 5 %.

The biocarbonates income, calculated for the site of the same length near Anapa city in 2010, was 2810 ton. An increase of clams productivity, which we observed in 2016, may be preconditioned by weakening of the predator effect of *R.venosa*: its biomass became 5.5 times less than in 2010. *R.venosa* tends to consume the largest bivalves foremost, and in 2016 we have observed an increase of average shell size of *C. gallina*, now comparable to that in 2001.

Thermohaline forcing and interannual variability of northwestern Inflows into the northern North Sea

Abstract ID : 270

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Peter Sheehan ,p.sheehan@uea.ac.uk ,(PhD Student) ,United Kingdom ,Norwich ,Not Presenting[1]

Dr. Bee Berx ,b.berx@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Alejandro Gallego ,a.gallego@marlab.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Rob Hall ,robert.hall@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Karen Heywood ,k.heywood@uea.ac.uk ,(None) ,United Kingdom ,Norwich ,Not Presenting[1]

Dr. Sarah Hughes ,s.hughes@marlab.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - University of East Anglia 2 - Marine Scotland 3 - Marine Scotland 4 - University of East Anglia 5 - University of East Anglia 6 - Marine Scotland

A long-established, 127 km-long hydrographic section in the northern North Sea at 59.28°N that runs from the eastern coast of Orkney (2.23°W) to the central North Sea (0°) crosses the path of the main inflows of Atlantic water. Data from 122 occupations between 1989 and 2015 are examined to determine the annual cycle and long-term trends of temperature, salinity and depth-varying geostrophic flow across the section. In an average year, the geostrophic flow referenced to the seafloor is at its narrowest (40 km) in winter, during which time it is driven by the strong horizontal salinity gradient; the horizontal temperature gradient is very weak. Velocity exceeds 4 cm/s, but transport is at a minimum (0.11 Sv). In the deeper water in the east of the section, thermal stratification develops throughout summer and persists until October, whereas the west is tidally mixed all year. The bottom temperature gradient becomes the primary driver of the geostrophic flow, which is fastest (9 cm/s) in September and broadest (100 km) in October. Maximum transport (0.36 Sv) occurs in October. Throughout the summer, the horizontal salinity gradient weakens, as does its contribution to the flow. However, it nevertheless acts to broaden the flow west of the location of the strongest horizontal temperature gradient. Section-mean de-seasoned temperature is found to be positively correlated to the Atlantic Multidecadal Oscillation and negatively correlated to the North Atlantic Oscillation. These results refine our understanding of the thermohaline forcing of Atlantic inflow into the northern North Sea, particularly in relation to the salinity distribution. Understanding the variability of this inflow is important for understanding the dynamics of the North Sea ecosystem.

Mechanical degradation of plastics in the swash zone with coarse bottom sediment: laboratory experiments

Abstract ID : 745

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Irina Poterukhina ,ira.poterukhina@gmail.com ,(Junior researcher) ,Russia ,Kaliningrad ,Presenting[1]

Ms. Margarita Bagaeva ,guineus@yandex.ru ,(None) ,Russia , ,Not Presenting[1]

Dr. Irina Chubarenko ,irina_chubarenko@atlantic.ocean.ru ,(None) ,Russia , ,Not Presenting[1]

1 - Atlantic branch of P.P.Shirshov Institute of Oceanology RAS 2 - Atlantic branch of P.P.Shirshov Institute of Oceanology RAS 3 - Atlantic branch of P.P.Shirshov Institute of Oceanology RAS

Contamination of marine environment by microplastics (1-5 mm) particles is the result of human influence. Transport properties and fate of MP particles depend on their shape, size, and density and are still poorly known.
We have examined the process of mechanical destruction of plastics in the swash zone. We chose the types of plastics most common for the Baltic Sea shores: LDPE (Low Density Polyethylene, film, 5 µm thick), PSs (polystyrene solid, disposable tableware), PP (polypropylene, disposable tableware), and PSf (polystyrene foam, building insulation). 200 g (50 g for PSf) of 2 cm x 2 cm samples of one of the listed plastics, 20 litres of fresh water and 40 kg of natural sea pebbles (4 - 6 cm) were mixed in a rotating (30 revolutions per minute) laboratory mixer during 24 h. Every 3 hours the material was washed, sieved, dried, and weighed.
Intensity and character of the destruction of plastics were examined. After 24 hours of destruction in a laboratory mixer with pebbles, the following proportions (by weight) were crashed into micro-particles (<5 mm) out of the 100% of the initial macro-samples: LDPE - about 30%, PSs - 100%, PP - about 5%, PSf - about 20%. LDPE samples were broken elongated filamentary fragments; microparticles obtained from PSs were flat fragments and scraps of various shapes; PP samples were divided into long plates; PSf were destroyed into separate spherical particles, which then fall apart.
A discontinuous character of the destruction of the samples was indicated: from a certain moment, the generation of microparticles increased dramatically. Plastic materials during the experiment significantly changed their original appearance, surface texture, and density. The experimental data are presented in the form of mass distribution curves and the number of microplastic particles by fractions (from 0.5 to 5 mm). For the used plastic types, the distribution curves variations are analysed with a time step of 3 hours. The results can be used for analytical assessments and modelling of microplastic generation in the surf zone of the sea.
The investigations are supported by Russian Science Foundation via grant number 15-17-10020.

Vertical distribution of microplastics within the body of sandy beaches of the south-eastern part of the Baltic Sea (Kaliningrad region)

Abstract ID : 892

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Andrei Bagaev ,a.bagaev1984@gmail.com ,(Senior Scientist) ,Russia ,Kaliningrad ,Presenting[1]

Dr. Elena Esiukova ,elena_esiukova@mail.ru ,(None) ,Russia , ,Not Presenting[1]

Dr. Irina Chubarenko ,irina_chubarenko@mail.ru ,(None) ,Russia , ,Not Presenting[1]

Ms. Margarita Bagaeva ,guineus@yandex.ru ,(None) ,Russia , ,Not Presenting[1]

Mr. Alexey Grave ,aleks3dw@gmail.com ,(None) ,Russia , ,Not Presenting[1]

1 - Atlantic branch of P.P.Shirshov Institute of Oceanology RAS 2 - Atlantic branch of P.P.Shirshov Institute of Oceanology RAS 3 - Atlantic branch of P.P.Shirshov Institute of Oceanology RAS 4 - Atlantic branch of P.P.Shirshov Institute of Oceanology RAS 5 - Atlantic branch of P.P.Shirshov Institute of Oceanology RAS

Data on vertical distribution of microplastic particles in the body of sandy beaches in the southeastern part of the non-tidal Baltic Sea is presented. Observations show that during the year the sandy beaches of the southeastern part of the Baltic Sea undergo strong changes. Natural processes of sediment migration (sand, pebbles, boulder material, etc.) under the influence of wind-wave forcing and sea level variations in the coastal zone lead to an increase / decrease in the thickness of the sand pillow of the beach and changes of the beach profile over time. On the surface of the beach (especially in the wrack lines) there are a large number of different types of plastic debris and microplastic (0.5-5 mm) particles. The goal of this study is to establish the quantitative and qualitative composition of microplastic in the sediment column of the beach - from the surface of the beach down to the sea level. Material was sampled with a steel sampler 10 cm high and 15 cm in diameter. Three locations with significantly different anthropogenic pressure were selected for the sampling: a city beach of popular resort town of Zelenogradsk, a beach near the small village of Kosa at the Vistula Spit, and a remote and difficult-to-reach coast of the Vistula Spit close to the Russian-Polish border. The number of collected layers is 6/15/16, respectively. Additionally, 4 samples were taken from the beach surface layer (down to 10 cm), and 3 samples from the surface layer in the wrack lines (upper 2 cm). The samples were collected in May 2016, during calm weather periods. The analysis showed that the beach has a heterogeneous structure: alternating layers of sand of various sizes and pebbles. Some layers have an increased content of organic matter (algae, shells, wood pellets), amber, coal, etc. Distribution of microplastics in the body of the beach is heterogeneous; higher microplastics

concentrations are found within the layers rich also in biological residues, amber, wood pellets.
Investigations are supported by Russian Science Foundation, grant No 15-17-10020.

Lagrangian particle tracking for the assessment of the flushing efficiency of harbor structures: the case of the Port of the Bay of Algeciras, Strait of Gibraltar

Abstract ID : 916

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Simone Sammartino ,ssammartino@ctima.uma.es ,(Post-Doctoral Researcher) ,Spain ,Málaga ,Not Presenting[1]

Dr. Jesús García Lafuente ,glafuente@ctima.uma.es ,(None) ,Spain , ,Not Presenting[2]

Dr. José Carlos Sánchez Garrido ,jcsanchez@ctima.uma.es ,(Postdoc researcher) ,Spain ,Malaga ,Not Presenting[2]

Dr. Cristina Naranjo Rosa ,cnaranjo@ctima.uma.es ,(Postdoctoral researcher) ,Spain ,Malaga ,Not Presenting[2]

1 - Physical Oceanography Group, University of Málaga 2 - University of Malaga 3 - University of Malaga 4 - University of Malaga

The Bay of Algeciras, an inlet of about 9 x 11 km located at the eastern margin of the Strait of Gibraltar, opens to the south, where the Atlantic jet leaves the Strait and starts spreading into the Alboran Sea. In its western side, the Bay hosts one of the main ports in Europe, neuralgic base of the major traffic load from Europe to Africa and from Europa to the rest of the oversea countries. The massive transport of liquid and solid bulk or bunkering activity, daily carried out in the Bay, combined with the harsh weather conditions that often lash the zone, give the ideal scenario for an incipient ecological disaster. This high environmental risk motivates the interest for a deeper understanding of the small scale dynamics of the Bay and the role played by the port structures in case of oil spill or other surface contaminations. A series of Lagrangian particles tracking (LPT) experiments were carried out to investigate the flushing patterns of the Bay and 8 different docks inside the local port, under a representative variety of external conditions, such as tide phase and strength, and winds. A 2D LPT algorithm has been adapted to fully exploit the outputs of a very high resolution (~30m) three-domain-nested hydrodynamic model, with the aim of resolving the complex circulation within the structures of the harbor. Winds are a clearly dominant factor, with westerlies featuring e-folding times one order of magnitude lower than easterlies. Fortnightly tidal modulation presents a counter-intuitive effect, with spring tides that, despite promoting higher ventilation in a first instance, end up providing higher accumulation of particles inside the docks and higher e-folding times than neap tides. Tide phase affects the current direction at the entrance of the docks during the first few hours of simulation

and its effect is progressively masked throughout the experiment. In the 45% of the experiments, a significant quantity of particles flow out to the Alboran Sea (55% in the whole Bay experiment), confirming the importance of the Bay on the exportation of pollutant/properties to the nearby basin.

WATER MASS STRUCTURE AND NEAR-SHORE CIRCULATION IN THE SOUTH-EASTERN PART OF THE BALTIC SEA

Abstract ID : 1167

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Nikita Rykov ,tin2006@inbox.ru ,(researcher) ,Russia ,Kaliningrad ,Not Presenting[1]

Dr. Alexandr Demidov ,alik1@mail.ru ,(None) ,Russia , ,Not Presenting[2]

1 - None 2 - Moscow State University

The water in the Baltic Sea is composed by a two-layer structure - the deep layer and the surface one. There are, however, differences in the near shore zone associated with bottom relief, seasonality and weather conditions. During joint expeditions of MSU, MIPT, BFU and SRIRAS in 2009-2016, we carried out ADCP measurements in more than 1000 CTD stations along the shore of Sambian peninsula near Kaliningrad.

The main characteristic of the hydrological structure of the Baltic Sea water, is a flow of warm and salty water from the North Sea in the bottom layer. The thermohaline structure of coastal waters is influenced by factors such as heat input from the atmosphere, river runoff, heat transfer processes of vertical mixing. Meteorological processes also plays an important role on the thermohaline structure of coastal waters.

The thermohaline structure of the waters of this region, discovered during the expeditions, consists of three layers: the top of the stratified warm layer, cold intermediate layer and the lower layer of saltier waters of the North Sea.

In 2014, at the core of the cold intermediate layer the temperature was of about 4° C, this is 2° C higher than found in previous expeditions in 2009-2011, due to the interannual variability of temperatures during the cold season, found during the formation of the cold intermediate layer. In 2015 there was an extremely change in the depth of this layer (below 50 m).

Halocline was observed in deep-water sections at 60-80 m. At the sea bottom, salinity values ??in some cases reach 13 psu, this lower more salty layer originates advection processes of North Sea waters movements. Measurements done in 2014-15 years, confirm the presence of a Major Baltic Inflow, which is accompanied by the absence of H_2S.

Direction of surface currents depends on prevailing wind direction. In general, there is north transfer along the western coast of the peninsula. Therefore, we described the summer vertical structure of coastal waters in the south-eastern Baltic Sea and create coastal current scheme for each year.

The expedition was supported by Russian Geographical Society.

Characterising Continental Shelf Waves in the Southern Adriatic Sea: from observational hints to a numerical modelling description.

Abstract ID : 1304

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Davide Bonaldo ,davide.bonaldo@ve.ismar.cnr.it ,(Post-doctoral research fellow) ,Italy ,Venice ,Presenting[1]

Dr. Mirko Orlic ,morlic@gfz.hr ,(None) ,Croatia , ,Not Presenting[2]

Dr. Andrea Bergamasco ,andrea.bergamasco@ismar.cnr.it ,(None) ,Italy , ,Not Presenting[1]

Dr. Sandro Carniel ,sandro.carniel@ismar.cnr.it ,(None) ,Italy , ,Not Presenting[1]

1 - Institute of Marine Scences, National Reearch Council, CNR-ISMAR 2 - Andrija Mohorovicic Geophysical Institute, Faculty of Science, University of Zagreb 3 - Institute of Marine Scences, National Reearch Council, CNR-ISMAR 4 - Institute of Marine Scences, National Reearch Council, CNR-ISMAR

Continental Shelf Waves (CSWs) are oscillatory phenomena associated with modulations induced by continental margin morphology in the potential vorticity field. They are controlled by a combination of the bathymetric gradient and the current rotation, in the same way as planetary Rossby waves are controlled by the meridional modulation of the Coriolis parameter. Under favourable conditions CSWs can be triggered by a number of factors, such as intense vorticity injections from wind or bathymetric perturbations. Along the continental margin of the Adriatic sea, an epicontinental basin of the Mediterranean sea, the possible occurrence of CSWs has been theoretically assessed, but these pulsing features have never been observed up to now.

In this work we combine observational data and numerical model fields for detecting the presence of CSWs along the Southern Adriatic Margin (SAM) and investigating their dynamics during an episode of dense water downflow in spring 2012. Starting from the observation of high-intensity velocity pulses with a period of approximately 2 days, we analyse the results of a high-resolution, ocean currents-waves coupled numerical modelling experiment reproducing dense water formation and migration in that episode. The properties and the extent of the perurbations are described in terms of their rotary spectral parameters and oscillation patterns, while their propagation along the continental margin is characterized by wave length and propagation velocity.

The comparison of the resulting wave parameters against dispersion relations theoretically compatible with the SAM morphology show that the observed modulation was indeed related to a perturbation system propagating south-eastwards along the Italian coast as a train of CSWs along the shelf break and on the continental slope. This provides, to the best of our knowledge, the first evidence of the occurrence of such waves on the SAM. Results allow to infer that CSWs provide a significant

contribution to dense water flows off the continental margin, by advecting dense water masses and triggering downflow throughout the slope.
This work paves the way to further investigations of these pulsing features, their implications on dense water dynamics and related impacts on benthic environments.

Characteristics and causes of Deep Western Boundary Current transport variability at 34.5°S during 2009-2014

Abstract ID : 68

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Christopher Meinen ,Christopher.Meinen@noaa.gov ,(Oceanographer) ,United States ,Miami ,Not Presenting[1]

Mr Olga Sato ,olga.sato@usp.br ,(None) ,Brazil , ,Not Presenting[2]

Mr Silvia Garzoli ,Silvia.Garzoli@noaa.gov ,(None) ,United States , ,Not Presenting[3]

Dr. Maria Paz Chidichimo ,mariapaz.chidichimo@gmail.com ,(Researcher) ,Argentina ,Ciudad Autónoma de Buenos Aires ,Not Presenting[4]

Mr Edmo Campos ,edmo@usp.br ,(None) ,Brazil , ,Not Presenting[2]

Mr Shenfu Dong ,Shenfu.Dong@noaa.gov ,(None) ,United States , ,Not Presenting[1]

Mr Alberto Piola ,apiola@hidro.gov.ar ,(None) ,Argentina , ,Not Presenting[7]

Dr. Renellys Perez ,Renellys.C.Perez@noaa.gov ,(Associate Scientist) ,United States ,Miami ,Not Presenting[3]

1 - NOAA-AOML 2 - Univ. Sao Paulo 3 - UM/CIMAS and NOAA-AOML 4 - Argentine Research Council (CONICET) / Hydrographic Service 5 - Univ. Sao Paulo 6 - NOAA-AOML 7 - Univ. Buenos Aires 8 - UM/CIMAS and NOAA-AOML

The Deep Western Boundary Current (DWBC) at 34.5°S in the South Atlantic carries a significant fraction of the cold deep limb of the Meridional Overturning Circulation (MOC), and therefore its variability affects the meridional heat transport and consequently the regional and global climate. Nearly six years of observations from a line of pressure-equipped inverted echo sounders (PIES) have yielded an unprecedented data set for studying the characteristics of the time-varying DWBC volume transport at 34.5°S. Furthermore, the horizontal resolution of the observing array was greatly improved in December 2012 with the addition of two current-and-pressure-equipped inverted echo sounders (CPIES) at the midpoints of the two westernmost pairs of PIES moorings. Regular hydrographic sections along the PIES/CPIES line confirm the presence of recently-ventilated North Atlantic Deep Water carried by the DWBC. The time-mean absolute geostrophic transport integrated within the DWBC layer, defined between 800-4800 dbar, and within longitude bounds of 51.5°W to 44.5°W is -15 Sv (negative indicates southward flow). The observed peak-to-peak range in volume transport using these integration limits is from -89 Sv to +50 Sv, and the temporal standard deviation is 23 Sv. Testing different vertical integration limits based on time-mean water-mass property levels yields small changes to these values, but no significant alteration to the character of the transport time

series. The time-mean southward DWBC flow at this latitude is confined west of 49.5°W, with recirculations dominating the flow further offshore. As with other latitudes where the DWBC has been observed for multiple years, the time variability greatly exceeds the time-mean, suggesting the presence of strong coherent vortices and/or Rossby Wave-like signals propagating to the boundary from the interior.

Investigating the link between sea-surface height and the AMOC in a transport decline scenario

Abstract ID : 150

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Delphine Lobelle ,delphine.lobelle@soton.ac.uk ,(PhD researcher) ,United Kingdom ,Southampton ,Not Presenting[1]

Prof. Sybren Drijfhout ,S.S.Drijfhout@soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Claudie Beaulieu ,C.Beaulieu@soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Florian Sevellec ,Florian.Sevellec@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Valerie Livina ,valerie.livina@npl.co.uk ,(None) ,United Kingdom , ,Not Presenting[5]

Dr. Eleanor Frajka-Williams ,E.Frajka-williams@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - University of Southampton/ National Physical Laboratory 2 - University of Southampton 3 - University of Southampton 4 - University of Southampton 5 - National Physical Laboratory 6 - University of Southampton

The Atlantic Meridional Overturning Circulation (AMOC) has a prominent role in northward heat transport from the Florida Straits, leading to Europe's climate being milder than the global average at the same latitudes. Several studies project a potential decrease in atmospheric temperatures as a consequence of a slow-down in the AMOC. The RAPID array at 26°N has collected 13 years of observational data from 2004, meaning the only continuous records available are both spatially and temporally constrained. This study develops a statistical method to link sea surface height (SSH) to the multi-decadal trend in the AMOC over multiple latitudes, using forced ocean-only (ORCA025) and coupled climate models under historical and future scenarios (CMIP5). The coefficients from the regression analysis of deseasonalised annually-averaged model AMOC data, against SSH model data are used to produce a quantitatively accurate trend of the AMOC over 60 years into the past and into the future. Analysing the long-term trend allows us to determine whether the current AMOC decline is a transient decadal or persistent multi-decadal feature.

Effect of tide-induced mixing on shallow Pacific Ocean circulation

Abstract ID : 573

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Takao Kawasaki ,kawasaki@aori.u-tokyo.ac.jp ,(Project Assistant Professor) ,Japan ,Chiba ,Presenting[1]

Prof. Hiroyasu Hasumi ,hasumi@aori.u-tokyo.ac.jp ,(None) ,Japan , ,Not Presenting[2]

1 - Atmosphere and Ocean Research Institute, the University of Tokyo 2 - Atmosphere and Ocean Research Institute, the university of Tokyo

It is well known that tidal mixing is one of the most important processes for maintenance of deep water upwelling and meridional overturning circulation. However, our previous study suggested that locally enhanced vertical mixing around the Kuril Strait induces not only upwelling of deep water but also downwelling of shallow water accompanied with the Pacific meridional overturning circulation. Since low resolution (not eddy resolving) ocean model is utilized in the previous study, the quantitative estimate of downwelling induced by the mixing is not completely accurate. Moreover, the vertical mixing-induced horizontal circulation is not truly calculated because of poor representation of Kuroshio separation and its extension. Here, we employ a realistically configured ocean general circulation model (named COCO). The horizontal grid size is 1/4 degree (eddy-permitting) and the vertical diffusivity is calculated based on the distribution of tidal energy dissipation rate, which is estimated by a tide model. The locally enhanced vertical mixing improves the representation of low salinity North Pacific Intermediate Water. The downwelling of shallow water is enhanced by the tide-induced vertical mixing around the Kuril Strait. These results are consistent with our previous study. The North Pacific meridional overturning circulation and its horizontal structure will be discussed in my presentation.

Major variations in subtropical North Atlantic heat transport at short (5 day) timescales and their causes

Abstract ID : 613

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ben Moat ,bim@noc.ac.uk ,(Research Scientist) ,United Kingdom ,Southampton ,Presenting[1]

Dr. Simon Josey ,sxj@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Bablu Sinha ,bablu.sinha@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Adam Blaker ,adam.blaker@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. David Smeed ,david.smeed@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Gerard McCarthy ,gerard.mccarthy@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. William Johns ,bjohns@rsmas.miami.edu ,(None) ,United States , ,Not Presenting[7]

Dr. Joel Hirschi ,joel.hirschi@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Eleanor Frajka-Williams ,E.Frajka-williams@noc.soton.ac.uk ,(None) ,United Kingdom , ,Not Presenting[9]

Mr. Darren Rayner ,darren.rayner@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Aurelie Duchez ,aurelie.duchez@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Andrew Coward ,andrew.coward@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - National Oceanography Centre 2 - NOC 3 - NOC 4 - NOC 5 - NOC 6 - NOC 7 - RSMAS 8 - NOC 9 - University of Southampton 10 - NOC 11 - NOC 12 - NOC

Variability in the North Atlantic ocean heat transport at 26.5°N on short (5 day) timescales is identified and contrasted with different behaviour at monthly intervals using a combination of RAPID/ MOCHA/WBTS measurements and the NEMO-LIM2 1/12° ocean circulation/sea ice model. Wind forcing plays the leading role in establishing the heat transport variability through the Ekman transport response of the ocean and the associated driving atmospheric conditions vary significantly with timescale. We find that at 5 day timescales the largest changes in the heat transport across 26.5°N coincide with north-westerly air- flows originating over the American land mass that drive strong southward anomalies in the Ekman flow. During these events the northward heat transport reduces by 0.5-1.4 PW. In contrast, the Ekman transport response at longer monthly timescales is smaller in

magnitude (up to 0.5 PW) and consistent with expected variations in the leading mode of North Atlantic atmospheric variability, the North Atlantic Oscillation. The north-westerly airflow mechanism can have a prolonged influence beyond the central 5 day timescale and on occasion can reduce the accumulated winter ocean heat transport into the North Atlantic by ~40%.

Meridional overturning circulation and heat budget in the eastern subpolar North Atlantic

Abstract ID : 714

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Patricia Zunino ,pzuninor@ifremer.fr ,(None) ,France ,Plouzané ,Presenting[1]

Dr. Herlé Mercier ,Herle.Mercier@ifremer.fr ,(None) ,France , ,Not Presenting[1]

Dr. Pascale Lherminier ,pascale.lherminier@ifremer.fr ,(None) ,France , ,Not Presenting[3]

Prof. Nathalie Daniault ,nathalie.daniault@univ-brest.fr ,(None) ,France , ,Not Presenting[4]

1 - CNRS 2 - CNRS 3 - Ifremer 4 - Université de Bretagne Occidentale

The OVIDE project allows the study of the variability of the Meridional Overturning Circulation (MOC) and water mass properties by occupying an oceanographic section in the eastern subpolar North Atlantic (from Greenland to Portugal) every other year since 2002. The 2014 cruise, GEOVIDE, was carried out in May-June 2014 in the framework of the GEOTRACES program. GEOVIDE data revealed that the MOC intensity and heat transport in the subpolar North Atlantic (SPNA) was above the 2002-2012 mean value in 2014; this result is supported by a MOC time series built from Argo and Altimetry data (Mercier et al. 2015). Simultaneously, the data showed an important cooling, freshening and oxygen increase in the surface water down to 500 m depth. Using ISAS database and ERA-INTERIM data we analyzed the winter-spring 2014 budgets of heat and freshwater in the eastern SPNA. We found that the cold and fresh anomaly observed in May-June 2014 was an oceanic response to the atmosphere forcing over the eastern SPNA and not due to the horizontal heat transport convergence. Our result contrasts with the fact that the heat content variability in the SPNA is controlled by the variability of the horizontal heat transport convergence and so, by the heat transported by the MOC; this theory has been broadly discussed in the literature for decadal time scales. In this context, and under the umbrella of the AtlantOS project, long term time series (1993 to 2015) of heat transport in the SPNA, based on *in situ* data, was created. This time series was analyzed together with time series of heat content and air-sea fluxes in order to elucidate what is the relationship between the variability of the different elements of the heat budget in the eastern SPNA and what are the controlling mechanisms at different time scales.

Meridional overturning transports at 30°S in the Atlantic Ocean in 2003 and 2011

Abstract ID : 888

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Alonso Hernández-Guerra ,alonso.hernandez@ulpgc.es ,(Director) ,Spain ,Las Palmas de Gran Canaria ,Not Presenting[1]

Prof. Lynne Talley ,ltalley@ucsd.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Alison Macdonald ,amacdonald@whoi.edu ,(Senior Research Specialist) ,United States ,None ,Not Presenting[3]

Prof. Josep L. Pelegrí ,pelegri@icm.csic.es ,(Research Professor) ,Spain ,Barcelona ,Not Presenting[4]

1 - Instituto de Oceanografía y Cambio Global, ULPGC 2 - Scripps Institution of Oceanography, UCSD 3 - Woods Hole Oceanographic Institution 4 - Institut de Ciències del Mar, CSIC

The focus of this work is to estimate the multi-year differences in meridional transport across 30°S in the Atlantic Ocean, using hydrographic sections and direct velocity observations. Geostrophic velocities and transports are calculated from temperature-salinity profiles collected in 2003 and in 2011 along the A10 section, nominally at 30°S in the Atlantic Ocean. Velocity observations come from lowered Acoustic Current Profiler (LADCP) and geostrophic reference velocities are obtained from three different inverse models using different constraints All models show the familiar Atlantic meridional overturning circulation (AMOC) pattern: Thermocline and intermediate waters flowing to the north (13.5±1.3 Sv in 2003 and 16.2±1.4 Sv in 2011), deep waters flowing to the south (-21.0±3.9 Sv in 2003 and -25.4±4.2 Sv in 2011) and bottom waters flowing to the north (6.7±1.8 Sv in 2003 and 8.4±2.1 Sv in 2011). Thus, the three models do not show any significant difference in the AMOC in 2003 and 2011. The net northward heat transport across 30°S Atlantic section is also stable, and in the range 0.28-0.37 PW in 2003 and 0.21-0.46 PW in 2011.

On the seasonal variability of the Canary Current and the Atlantic meridional overturning circulation

Abstract ID : 907

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Pedro Vélez-Belchí ,pedro.velez@oceanografia.es ,(Assistant Professor) ,Spain ,Santa Cruz de Tenerife ,Presenting[1]

Mrs. Maria Dolores Pérez-Hernández ,mperezhernandez@whoi.edu ,(None) ,United States , ,Not Presenting[2]

Mrs. Maria Casanova-Masjoan2 ,maria.casanova102@alu.ulpgc.es ,(None) ,Spain , ,Not Presenting[3]

Prof. Alonso Hernández-Guerra ,alonso.hernandez@ulpgc.es ,(Director) ,Spain ,Las Palmas de Gran Canaria ,Not Presenting[4]

1 - IEO 2 - WHOI 3 - ULPGC 4 - Instituto de Oceanografía y Cambio Global, ULPGC

The Atlantic meridional overturning circulation (AMOC) is an important component of the climate system. Due to its importance, the strength of the AMOC is continually monitored along 26ºN by several moorings situated east of the Bahamas, at the Mid-Atlantic Ridge and on the African slope, south of the Canary Islands. This observing system is known as the RAPID-MOCHA array. Measurements from this array show a 6.7 Sv (1 Sv = $1x10^6 m^3/s^{-1}$) seasonal cycle for the AMOC, with a 5.9 Sv contribution from the upper-mid-ocean. Recent studies argue that the dynamic of the eastern Atlantic is the main driver for this seasonal cycle; specifically, Rossby waves excited south of the Canary Islands. Due to this important role attributed to the eastern Atlantic, in this study we describe the seasonal cycle of the circulation around the Canary Islands and at the eastern boundary that is under the influence of the African slope. We find a seasonal cycle of -4.1±0.5 Sv for the oceanic waters of the Canary Current, and +3.7±0.4 Sv at the eastern boundary. The seasonal cycle along the eastern boundary is in agreement with the seasonal cycle of the AMOC, that requires the smallest contribution to the transport in the upper-mid-ocean to occur in fall. We demonstrate that the linear Rossby wave model used previously to explain the seasonal cycle of the AMOC is not robust, since it is extremely sensitive to the wind stress curl and produces the same results with a Rossby wave speed of zero.

The Global Warming Hiatus and the Indian Ocean Heat Content: Simulating Lagrangian Flows from the North Pacific to the South Atlantic

Abstract ID : 1241

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Bruno Castaldi ,brunocastaldi@gmail.com ,(PhD student at Oceanographic Institute - University of Sao Paulo Research scholar at the Rosential School of Marine and Atmosphere Sciences - University of Miami) ,United States ,Miami, FL ,Not Presenting[1]

Mr Edmo Campos ,edmo@usp.br ,(None) ,Brazil , ,Not Presenting[2]

Dr. Mohamed Iskandarani ,miskandarani@rsmas.miami.edu ,(None) ,United States , ,Not Presenting[3]

1 - University of Sao Paulo 2 - Univ. Sao Paulo 3 - University of Miami

The Climate on the first decade of the XXI century was marked by the Global Warming Hiatus, the period when the mean global surface temperature didn't increase as in past years, although other empirical evidences have pointed out to a warming planet. Recently, this behavior has been reported as holding some relation to the abrupt increase in the Indian Ocean's subsurface heat content in the same period. This additional heat, previously absorbed from the atmosphere in the North Pacific, was transferred to the Indian Ocean by flowing through the different straits and passages around the Indonesia's archipelago, the so-called Indonesian Throughflow that transports about 12 Sv in the upper 700 m of depth from Pacific to Indian Oceans. Occasionally, these waters merge into the subtropical gyre of the South Indian Ocean and, eventually, can be conveyed to the South Atlantic Ocean by the Agulhas Leakage system, composed of large anticyclonic eddies in the south of Africa, linking both basins. All this flow is part of the superficial branch of the Global Meridional Overturning Circulation. In this work, the Connectivity Modeling System (CMS v.2) has been used to numerically simulate Lagrangian flows from the North Pacific to the South Atlantic in the upper 700 m of depth. For the velocity field input, data of two global, eddy-resolving runs of the Hybrid Coordinate Ocean Model (HYCOM GLBa0.08), with 1/12° of horizontal resolution and 32 vertical levels, have been applied. The first one using only climatology data of the NCEP Reanalysis 1, forced for 27 years, and the other one also forced with NCEP data from 1946 to 2015 with interannual variability. Results concerning the heat and volume transports of both Lagrangian and Eulerian flows, comparing their values and variabilities, will be presented. Correlations between the Indonesian Throughflow and the Agulhas Leakage will be shown using the Lagrangian flow data obtained from the CMS experiments. Further works include comparison and correlating ocean's physical properties with the atmosphere in a coupled air-ocean model and with in situ data measurements.

AMOC response to tropical Atlantic river runoff fluctuations

Abstract ID : 1307

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Sharif Jahfer ,jahfersharif@caos.iisc.ernet.in ,(Ph.D. Student) ,India ,Bangalore ,Not Presenting[1]

Prof. P N Vinayachandran ,vinay@caos.iisc.ernet.in ,(Professor) ,India ,Bengaluru ,Not Presenting[2]

Prof. Ravi S. Nanjundiah ,ravi@caos.iisc.ernet.in ,(None) ,India , ,Not Presenting[1]

1 - IISc 2 - Indian Institute of Science 3 - IISc

Climate model simulations have shown that freshwater fluctuations in the tropical Atlantic have a significant impact on the strength of Atlantic Meridional Overturning Circulation (AMOC). Tropical Atlantic rivers including Amazon, Congo and Orinoco discharge about 40% of global runoff and play a major role in the freshwater budget of the Atlantic ocean. Amazon runoff into the Atlantic alone constitutes about one-third of global runoff into the ocean. But the impact of this huge freshwater influx on AMOC, a major source of low-frequency climate variability, remains unknown. Here we show the response of AMOC to various river runoff fluctuation scenarios in the tropical Atlantic using global climate model simulations. Enhanced runoff into the Atlantic resulted in the weakening of the AMOC. On the other hand, a considerable reduction in tropical Atlantic river runoff reinforced the AMOC. Model simulations reveal that Amazon runoff contributes about 10% of the AMOC variability, whereas entire tropical Atlantic runoff contribution is about 15%. In the absence of tropical Atlantic rivers, the western boundary currents strengthen, carrying saltier tropical Atlantic waters to the extratropical Atlantic, further enhancing the rate of sinking. On the contrary, higher river influx into the tropical Atlantic ocean would lead to a weakening of boundary currents and reduction in sinking rate, considerably affecting the AMOC strength. Since these changes in AMOC has global climatic impacts on a global scale, we strongly suggest that the over-exploitation of inland freshwater need to be halted on an immediate basis.

Observed Circulation and Water Mass Variability in the South Atlantic Subtropical Gyre

Abstract ID : 1324

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Renellys Perez ,Renellys.C.Perez@noaa.gov ,(Associate Scientist) ,United States ,Miami ,Presenting[1]

Prof. Ricardo P. Matano ,rpm@coas.oregonstate.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Rym Msadek ,msadek@cerfacs.fr ,(None) ,United States , ,Not Presenting[3]

Mr Silvia Garzoli ,Silvia.Garzoli@noaa.gov ,(None) ,United States , ,Not Presenting[1]

Dr. Maria Paz Chidichimo ,mariapaz.chidichimo@gmail.com ,(Researcher) ,Argentina ,Ciudad Autónoma de Buenos Aires ,Not Presenting[5]

Mr. Elbio Palma ,uspalma@criba.edu.ar ,(None) ,Argentina , ,Not Presenting[6]

Dr. Christopher Meinen ,Christopher.Meinen@noaa.gov ,(Oceanographer) ,United States ,Miami ,Not Presenting[7]

1 - UM/CIMAS and NOAA-AOML 2 - Oregon State University/CEOAS 3 - CERFACS/CNRS 4 - UM/CIMAS and NOAA-AOML 5 - Argentine Research Council (CONICET) / Hydrographic Service 6 - Universidad Nacional del Sur 7 - NOAA-AOML

The subtropical gyres are well-known features of the global oceans, forced by the large-scale mid-latitude wind stress curl patterns that form between the easterly Trade Winds and the subtropical westerlies. Sea surface height (SSH) and upper ocean heat storage in the South Atlantic subtropical gyre have recently been observed to increase associated with the spin-up of the gyre in response to a southward shift and intensification of the subtropical westerlies. In this study, multi-decadal satellite and in situ observations are used to examine low-frequency (interannual to decadal) variations of sea level anomalies, upper ocean heat content, water mass properties, ocean circulation, and wind stress curl in the South Atlantic subtropical gyre (between 35°S to 15°S) and the sector just south of the gyre (between 55°S and 35°S). Based on our analysis, SSH and heat content in the South Atlantic have indeed been increasing over the past decades, but at disparate rates within the subtropical gyre (larger heat content trends) and south of the gyre (larger SSH trends). Salinity driven (halosteric) SSH changes compensate for temperature driven (thermosteric) SSH changes in the gyre in the upper 700 m of the water column - over the past decade the surface waters in the gyre have become warmer and saltier on average. This halosteric - thermosteric compensation is less prevalent south of the gyre because upper ocean warming is paired with freshening. Water mass changes between 700 and

2000 m also influence SSH variations, where weak warming is combined with weak freshening in intermediate water layers. Once the trend is removed, the dominant mode of SSH variability shows interannual to decadal gyre spin-up and spin-down. Although this mode captures only 14% of the total variance, it is strongly correlated with SSHA variability within the gyre. Similar EOF modal structures are reproduced from total steric SSH observations in the upper 700m and 2000m of the water column, as well as from multi-decadal numerical simulations from ocean-only and coupled climate models, as well as global ocean reanalyses. We also examine how changes in the South Atlantic subtropical gyre strength modify the volume transport by its boundary currents and the Atlantic Meridional Overturning Circulation.

Nonseismic sea level oscillations at tsunami timescales: measurability, relevance and origin

Abstract ID : 75

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ivica Vilibic ,vilibic@izor.hr ,(research scientist) ,Croatia ,Split ,Not Presenting[1]

Mr Jadranka Sepic ,sepic@izor.hr ,(None) ,Croatia , ,Not Presenting[1]

1 - Institute of Oceanography and Fisheries 2 - Institute of Oceanography and Fisheries

Coastal sea level extremes are a result of different contributors over a variety of timescales. Most of these contributions are well covered by the present sea level measurements. Yet, the available sea level data have been restricted to hourly values until recently, constraining the analyses to periods higher than 2 hours. This changed after launch of the IOC Sea Level Station Monitoring Facility (http://www.ioc-sealevelmonitoring.org) in the late 2000s. This database embraces global real-time sea level observations at a minute resolution. Presently, the number of stations that transmit sea level data in real-time is slightly lower than 900. However, quality check of the data reveals a great number of problems, including gaps, spikes, drifts, shifts, changes in tidal range, etc. We performed an automatic and manual global data quality check and found more than 300 records longer than one year with quality of data sufficient for performing analysis at tsunami timescales. Quality-checked series have been used for extraction and global assessment of sea level oscillations at periods shorter than 2 hours. Data containing seismic tsunami records have been removed prior to the analysis. Significant oscillations have been found to occur with wave height higher than 1 metre at a large number of stations. The oscillations contribute significantly, from 10% to 50%, to the recorded sea level ranges. Mean and maximum intensity of oscillations resemble zonal distribution of 500-hPa winds, with a minimum at tropical and subtropical regions. The strongest events are largely connected with specific synoptic patterns, which are also characteristic for meteotsunami events. The synoptic patterns indicate that the recorded sea level oscillations are mostly generated by atmospheric gravity waves trapped in the lower troposphere. Significant correlations between nonseismic sea level oscillations at tsunami timescales and synoptic settings allow for proxy-based quantification of the oscillations from synoptic patterns in past, present and future climates, including their trends, variability and seasonality.

The Permanent Service for Mean Sea Level (PSMSL) – a global dataset of sea level change information

Abstract ID : 446

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Andrew Matthews ,antt@noc.ac.uk ,(Data Scientist) ,United Kingdom ,Liverpool ,Presenting[1]

Ms. Elizabeth Bradshaw ,elizb@bodc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Simon Williams ,sdwil@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mrs. Kathy Gordon ,kmg@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Svetlana Jevrejeva ,sveta@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Philip Woodworth ,plw@noc.ac.uk ,(Visiting Scientist (Retired)) ,United Kingdom ,Liverpool ,Not Presenting[6]

Dr. Lesley Rickards ,ljr@bodc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Angela Hibbert ,anhi@noc.ac.uk ,(Sea Level Scientist) ,United Kingdom ,Liverpool ,Not Presenting[1]

1 - National Oceanography Centre 2 - British Oceanographic Data Centre 3 - National Oceanography Centre 4 - National Oceanography Centre 5 - National Oceanography Centre 6 - National Oceanography Centre Liverpool 7 - British Oceanographic Data Centre 8 - National Oceanography Centre

The Permanent Service for Mean Sea Level (PSMSL) is the internationally recognised global sea level data bank for long term sea level change information from tide gauges. Established in 1933, the PSMSL continues to be responsible for the collection, publication, analysis and interpretation of sea level data, and is based in Liverpool at the National Oceanography Centre. The PSMSL operates under the auspices of the International Council for Science (ICSU), is a regular member of the ICSU World Data System and is associated with the International Association for the Physical Sciences of the Oceans (IAPSO) and the International Association of Geodesy (IAG). The PSMSL continues to work closely with other members of the sea level community through the Intergovernmental Oceanographic Commission's Global Sea Level Observing System (GLOSS).
Currently, the PSMSL data bank holds over 68,500 station-years of monthly and annual mean sea level data from over 2300 tide gauge stations. Data from each site are quality controlled and, wherever possible, reduced to a common datum, whose stability is monitored through a network of

geodetic benchmarks. PSMSL also distributes a data bank of measurements taken from in-situ ocean bottom pressure recorders.
Here we will present an overview of the PSMSL dataset, how it can be obtained and where it has been used. We will describe how the global tide gauge network has evolved over the past 200 years and examine its current state, and introduce the products on the PSMSL website that allow the user to interactively examine the dataset. We will also discuss our ongoing work with Système d'Observation du Niveau des Eaux Littorales (SONEL) to exchange information about geodetic links between tide gauges and GNSS receivers, allowing us to link relative sea level measured at tide gauges to the reference ellipsoid, and to provide an estimate of the rate of vertical land movement.

Recent efforts to increase co-ordination of sea level monitoring in Europe : EuroGOOS Tide Gauges Task Team

Abstract ID : 593

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Andrew Matthews ,antt@noc.ac.uk ,(Data Scientist) ,United Kingdom ,Liverpool ,Not Presenting[1]

Dr. Begoña Pérez Gómez ,bego@puertos.es ,(None) ,Spain , ,Not Presenting[2]

Dr. Vincent Donato ,vincent.donato@shom.fr ,(None) ,France , ,Not Presenting[3]

Dr. Angela Hibbert ,anhi@noc.ac.uk ,(Sea Level Scientist) ,United Kingdom ,Liverpool ,Presenting[1]

1 - National Oceanography Centre 2 - Puertos del Estado 3 - Service hydrographique et océanographique de la Marine 4 - National Oceanography Centre

EuroGOOS (http://www.eurogoos.eu/) is an international non-profitmaking organisation committed to European-scale operational oceanography within the context of the Global Ocean Observing System of the Intergovernmental Oceanographic Commission of UNESCO (GOOS, IOC). EuroGOOS has established Task Teams for different marine observational technologies to promote scientific and technological collaboration across borders. Task Team members exchange tools, knowledge and data, the latter of which ultimately contribute to European Marine Observation and Data Network (EMODnet) and Copernicus Marine Environmental Monitoring System (CMEMS). Task Teams operate within the framework of the European Ocean Observing System (EOOS).

Sea level is a critical environmental variable, with significant impact on the coastal population and tide gauges have long since been the primary method of monitoring its variability, from tides, storm surges and tsunamis, to the long terms trends associated with Climate Change. As a result, the EuroGOOS Tide Gauge Task Team (EuroGOOS TGTT: http://www.eurogoos.eu/tide-gauge-task-team/) was established to bring together the European tide gauge community, compiling information on tide gauge networks, provide expertise on their observations and supporting initiatives to maintain a permanent and sustainable sea level observing system.

An initial survey by the TGTT to evaluate the sustainability of national tide gauge networks showed that over half of the institutions that responded and nearly 30% of the associated tide gauge stations faced future funding problems. There is clearly an urgent need to address this.

Thereafter, the TGTT held a European workshop for the sea level community at La Rochelle in November 2016. Discussions included the status of existing national networks and data portals, technology, quality control and data processing and scientific studies based upon tide gauge data. This workshop was held alongside the OST/ST International Congress on Satellite Altimetry, to facilitate engagement between the altimetry and tide gauge communities.

We hope that this initiative will foster collaboration and scientific/technological development within Europe, under the new umbrella of international data exchange programmes such as CMEMS, as well as existing ones such as the Global Sea Level Observing System (GLOSS).

Caribbean Sea Level Network

Abstract ID : 691

Conflict Declaration : None

Content Motivation : None

Additional Information : CARIBE EWS Working Group 1 Tsunami Monitoring

Mrs. Christa von Hillebrandt-Andrade ,christa.vonh@noaa.gov ,(Manager NOAA NWS Caribbean Tsunami Warning Program) ,United States ,Mayaguez ,Presenting[1]

Mrs. Carolina Hincapie ,carolina.hincapie@noaa.gov ,(None) ,Puerto Rico , ,Not Presenting[1]

1 - NOAA NWS Caribbean Tsunami Warning Program 2 - NOAA NWS Caribbean Tsunami Warning Program

Over 75 tsunamis with 4484 deaths have been documented in the Caribbean and Adjacent Regions over the past 500 years. The most recent devastating tsunami occurred in 1946 in Dominican Republic; almost 2000 were reported to have died. With the explosive increase in residents, tourists, infrastructure, and economic activity along the Caribbean coasts, the potential for human and economic loss is enormous. It has been estimated that on any day, upwards of more than 500,000 people could be in harm's way just along the beaches, with hundreds of thousands more working and living in tsunamis zones. In 2005 the UNESCO Intergovernmental Oceanographic Commission established the Intergovernmental Coordination Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (CARIBE EWS) to coordinate tsunami efforts among the 48 countries and territories in the region from Bermuda thru Brazil.
Significant progress in the Region has been made in monitoring, threat and hazard assessments, as well as in community preparedness, readiness and resilience. The presentation will highlight status of sea level monitoring, which is critical for the detection and forecasting of tsunamis impact.
Despite multiple efforts and investments in the installation of sea level stations in the region, in 2004 there were only a handful of sea level stations operational in the region. Nevertheless, over the past 12 years there has been a steady increase in the number of stations operating in the greater Caribbean. As of 2017 there are 7 DARTS and 79 coastal gauges with additional ones being installed or funded.
The goal is to have 116 operational sea level stations supporting the Tsunami Warning System. For this, the CARIBE EWS appreciates support and seeks funding for new stations, maintenance and capacity building. Since 2008, five training courses have been delivered to operators, also user-friendly tools have been developed to visualize and analyze the data like the IOC Sea level Monitoring Facility and the Tide Tool program. These efforts are important for the strengthening of the CARIBE EWS, but also provide valuable information for scientist interested in other research areas and risk reduction initiatives.

Coastal Sea Level Variability from Satellite Altimetry - Applications in the UK and the Southern Indian Ocean

Abstract ID : 727

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Angela Hibbert ,anhi@noc.ac.uk ,(Sea Level Scientist) ,United Kingdom ,Liverpool ,Not Presenting[1]

Mr. David Cotton ,d.cotton@satoc.eu ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Paolo Cipollini ,cipo@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Mr. Ellis Ash ,e.ash@satoc.eu ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Francisco Mir Calafat ,Francisco.Calafat@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Simon Williams ,sdwil@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Ms. Christine Sams ,chrams@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr. Nadim Dayoub ,nayoub@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - National Oceanography Centre 2 - SATOC 3 - National Oceanograpgy Centre 4 - SATOC 5 - National Oceanography Centre 6 - National Oceanography Centre 7 - National Oceanography Centre 8 - National Oceanography Centre

Historically, the use of satellite altimetry at the coast has been hindered by contamination of the radar reflection by land. To address this, the UK National Oceanography Centre (NOC) developed the "ALES" altimeter re-tracker to reprocess coastal altimetry data, providing a continuous 20-year time series. Here we describe its application to the coastal seas around the UK and those surrounding Mozambique, Madagascar and South Africa.

UK Sea Level SpaceWatch is a service designed to support the UK agencies responsible for the management and planning of national flood defences and for the preservation of coastal habitats threatened by sea level change. Using data from the Jason-1, Jason-2 and Envisat satellite altimeters together with tide gauge data, Sea Level SpaceWatch is a web-based suite of the latest observations of UK sea level, estimated long-term trends, regional variability and confidence intervals showing the lower and upper limit for the present mean sea levels. This altimetry-based data was validated against tide gauge records and further analysed to evaluate regional sea level variability on seasonal and interannual timescales. The service complements the sea level scenarios of UK Climate Projections.

C-RISe is a new initiative to develop a Coastal Risk Information service for the coastal region around South Africa, Mozambique and Madagascar, providing information on sea level rise, storm surges, wind speed and wave heights from satellite altimetry and validated with local *in situ* measurements. It aims to supply local stakeholders with information to reduce the social and economic impact of coastal inundation and increasingly variable weather patterns. In this project, "ALES" reprocessed altimetry data will be delivered through a web-based data portal and evaluated through case studies in a number of application areas. Local users will trained in the validation and use of satellite data to quantify coastal hazards and incorporate these into mitigation initiatives.

Both projects are funded by the UK Space Agency, through the Space for Smarter Government Programme and the International Partnership Programme.

Adaptations in Tide Gauge Technology - from the Tropics to the Poles

Abstract ID : 729

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Angela Hibbert ,anhi@noc.ac.uk ,(Sea Level Scientist) ,United Kingdom ,Liverpool ,Not Presenting[1]

Mr. Jeff Pugh ,jpugh@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr. Peter Foden ,prf@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr. David Jones ,dsj@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Philip Woodworth ,plw@noc.ac.uk ,(Visiting Scientist (Retired)) ,United Kingdom ,Liverpool ,Not Presenting[5]

Mr. Emlyn Jones ,emj@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - National Oceanography Centre 2 - National Oceanography Centre 3 - National Oceanography Centre 4 - National Oceanography Centre 5 - National Oceanography Centre Liverpool 6 - National Oceanography Centre

The South Atlantic Tide Gauge Network (SATGN) was formed more than 30 years ago and operates at 9 sites in some of the most remote and hostile locations in the World. Historically, this was an under-sampled ocean region and the SATGN has been crucial in addressing knowledge gaps, for example regarding the scale of ACC variability. However, decadal variability in this region is still poorly understood and from this perspective the SATGN is just entering its useful life. NOC engineers are therefore developing low cost, low maintenance and highly accurate, robust technology that can be used in such locations for many years to come, minimising costs and ensuring the future availability of these data. One such development involved the installation of a guided-wave radar gauge at Rothera Base on the Antarctic Peninsula in December 2015, fitted within a purpose-built insulated and heated stilling well to prevent ice formation. The technology has successfully functioned year-round, transmitting data in near real-time via the GOES satellite.
More recently, NOC Scientists and Engineers harnessed technology solutions developed for the South Atlantic and applied them to the needs of Tropical Small Island Developing States. Located within the Caribbean Hurricane Belt and in a region of seismic activity, St Lucia is vulnerable to coastal hazards such as tsunamis, storm surges and the longer-term impacts of sea level rise associated with Climate Change. However, the island lacked sea level monitoring systems to improve the planning and mitigation of such events. NOC therefore designed and installed bespoke low-cost, low-maintenance tide gauge instruments to transmit real-time sea level data for use by St Lucia government agencies and the Intergovernmental Oceanographic Commission's Caribbean Tsunami

Early Warning Centre (ICG/CARIBE-EWS). The technology was specifically designed to minimise costs to local agencies and ensure the longevity of the tide gauge equipment.

High-resolution numerical simulation of the 2006-2007 Central Kuril Islands tsunamis

Abstract ID : 1099

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Anastasiia Ivanova ,lapoul@gmail.com ,(Junior researcher) ,Russia ,Moscow ,Not Presenting[1]

Dr. Eugeniy Kulikov ,kulikove@ocean.ru ,(None) ,Russia , ,Not Presenting[1]

Dr. Isaak Fine ,finei@pac.dfo-mpo.gc.ca ,(None) ,Canada , ,Not Presenting[3]

1 - P. P. Shirshov Institute of oceanology RAS 2 - P. P. Shirshov Institute of oceanology RAS 3 - Institute of Ocean Sciences, Sidney, BC, Canada

Matua Island is located in the central part of the Kuril Islands. There are no permanent human settlements, but in recent years there is increased attention to the island due to the government's plans to build there a military dock. In the present research, we will attempt to simulate the tsunami waves after the tsunamigenic earthquake of November 15, 2006 (M = 8.3) and following earthquake of January 13, 2007 (M = 8.1), that occurred in the region of Central Kuril Islands. Particular attention was paid to the distribution of the maximum tsunami heights along the coast of Matua Island, but also a similar calculation was made for the coast of Simushir Island. The digital bathymetric data set was compiled on the basis of the GEBCO_2014 data and additional bathymetry data of higher resolution around the Central Kuril islands. A numerical experiment was carried out on a grid of 10 angular seconds in resolution and 2521 × 1801 nodes in size. The maximum tsunami heights for both cases are about 16-20 meters for Matua Island and about 8-10 meters for Simushir Island. Simulation results are in good agreement with the field observations data on the coast of the islands in summer 2007.

Real-time tsunami monitoring system by detection of geomagnetic vector difference

Abstract ID : 1197

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Hiroaki Toh ,toh@kugi.kyoto-u.ac.jp ,(Assoc. Prof.) ,Japan ,Kyoto ,Presenting[1]

Mr. Satoshi Abe ,abe-s96gt@mlit.go.jp ,(None) ,Japan , ,Not Presenting[2]

Mr. Jumpei Ogi ,oogi.jun@met.kishou.go.jp ,(None) ,Japan , ,Not Presenting[3]

Mr. Akira Yamazaki ,a_yamazaki@met.kishou.go.jp ,(None) ,Japan , ,Not Presenting[3]

Dr. Ryokei Yoshimura ,ryokei@eqh.dpri.kyoto-u.ac.jp ,(None) ,Japan , ,Not Presenting[1]

1 - Kyoto Univ. 2 - Geospatial Information Authority of Japan 3 - Japan Meteorological Agency 4 - Japan Meteorological Agency 5 - Kyoto Univ.

It has been found that tsunamis are associated with small but significant electromagnetic (EM) fields (e.g., Toh et al., 2011) that can be used for tsunami early warning purposes. ?Since then, the tsunami-generated EM fields have been studied intensively by many researchers (Suetsugu et al., 2012; Minami and Toh, 2013; Zhang et al., 2014; Minami et al., 2015; Schnepf et al., 2016) to reveal their useful features for tsunami early warning such as strong correlation of the vertical magnetic component with tsunami wave height, detectable phase leads of magnetic components w.r.t. the maximum wave height and so on.

However, as they were first discovered by seafloor EM observation, they are primarily detectable on the seafloor since incessant geomagnetic disturbances of external origin in the tsunami period band are strongly attenuated there. Furthermore, it was also found that magnetic disturbances may possibly be generated by tsunamis as a result of interaction between the ionosphere and waves in the neutral atmosphere excited by tsunamis (e.g., Kherani et al., 2016), which can dominate geomagnetic data on land at the time of tsunami occurrence.

This means that it is essential to remove both effects from raw geomagnetic data on land in order to make them available for tsunami early warning purposes. To achieve this, we newly established a land-based monitoring system of vector geomagnetic difference in Kochi, Japan. The system consists of a geomagnetic observatory at the tip of Muroto Peninsula and another at Umaji in the middle of Shikoku Mountains approximately 30 km north-northwest of the Muroto observatory. Correction of both external and ionospheric effects has been realized in real-time by subtracting the vector geomagnetic data at Umaji from those at Muroto.

In this paper, characteristics of the tsunami-generated EM fields, the principle of the real-time tsunami detection by taking geomagnetic vector difference and the result of simultaneous

observation at the coastal and in-land geomagnetic observatories in Shikoku, Japan since 2014 will be reported.

African Sea Level Data Rescue - finding data in a data sparse region

Abstract ID : 1283

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Elizabeth Bradshaw ,elizb@bodc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Angela Hibbert ,anhi@noc.ac.uk ,(Sea Level Scientist) ,United Kingdom ,Liverpool ,Presenting[2]

Dr. Andrew Matthews ,antt@noc.ac.uk ,(Data Scientist) ,United Kingdom ,Liverpool ,Not Presenting[2]

Dr. Svetlana Jevrejeva ,sveta@noc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Lesley Rickards ,ljr@bodc.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - British Oceanographic Data Centre 2 - National Oceanography Centre 3 - National Oceanography Centre 4 - National Oceanography Centre 5 - British Oceanographic Data Centre

African Sea Level Data Rescue - finding data in a data sparse region
The Permanent Service for Mean Sea Level (PSMSL) is the global data bank for long-term sea level change information but it contains no records longer than 100 years from around the African coastline. The longest record in Africa is from Takordadi, Ghana (1929 - 2012). Data from the Southern Hemisphere, in general, is sparse.
Long-term sea level records are essential for climate change studies and at least 60 years of data are recommended for analysis of long-term trends. Historical high frequency data are used to study the frequency of storm surges, coastal flooding, tsunami propagation etc.
Data archaeology activities have uncovered large numbers of tidal charts in archives around the world that could help fill in the gaps in the data record.
The Global Sea Level Observing System (GLOSS) Group of Experts (GE) data archaeology group aims to share experiences with scanning and digitising analogue tide gauge charts and sea level ledgers and will use the GLOSS website as a repository of software to carry out these tasks.
The priorities of the GLOSS-GE are to explore mareogram digitisation applications, to publicise sea level data archaeology and rescue, investigate sources of funding and to propose Guidelines for rescuing sea level data. Their goal is to improve the quality, quantity and availability of long-term sea level data series.
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Signature of the Agulhas Current in ASAR derived wind fields

Abstract ID : 914

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Marjolaine Krug ,mkrug@csir.co.za ,(Dr.) ,South Africa ,Cape Town ,Not Presenting[1]

Mr. Daniel Schilperoort, ,danielschilperoort@ostenergy.com ,(None) ,South Africa , ,Not Presenting[2]

Prof. Mathieu Rouault ,Mathieu.Rouault@uct.ac.za ,(Professor) ,South Africa ,Cape Town ,Not Presenting[3]

Dr. Fabrice Collard ,dr.fab@oceandatalab.com ,(None) ,France , ,Not Presenting[4]

Dr. Morten Hansen ,morten.hansen@nersc.no ,(None) ,Norway , ,Not Presenting[5]

1 - Council for Scientific and Industrial Research 2 - Nansen-Tutu Centre for Marine Environmental Research 3 - University of Cape town 4 - OceanDataLab 5 - Nansen Environmental and Remote Sensing Center

A 5-year archive of Advanced Synthetic Aperture Radar (ASAR) wide swath images is used to investigate SAR derived wind variations over the Agulhas Current, near 34^{o}S. These wind fields are extracted at a 1 km spatial resolution from the ASAR Normalized radar cross-sections using the CMOD5.n GMF and wind directions from the hourly Climate Forecast System Reanalysis (CFSR) reanalysis product. The derived wind speeds are compared to those analysed in the CFSR dataset. The magnitude of the Agulhas Current at the time of the ASAR acquisition are estimated using the Globcurrent product.
Comparisons between the CFSR winds and winds measured by the Advanced *Scatterometer* (*ASCAT* METOP-A) show that the wind directions in the CFSR and ASCAT products are in good agreement. Winds over the Agulhas Current are generally aligned along a north-east / south-west axis, in line with the mean direction of the Agulhas Current. In an upwind configuration , marked differences exist between the ASAR and CFSR wind speeds. On average, the ASAR wind speeds over the Agulhas Current exceed those estimated in the CFSR product by about 5 m/sec. The differences in wind speeds between the ASAR and CFSR product are greatest at the northern wall of the Agulhas Current, where the largest gradient of SST are observed. In a downwind configuration, the differences between the ASAR and CFSR wind speeds still remain large, with differences in wind speeds in the 2-4 m.sec range. The large discrepancies between the ASAR and CFSR winds in an upwind configuration is questioning the validity of the CMOD5.n GMF in western boundary current

regions. In a downwind configuration, the CFSR product tends to under-estimate wind speeds increases over the Agulhas current which we attribute to the unstable marine boundary layer over the warm Agulhas Current.

Propagating ocean structures within the Agulhas Current in a series of simulations with FESOM and NEMO models and in satellite altimetry

Abstract ID : 924

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Natalia Tilinina ,natalia.tilinina@awi.de ,(Postdoctoral researcher) ,Germany ,Bremerhaven ,Not Presenting[1]

Dr. Qiang Wang ,qiang.wang@awi.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Dmitry Sein ,Dmitry.Sein@awi.de ,(None) ,Germany , ,Not Presenting[3]

Dr. Sergey Danilov ,Sergey.Danilov@awi.de ,(None) ,Germany , ,Not Presenting[1]

Prof. Arne Biastoch ,abiastoch@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[5]

Dr. Franziska Schwarzkopf ,fschwarzkopf@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[6]

Dr. Jan Harlaß ,jharlass@geomar.de ,(None) ,Germany , ,Not Presenting[5]

Mr. René Schubert ,rschubert@geomar.de ,(None) ,Germany , ,Not Presenting[5]

Dr. Jonathan V. Durgadoo ,jdurgadoo@geomar.de ,(None) ,Germany , ,Not Presenting[9]

Dr. Sergey Gulev ,gul@sail.msk.ru ,(None) ,Russia , ,Not Presenting[10]

1 - Alfred Wegener Institute for Polar and Marine Research 2 - Alfred Wegener Institute for Polar and Marine Research 3 - Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research 4 - Alfred Wegener Institute for Polar and Marine Research 5 - GEOMAR Helmholtz Centre for Ocean Research Kiel 6 - GEOMAR Helmholtz Cebtre for Ocean Research Kiel 7 - GEOMAR Helmholtz Centre for Ocean Research Kiel 8 - GEOMAR Helmholtz Centre for Ocean Research Kiel 9 - - GEOMAR Helmholtz Centre for Ocean Research Kiel 10 - Russian Academy of Sciences, Shirshov Institute of Oceanology

The Agulhas Current system plays an important role in the general ocean circulation and formation of the Atlantic Meridional Overturning Circulation. The scope of this work is to qualitatively analyse mesoscale and submesoscale ocean dynamics within the Agulhas Current. The main questions addressed in this study are (i) what are the main dynamical structures that lead to the variability of the Agulhas Current, (ii) how well modern high-resolution OGCMs (with respect to the satellite data) resolve the dynamics and structure of the Agulhas Current, and (iii) what role do stationary and propagating eddies have in modulating Agulhas leakage? To answer these questions, we performed simulations (more than 50 years) with two OGCMs: FESOM (Finite-Element/volume Sea ice-Ocean

Model) with unstructured mesh locally refined (up to ~4 km) over the Agulhas region and NEMO (Nucleus for European Modelling of the Ocean) with a nested configurations at different horizontal resolutions (up to 1/60°).
Validation of the Sea Surface Height (SSH) in model outputs against satellite altimetry data shows the good agreement between two models and satellite data in the size, shape and speed of the propagating patterns. Those patterns are mostly anticyclonic eddies in the Mozambique Channel and Agulhas Current, and meanders in the Agulhas retroflection. The band-pass and spectral analysis of the SSH and other ocean parameters reveals a strong variability over the Agulhas Current within the temporal range of 30-90 days and spatial range of 100-300 km.

Dynamics of Brazil Current transport variability observed at 34.5°S on intraseasonal to interannual time scales

Abstract ID : 1162

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Maria Paz Chidichimo ,mariapaz.chidichimo@gmail.com ,(Researcher) ,Argentina ,Ciudad Autónoma de Buenos Aires ,Not Presenting[1]

Mr Alberto Piola ,apiola@hidro.gov.ar ,(None) ,Argentina , ,Not Presenting[2]

Dr. Christopher Meinen ,Christopher.Meinen@noaa.gov ,(Oceanographer) ,United States ,Miami ,Not Presenting[3]

Mr Silvia Garzoli ,Silvia.Garzoli@noaa.gov ,(None) ,United States , ,Not Presenting[4]

Mr Edmo Campos ,edmo@usp.br ,(None) ,Brazil , ,Not Presenting[5]

Dr. Renellys Perez ,Renellys.C.Perez@noaa.gov ,(Associate Scientist) ,United States ,Miami ,Not Presenting[4]

Prof. Sabrina Speich ,speich@lmd.ens.fr ,(None) ,France , ,Not Presenting[7]

Mr Shenfu Dong ,Shenfu.Dong@noaa.gov ,(None) ,United States , ,Not Presenting[3]

1 - Argentine Research Council (CONICET) / Hydrographic Service 2 - Univ. Buenos Aires 3 - NOAA-AOML 4 - UM/CIMAS and NOAA-AOML 5 - Univ. Sao Paulo 6 - UM/CIMAS and NOAA-AOML 7 - ENS 8 - NOAA-AOML

The Brazil Current (BC) closes the subtropical gyre in the western South Atlantic, carrying relatively warm and salty along the continental margin of South America between approximately 15ºS to 38ºS. As it flows southward the BC contributes to the Meridional Overturning Circulation (MOC) variability in the South Atlantic and the associated meridional heat transport. Variations in the BC cause significant anomalies in the regional sea surface temperature, which have an impact on the regional climate and marine ecosystems. Previous studies using satellite data have shown that in the last few decades the BC penetrated further south, but the associated impacts of this displacement are not yet well understood. Here, the BC transport variability is analyzed from data collected along a line in the western South Atlantic at 34.5ºS with four pressure-equipped inverted echo sounders (PIES) from May 2009 to present. In 2012, two current-and-pressure-equipped inverted echo sounders (CPIES) were deployed midway between three of the existing sites to augment the horizontal resolution of the array. The combination of the data from the PIES/CPIES and regional hydrographic surveys yields daily estimates of full-depth vertical profiles of temperature, salinity, density, and the meridional

component of the absolute geostrophic velocity. Daily time series of absolute BC transport are estimated by vertically integrating the geostrophic velocities (baroclinic referenced to the bottom plus barotropic) across the array. Continental shelf flows are estimated using high-resolution hydrographic transects, direct velocity measurements from an ADCP mooring, and numerical models. The estimated time-mean absolute southward BC transport at 34.5ºS is -13.5 ± 0.8 Sv with a standard deviation of 5.0 Sv. Fluctuations with periods shorter than 100 days account for 60% of the variance. The variability of the baroclinic component accounts for the largest fraction of the absolute transport variability (80%). The baroclinic and barotropic transports are uncorrelated, highlighting the need of measuring both transport components independently. Local and basin-wide drivers of BC variability on intraseasonal to interannual time scales as well as the linkage between BC and MOC variability observed at 34.5ºS will be presented and discussed.

Crossroads of the Agulhas System

Abstract ID : 1164

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jeffrey Book ,jeff.book@nrlssc.navy.mil ,(None) , , ,Not Presenting[1]

Prof. Isabelle Ansorge ,Isabelle.Ansorge@uct.ac.za ,(Head of Department) ,South Africa ,None ,Not Presenting[2]

Dr. Tarron Lamont ,tarron.lamont@gmail.com ,(Marine Scientist) ,South Africa ,Cape Town ,Not Presenting[3]

Mr. Marcel van den Berg ,MARCEL@OCEANAFRICA.COM ,(None) ,South Africa , ,Not Presenting[4]

Dr. Ana Rice ,Ana.Rice@nrlssc.navy.mil ,(None) ,United States , ,Not Presenting[5]

1 - US Naval Research Laboratory 2 - UCT 3 - Department of Environmental Affairs 4 - Oceans and Coasts Research, DEA 5 - U.S. Naval Research Laboratory

The Agulhas Current System, uniquely among Western Boundary Currents, turns back upon itself in a tight loop forming the Agulhas Retroflection. The shedding of Agulhas Rings at the retroflection provides a pathway of exchange between the Atlantic and Indian Oceans with important implications for the meridional overturning circulation. After the retroflection, the Agulhas Return Current (ARC) meanders northward around the Agulhas Plateau before returning to its easterly pathway. At its most northerly point, the ARC passes within 300 km of the oppositely flowing Agulhas Current (AC), and an altimetry track line crosses through both currents. Annual measurement of The AC and ARC along this "Crossroads" Line has been conducted for five years, starting with a cruise to study the ARC in 2012 and then by cruises returning from Marion Island from 2013 through 2017. Absolute geostrophic volume and temperature transports were calculated for both these major currents using CTD and XBT hydrographic measurements referenced to shipboard ADCP currents. We will present the results of these Crossroads Line studies with respect to the dynamics and snapshot transports of the AC, ARC, and several major mesoscale eddies that also crossed the transect line during the crossings.

Role of Interannual Kelvin wave propagations in the equatorial Atlantic on the Angola Benguela Curent system.

Abstract ID : 156

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Rodrigue Anicet Imbol Koungue ,rodrigueanicet@yahoo.fr ,(PhD Student) ,South Africa ,Cape Town ,Presenting[1]

Dr. Serena Illig ,serena.illig@gmail.com ,(None) ,South Africa , ,Not Presenting[2]

Prof. Mathieu Rouault ,Mathieu.Rouault@uct.ac.za ,(Professor) ,South Africa ,Cape Town ,Not Presenting[3]

1 - University of Cape Town 2 - Department of Oceanography, MARE Institute, University of Cape Town, South Africa/Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS), Université de Toulouse, CNES, CNRS, IRD, UPS, Toulouse, France; part of the International Mixed Laboratory ICEMASA. 3 - University of Cape town

The link between equatorial Atlantic Ocean variability and the coastal region of Angola and Namibia is investigated at interannual time scales from 1998 to 2012. An index of equatorial Kelvin wave activity is defined based on Prediction and Research Moored Array in the Tropical Atlantic (PIRATA). Along the equator, results show a significant correlation between PIRATA monthly dynamic height anomalies, altimetric monthly Sea Surface Height anomalies (SSHA) and SSHA calculated with an Ocean Linear Model. This allows us to interpret PIRATA records into equatorial Kelvin wave. Estimated phase speed of eastward propagations from PIRATA equatorial mooring remains in agreement with the linear theory, emphasizing the dominance of the second baroclinic mode. Systematic analysis of all strong interannual equatorial SSH anomalies shows that they precede by 1-2 months extreme interannual SST Anomalies (SSTA) along the African coast, which confirms the hypothesis that major warm and cold events in the Angola-Benguela current system are remotely forced by ocean atmosphere interactions in the equatorial Atlantic. Equatorial wave dynamics is at the origin of their developments. Wind anomalies in the Western Equatorial Atlantic force equatorial downwelling and upwelling Kelvin waves that propagate eastward along the equator and then polewards along the African coast triggering extreme warm and cold events respectively. A proxy index based on linear ocean dynamics appears to be significantly more correlated with coastal variability than an index based on wind variability. Results show a seasonal phasing, with significantly higher correlations between our equatorial index and coastal SSTA in October-April.

Changes in Upwelling along the Arabian coast in a warming scenario

Abstract ID : 250

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Praveen Veluthedathekuzhiyil ,pv25@nyu.edu ,(None) ,United Arab Emirates , ,Not Presenting[1]

Dr. Vinu Valsala ,valsala@tropmet.res.in ,(None) ,India , ,Not Presenting[2]

Dr. Sandeep Sukumaran ,ss7675@nyu.edu ,(Postdoc) ,United Arab Emirates ,Abu Dhabi ,Not Presenting[1]

Dr. Ajaya Mohan Ravindran ,ajaya.mohan@nyu.edu ,(Senior Scientist) ,United Arab Emirates ,Abu Dhabi ,Not Presenting[1]

1 - New York University Abu Dhabi 2 - IITM 3 - New York University Abu Dhabi 4 - New York University Abu Dhabi

The oceanic impact of poleward shift in Monsoon Low-Level Jet (MLLJ) is examined using a regional ocean model (ROMS). Two sets of downscaling experiments were conducted using ROMS with boundary and initial conditions from six CMIP5 models. While outputs from the historical run (1981-2000) acts as forcing for the first, the second uses RCP8.5 (2080-2099). By comparing the outputs, it is found that Oman coast will experience an increase in upwelling in tune with MLLJ shift. Consistent with the changes in upwelling and zonal Ekman transport, temperature, salinity and productivity show significant changes near the Oman coast. The changes in MLLJ causes the coastal wind to angle against the Oman coast in such a fashion that the net upwelling increases in the next century and so does the marine productivity. This study contrasts the general view of weakening of upwelling along the Arabian coasts due to the weakening of monsoon winds. Above findings has major implications on the livelihood and economy of the region

Fishing for Answers: Utilising fishing vessel data to explore sea surface and bottom temperature on the South African shelf edge

Abstract ID : 429

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Kirsten du Plessis ,kirstend@ij.co.za ,(Oceanographer) ,South Africa ,Cape Town ,Not Presenting[1]

Prof. Marcello Vichi ,marcello.vichi@uct.ac.za ,(Director of the Marine Research Institute) ,South Africa ,Cape Town ,Not Presenting[2]

Mr. Robert Landman ,robertla@ij.co.za ,(None) ,South Africa , ,Not Presenting[1]

1 - I&J 2 - Department of Oceanography and Institute of Marine Research, University of Cape Town 3 - I&J

K. du Plessis (I&J, Department of Oceanography, University of Cape Town), Marcello Vichi (Department of Oceanography and Institute of Marine Research, University of Cape Town), Robert Landman (I&J)
The demersal trawl industry in South Africa are limited to fishing along the western and southern continental shelf edge, however this region is intensively fished, with vessel collecting ocean and atmospheric measurements up to 4 times a day, every day of the year. I&J is one of the major industrial fishing company in South Africa and its fleet of 12 vessels has resulted in a large dataset spanning 12 years, of both sea surface and bottom temperatures. The fisheries vessels, used as ships of opportunity, could potentially be providing the scientific community with near real time *in situ* measurements of the sea surface and bottom temperatures along the South African continental shelf edge. This dataset however is not without its nuances: Firstly the sampled data is prefiltered to temperature brackets that are suitable for targeting hake (*Merluccius capensis* and *Merluccius paradoxus* - the fishes the industry is focused on), as well as the sensors used to measure the temperature are not regularly calibrated, and require the operator to manually record the information. Therefore, the data, grouped into 30 km by 30 km cells, underwent a rigorous cleaning process. The cleaned data were then compared against satellite and World Ocean Database *in situ* measurements, showing a similar distribution of temperatures, suggesting the fishing data is representative of the actual temperatures. The highest density cells' sea surface temperatures were then assessed, over the 12 year time period, both for the long term trend and short term variability. The outcome of the research is to gain a stronger understanding of the mechanisms driving trends in both surface and bottom temperature of the South African upwelling systems, along with linking these driving forces to the movement of hake stocks, as well as building a protocol for the collection, assessment of limitations and cleaning of the commercial vessel data.

Interannual phytoplankton size structure in the Benguela Upwelling System.

Abstract ID : 950

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Tarron Lamont ,tarron.lamont@gmail.com ,(Marine Scientist) ,South Africa ,Cape Town ,Presenting[1]

Mr. Ray Barlow ,rgb.barlow@gmail.com ,(None) ,South Africa , ,Not Presenting[2]

Mr. Robert Brewin ,robr@pml.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

1 - Department of Environmental Affairs 2 - Bayworld Centre for Research & Education 3 - Plymouth Marine Laboratory

The three-component model of Brewin et al. (2010) computes fractional contributions of three phytoplankton size classes (micro-, nano-, picophytoplankton) to the overall chlorophyll *a* (chla) concentration. Using in situ HPLC data, model coefficients were fine-tuned for application to the Benguela Upwelling System (BUS). The refined model was applied to monthly averages of SeaWiFS (1997-2007) and MODIS Aqua (2002-2015) chla in three regions of the BUS, namely northern Benguela (NB), southern Benguela (SB), and the Agulhas Bank (AB). The 1 mg m^{-3} chla contour was used to further sub-divide each region into shelf and open ocean domains. Annual (July-June) means of chla and fractional contributions of micro-, nano-, and picophytoplankton were computed and linear regressions were calculated for both the SeaWiFS and MODIS Aqua time series. On the shelf, micro-phytoplankton comprised 63-73 % of the total chla in the NB, 67-75 % in the SB, and 50-66 % in the AB region. Nano-phytoplankton proportions on the shelf were 23-31 % in the NB, 21-28 % in the SB, and 23-38 % in the AB region, while higher proportions (45-48 %) were noted in the open ocean domains. Picophytoplankton proportions were lower (4-6 %) in the NB and SB shelf regions and slightly higher (8-12 %) in the AB region, while values were 24-36 % in the open ocean domains. In the shelf domains, the MODIS Aqua time series showed higher micro- and nano-, and lower picophytoplankton proportions than the SeaWiFS time series, while MODIS Aqua and SeaWiFS values in the open ocean domains of each region were similar. The SeaWiFS chla time series showed a significant positive linear trend in the NB shelf region, while the SeaWiFS picophytoplankton proportion on the AB shelf showed a significant linear increase. These trends are not evident in the latter MODIS Aqua time series.

Upwelling indices for comparative ecosystem studies: variability in the Benguela Upwelling System

Abstract ID : 951

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Tarron Lamont ,tarron.lamont@gmail.com ,(Marine Scientist) ,South Africa ,Cape Town ,Not Presenting[1]

Dr. Marisol Garcia-Reyes ,marisolgr@gmail.com ,(None) ,United States , ,Not Presenting[2]

Dr. Steven Bograd ,steven.bograd@noaa.gov ,(None) ,United States , ,Not Presenting[3]

Dr. Carl van der Lingen ,carl.vanderlingen@gmail.com ,(None) ,South Africa , ,Not Presenting[4]

1 - Department of Environmental Affairs 2 - Farallon Institute 3 - NOAA Southwest Fisheries 4 - Department of Agriculture, Foresty, and Fisheries

The influence of climate variability on Eastern Boundary Upwelling Ecosystems (EBUE) is evident through changes in productivity and shifts in species' distributions, yet to date, metrics of upwelling variability appropriate for comparative ecosystem studies have yet to be implemented. In this study, we develop new synoptic-scale upwelling indices to quantify inter-annual to decadal variations in Ekman transport, at temporal and spatial scales relevant to the biota of EBUE, and apply them to the Benguela Upwelling System (BUS). From 1979 to 2015, interannual, decadal-scale, and unidirectional variability in upwelling was observed, including a significant recent decrease in upwelling in the northern BUS, and a significant increase on the Agulhas Bank. These trends are associated with changes in the number of upwelling days and events in these regions, and may correspond to a shift in the meridional positioning of the South Atlantic High pressure system.

Role of the remote equatorial forcing on coastal physical and biogeochemical interannual variability in the southeast Atlantic Ocean

Abstract ID : 1089

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Marie-Lou Bachelery ,bachelery.marielou@gmail.com ,(Post doctoral fellow) ,South Africa ,Cape Town ,Not Presenting[1]

Dr. Serena Illig ,serena.illig@gmail.com ,(None) ,South Africa , ,Not Presenting[2]

Prof. Isabelle Dadou ,isabelle.dadou@legos.obs-mip.fr ,(None) ,France , ,Not Presenting[3]

1 - Department of Oceanography, MARE Institute, LMI ICEMASA, University of Cape Town 2 - Department of Oceanography, MARE Institute, University of Cape Town, South Africa/Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS), Université de Toulouse, CNES, CNRS, IRD, UPS, Toulouse, France; part of the International Mixed Laboratory ICEMASA. 3 - Laboratoire d'Etude en Geophysique et Oceanographie Spatiale

The recurrent occurrences of interannual warm and cold events along the southwest coast of Africa (called Benguela Niño/Niña for extreme events) have been intensively studied because of their striking effects on climate and fisheries. The methodology is based on model experimentation with a regional coupled physical/biogeochemical (ROMS/BioEBUS) model configuration of the southeastern Atlantic. We aim at determining the dominant forcing and processes controlling physical (Sea level, density and temperature) and biogeochemical (oxygen and nitrate) properties along the African coast up to the Benguela Upwelling System (BUS). Two forcings are at work 1) the remote equatorial associated with equatorial Kelvin Wave dynamics and 2) the local atmospheric forcing (wind and heat fluxes). Results show that, at interannual time scales, the oceanic remote equatorial forcing exerts a dominant influence on coastal circulation, sea level, temperature, and biogeochemical tracers variability. Indeed, the connection with the equatorial variability explains 89% of coastal sea level interannual variability and more than 85% of coastal nitrate and oxygen interannual fluctuations along the Angolan and Namibian coasts. Interannual variations of temperature, nitrate, and oxygen, associated with poleward propagations of upwelling and downwelling CTW, are maximum in subsurface. Analysis of model online budget reveals that they are controlled by physical advection processes. Surprisingly, an abrupt change in the CTW biogeochemical signature is observed in the BUS, associated with mixed vertical gradients due to the strong local upwelling dynamics. Coastal modifications of biogeochemical features result in significant primary production variations that may affect fisheries habitats and coastal biodiversity along the southwestern African coasts and in the BUS.

Quantifying the impact of mesoscale activity on the Benguela upwelling front

Abstract ID : 1504

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Matthew Carr ,Matthewcarr03@gmail.com ,(Masters candidate) ,South Africa ,Cape Town ,Presenting[1]

Dr. Tarron Lamont ,tarron.lamont@gmail.com ,(Marine Scientist) ,South Africa ,Cape Town ,Not Presenting[2]

Dr. Marion Kersale ,marion.kersale@univ-brest.fr ,(None) ,France , ,Not Presenting[3]

Prof. Isabelle Ansorge ,Isabelle.Ansorge@uct.ac.za ,(Head of Department) ,South Africa ,None ,Not Presenting[1]

1 - UCT 2 - Department of Environmental Affairs 3 - University of Cape Town 4 - UCT

Located off the west coast of southern Africa, the Cape Basin is characterised by a unique combination of strong coastal upwelling and vigorous offshore mesoscale variability. The coastal upwelling is primarily controlled by the prevailing equatorward winds, while mesoscale variability occurs in the form of eddies and filaments originating from the Agulhas retroflection and within the Cape Basin itself. The upwelling front is well defined following the shelf edge. However, mesoscale features are observed to interact with and modify the upwelling front exchanging shelf and open ocean waters. The South Atlantic MOC Basin-wide Array (SAMBA) provides high resolution *in situ*

velocity measurements from four deep-sea moorings at 34°S on the 1000, 2000, 3000 and 4000 m isobaths respectively. In conjunction with remote sensing products, the *in situ* data was used to identify a cyclonic/anti-cyclonic eddy pair interacting with the upwelling front inducing significant cross-shelf transport. Strong westward (offshore) flow was observed from 28/09/2014 to 16/11/2014 at each of the moorings. This offshore flow was associated with a large chlorophyll *a* (chl-a) filament extending from the upwelling front to a distance of 362 km offshore, indicating substantial offshore transport of productive shelf waters. The chl-a filament and offshore transport were centred directly over the mooring array, providing a unique opportunity to quantify the volume of water and amount of chl-a transported offshore; the mechanisms and quantification of the cross shelf transport is presented highlighting the impact of mesoscale features on the Benguela upwelling system.

IAMAS

Clustering of seasonality of the lower tropospheric ozone over central China observed by Ozone Monitoring Instrument (OMI)

Abstract ID : 185

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Sachiko Hayashida ,sachiko@ics.nara-wu.ac.jp ,(Professor) ,Japan ,Nara ,Presenting[1]

Dr. Mizuo Kajino ,kajino@mri-jma.go.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Xiong Liu ,xliu@cfa.harvard.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Makoto Deushi ,mdeushi@mri-jma.go.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Thomas Sekiyama ,tsekiyam@mri-jma.go.jp ,(None) ,Japan , ,Not Presenting[2]

1 - Nara Women's University 2 - Meteorological Research Institute 3 - Harvard-Smithsonian Center for Astrophysics, Cambridge 4 - Meteorological Research Institute 5 - Meteorological Research Institute

Liu et al. (ACP, 2010) successfully derived ozone profiles from the surface up to 60 km in 24 layers, using ultraviolet spectra observed by the Ozone Monitoring Instrument (OMI). Hayashida et al. (ACP, 2015) assured the reliability of the 24th lowermost layer of the OMI products, corresponding from 0 km to about 2.5-3 km. They reported O3 enhancement observed in Central and Eastern China (CEC) with Shandong as its center. This enhancement is most notable in June in any given year. In this study, to reveal spatial and temporal variation of ozone distribution over CEC, we applied cluster analysis to the OMI O3 data from the region. We focus on the anomaly of ozone (DO3), which is defined as the difference between the retrieval values and the a priori values (DO3 = O3[retrieval] - O3[a priori]). This analysis is effective in tracking the O3 enhancement under polluted conditions, because our focus is the temporal O3 enhancement from background levels, i.e., the climatological values. The DO3 values can be interpreted as an indicator of the ozone enhancement from the background level. We divided the 1° ´ 1° grids in the range of 25-40° N and 100-135° E into clusters according to the similarity of the seasonal variation of DO3 at the 24th layer. By this analysis, we can distinguish the areas (Cluster 1) where DO3 has outstanding seasonality with high values in summer (June, in particular) and low values in winter over the North China Plain and Sichuan basin, which corresponds to the areas of high NO2 concentration observed by satellite sensors. We compared the

results with model simulations by the Meteorological Research Institute - Chemistry Climate Model (MRI-CCM2) (Deushi and Shibata, MRIpapers, 2011) as well as meteorological data. Cluster 1 corresponds to areas of high chemical production rates in June in the model simulation. Along the coastal area, DO3 tends to drop to negative values (retrieval values less than the climatological values) temporarily in August, which can be interpreted as due to the inflow of oceanic clean air into the inland area.

On the order of atmospheric scattering, its polarization and computation efficiency

Abstract ID : 296

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Minzheng Duan ,dmz@mail.iap.ac.cn ,(None) ,China ,Beijing ,Not Presenting[1]

1 - LAGEO, Institute of Atmospheric Physics, Chinese Academy of Sciences

Polarization becomes more and more important in current and future remote sensing of earth's atmosphere and astronomical observations, as it could provide more information than that of intensity-only measurements. While forward simulation of polarization of light during its transfer in the earth-atmosphere system is still a burden especially for the full polarized radiative transfer with heavy aerosol loading. Based on previously established model-SOSVRT, a full polarized radiative transfer model with successive order of scattering method, the polarization of atmospheric scattering under different aerosol loadings are simulated, the lights for each scattering order, its polarization and the errors introduced by ignoring the polarization are analyzed. We are trying to answer how many orders are necessary in polarization simulations. Finally, a new method to speed up the modelling of polarized radiative transfer is proposed.

Tammy Maart : None

Tropical tropospheric ozone trends using the Convective clouds differential technique

Abstract ID : 695

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Elpida Leventidou ,levent@iup.physik.uni-bremen.de ,(None) ,Germany ,Bremen ,Not Presenting[1]

1 - University of Bremen

Tropical tropospheric ozone columns can be retrieved with the Convective Cloud Differential (CCD) technique using retrieved total ozone columns and cloud parameters from space-borne observations. A CCD-IUP algorithm has been developed and applied to GOME, SCIAMACHY, and GOME-2 weighting function DOAS total ozone data. A 20 years record of monthly averaged tropical tropospheric ozone columns (20S - 20N) was created starting in 1996 and was extensively validated by comparisons with SHADOZ ozonesonde data. The comparison shows good agreement, biases were found to be within 5 DU and the RMS errors less than 10 DU. Next, the dataset has been harmonized into one consistent time series. Tropospheric ozone in the tropics follows a distinctive wave one pattern, with higher values over the Atlantic (~40 DU maximising in autumn) and lower over the Pacific ocean (10-15 DU minimising in spring). Tropospheric ozone variability follows the atmospheric, solar, and seasonal oscillations. The El Niño-Southern Oscillation (ENSO) has a positive statistically significant contribution on the order of 6-8 DU over the Indian ocean and negative contribution of more than 10 DU over the Pacific ocean. The 11-years solar cycle increases significantly tropospheric ozone by ~6 DU over the northern tropics. The seasonal cycle contributes by 15-25 DU over the northern tropics and south Atlantic ocean while anywhere else the contribution in tropospheric ozone variability is less than 10 DU. Finally, Quasi-biennial oscillation (QBO) increases ozone around the equator by ~4 DU. The mean tropical tropospheric ozone trends range between the trend ranges between -5 and 5 DU, with a mean value of +1.11+\-1.07 DU/decade (2sigma). The trend of the tropically averaged tropospheric ozone is equal to 0.89$ +\-0.64 DU/decade. Regionally, tropospheric ozone has a statistically significant increase over northern South America, central and south Atlantic ocean, central east Pacific Ocean, India and South Africa on the order of ~2 DU/decade and decreases over central America by -1.6 DU/decade.

Tammy Maart : None

Preliminary Results From the SHOW ER-2 Flight over the Pacific Ocean in July 2017

Abstract ID : 746

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Nick Lloyd ,nick.lloyd@usask.ca ,(Research Scientist) ,Canada ,Saskatoon ,Not Presenting[1]

Dr. Brian Solheim ,brian.solheim@rogers.com ,(None) ,Canada , ,Not Presenting[1]

Dr. Jeff Langille ,jeff.langille@usask.ca ,(None) ,Canada , ,Not Presenting[1]

Mr. Daniel Letros ,dsl935@mail.usask.ca ,(None) ,Canada , ,Not Presenting[1]

Prof. Doug Degenstein ,doug.degenstein@usask.ca ,(None) ,Canada , ,Not Presenting[5]

Prof. Adam Bourassa ,aeb192@campus.usask.ca ,(None) ,Canada , ,Not Presenting[6]

Mr. Fabien Dupont ,fabien.a.dupont@ca.abb.com ,(None) ,Canada , ,Not Presenting[7]

1 - University of Saskatchewan 2 - University of Saskatchewan 3 - University of Saskatchewan 4 - University of Saskatchewan 5 - University of Saskatchewan, Institute of Space and Atmospheric Studies 6 - University 7 - ABB

The Spatial Heterodyne Observations of Water (SHOW) instrument built by a joint effort between the University of Saskatchewan, York University, ABB and the Canadian Space Agency was scheduled at the time of writing to make three 8+ hour flights in July over the Pacific ocean off the coast of California on-board a NASA-ER2 high altitude airplane. The SHOW instrument implements a field-widened spatial heterodyne spectrometer observing the atmospheric limb across a 3.5 nm spectral window centered on the strong absorption band of water at 1.363 microns and is under consideration by Canada for spacecraft deployment. The instrument images the entire atmosphere from ~8km to ~20 km every 0.5 seconds with water spectra observed at 200 meter intervals in altitude. The goal of the flight is to both validate the engineering concept of the instrument and to resolve detailed profiles of water vapour from the upper troposphere across the UTLS region and into the lower stratosphere. This paper presents preliminary results from the flight and while the measurements are still several months from being collected at the time of writing we are confident the results will be very exciting.

Tammy Maart : None

OSIRIS: Ozone, stratospheric aerosol and nitrogen dioxide profiles since the autumn of 2001

Abstract ID : 819

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Doug Degenstein ,doug.degenstein@usask.ca ,(None) ,Canada , ,Not Presenting[1]

1 - University of Saskatchewan, Institute of Space and Atmospheric Studies

The Canadian built Optical Spectrograph and InfraRed Imaging System (OSIRIS) has been in full operation onboard the Swedish built Odin spacecraft since the autumn of 2001. The 16 years of vertically resolved profile measurements of ozone, nitrogen dioxide and stratospheric aerosol make up the longest data record produced from observations made by any existing space based instrument. The OSIRIS ozone data record is featured within the ozone_cci merged time series as well as stand alone data records used for trend analysis including the 33 year (SAGE II/OSIRIS/OMPS-LP USask 2D) data record currently under evaluation by the SPARC Initiative, LOTUS. This presentation will feature highlights of the OSIRIS ozone data record including its use for the study of the Asian Monsoon. The OSIRIS stratospheric aerosol data record has been used to continue the SAGE II aerosol extinction time series and provide the CMIP-6 scientists with a high fidelity data record to study the climate impact of sulphate aerosol in the stratosphere. This presentation will highlight progress made using the OSIRIS aerosol data set including the climatic impact of volcanic activity. Finally, the OSIRIS nitrogen dioxide data record has been used within many studies including the production of a tropospheric NO2 data product derived using vertical column measurements made by OMI. This presentation will provide detail associated with this valuable 16 year data record. OSIRIS has been in operation for over 16 years and there is no evidence that its data production will end any time soon.

Source apportionment of particulate matter at South Asian Mega City: A case study of Karachi

Abstract ID : 954

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Imran Shahid ,imran.shahid@grel.ist.edu.pk ,(Assistant Professor) ,Pakistan ,islamabad ,Not Presenting[1]1 - Institute of Space Technology, Islamabad Pakistan

The increase in population, urbanization, industrialization, transportation and other human activities have worsend the air quality in Asian mega cities. In year June 2015 heat wave in largest South Asian mega city Karachi more than 1500 people died in one week. Unfortunately no air quality monitoring system is operation in any city of Pakistan. There is a sharp increase in both the variety and quantity of air pollutants and their corresponding sources. In this study contributions of different sources to particulate matter concentration has estimated in urban area of Karachi. Carbonaceous species (elemental carbon, organic carbon, carbonate carbon), soluble ions (Ca^{++}, Mg^{++}, Na^{+}, K^{+}, $NH4^{+}$, Cl-, NO_3^{-}, $SO4^{--}$), saccharides (levoglucosan, galactosan, mannosan, sucrose, fructose, glucose, arabitol and mannitol) were measured in atmospheric fine (PM2.5) and coarse (PM10) particles collected under pre-monsoon conditions (March - April 2009) at an urban site in Karachi (Pakistan). Average concentrations of PM2.5 were 75µg/m3 and of PM10 437µg/m3. The large difference between PM10 and PM2.5 originated predominantly from mineral dust. "Calcareous dust" and "siliceous dust" were the overall dominating material in PM, with 46% contribution to PM2.5 and 78% to PM10-2.5. 20 Combustion particles and secondary organics (EC+OM) comprised 23% of PM2.5 and 6% of PM10-2.5. EC, as well as OC ambient levels were higher (59% and 56%) in PM10-2.5 than in 22 PM2.5. Biomass burning contributed about 3% to PM2.5, and had a share of about 13% of "EC+OM" in PM2.5. The impact of bioaerosol (fungal spores) was minor and had a share of 1 and 2% of the OC in the PM2.5 and PM10-2.5 size fractions. Of secondary inorganic constituents (NH4)2SO4 contributes 4.4% to PM2.5 and no detectable quantity to PM10-2.5. The sea salt contribution is about 2% both to PM2.5 and PM10-2.5. In order to make air quality better and risk free in South Asian cities a comprehensive and integrated regional effort is required that include establishment of continuous air monitoring, indepth characterization of pollutants along with source identification.

Comprehensive Observation Campaign for Whole Snow Processes over Altai Station: System and Preliminary Results

Abstract ID : 1083

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Jinli Liu ,jliu@mail.iap.ac.cn ,(None) ,China , ,Not Presenting[1]

Dr. QIANG SUN ,franklin_sun@tom.com ,(None) ,China , ,Not Presenting[2]

Dr. Shengjie JIA ,jsjl@mail.iap.ac.cn ,(None) ,China , ,Not Presenting[2]

Mr. Daren Lu ,ludr@mail.iap.ac.cn ,(None) , , ,Not Presenting[4]

1 - Institute of Atmospheric Physics, Chinese Academy of Science 2 - Institute of Atmospheric Physics 3 - Institute of Atmospheric Physics 4 - None

Snow plays significant roles in global and regional surface energy budget, water cycle and even climate abnormal. As the complexity of snow related processes, i.e. snow weather system, microphysical characteristics. As the complexity of snow related processes, i.e., snow weather system, microphysical characteristics, environmental, surface and underlying soil situations, so far significant uncertainties still exist as from limited comprehensive and representative observation. Northern China is a vast snowing area. For investigate the whole snow processes, we developed a comprehensive snow observation system in collaboration with routine meteorological station at Altai Station (88.07E, 47.74N,733mASL) in northern Xinjiang. The system is consisted of: 1) routine observation of snow cover, 2) snow research observation of snowfall, snowpack and snow melting, 3) surface meteorological and relation observation, 4) underlying soil profile observation.
Since the beginning of Oct.2016, this system is continuously operating the snow processes for whole winter/early spring season.
In this paper, we will present the observation system, observation process, as well as preliminary results.

Long-term climatology of aerosol optical properties measured at Welgegund, South Africa

Abstract ID : 1275

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Marcell Venter ,marcelldunn@gmail.com ,(PhD Student) ,South Africa ,Potchefstroom ,Not Presenting[1]

Prof. Johan Paul Beukes ,paul.beukes@nwu.ac.za ,(None) ,South Africa ,Potchefstroom ,Not Presenting[2]

Dr. Pieter van Zyl ,pieter.vanzyl@nwu.ac.za ,(Senior Lecturer) ,South Africa ,Potchefstroom ,Not Presenting[2]

Dr. Ville Vakkari ,ville.vakkari@fmi.fi ,(None) ,Finland , ,Not Presenting[4]

Dr. Miroslav Josipovic ,Micky.Josipovic@nwu.ac.za ,(None) ,South Africa , ,Not Presenting[2]

Dr. Kerneels Jaars ,20162750@nwu.ac.za ,(Postdoctoral Research Fellow) ,South Africa ,Potchefstroom ,Not Presenting[2]

1 - North-West University Potchefstroom 2 - North-West University 3 - North-West University 4 - Finnish Meteorological Institute 5 - North-West University 6 - North-West University

Adverse effects of aerosols on the general planetary health include soil nutrient enrichment/depletion, changing of the aquatic balance (e.g. pH) and changing of the global radiative balance due to their optical properties. There are large uncertainties associated with the effect (direct or indirect) of atmospheric aerosols on the earth's radiative budget due to their high spatial and temporal variability. Thus, in order to reduce these uncertainties longer-term continuous measurements on a global scale are needed. Although southern Africa is a significant source region of pollution and has unique meteorological conditions, few studies have been done on aerosol optical properties. In this study the aerosol optical properties, such as scattering and absorption coefficients, single-scattering albedo and Ångström exponent are investigated based on data gathered from June 2010 to January 2016 at the Welgegund atmospheric research station, situated in the interior of South Africa ~100 km west of Johannesburg megacity. Instrumentation used to collect the aerosol data included a multi-angle absorption photometer and a three wavelength light scattering nephelometer for aerosol absorption and aerosol scattering, respectively. Back trajectory analysis was used to determine air mass history before being samples at Welgegund. The optical properties can be classified in terms of air masses passing over the major source regions in the interior of South Africa, which include the Johannesburg-Pretoria conurbation, the Bushveld Igneous Complex, the Mpumalanga Highveld and the Vaal Triangle, as well as over the regional background. Seasonal and diurnal patterns of the four optical

parameters will be presented and the mean values of each optical parameter are contextualised with international measurements. It is believed that the aerosol optical measurements conducted at Welgegund are likely the most comprehensive in South Africa. It is therefore foreseen that the study will make a significant contribution to understanding aerosol optical properties and the associated impacts on climate change in South Africa.

Identification of emission and climatological factors shaping Hong Kong's PM10 levels during 1998-2015

Abstract ID : 1282

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Zibing Yuan ,zibing@scut.edu.cn ,(None) ,China ,Guangzhou ,Not Presenting[1]

1 - South China University of Technology

Both emissions and meteorology impacts the ambient pollution levels, and accurate quantification of their relative impacts is important to formulate effective pollution control measures. This study examines the long-term trends of source contributions to ambient PM10 in Hong Kong from 1998 to 2015 and the relative impacts from emission and climatological changes to the contributions from different sources and to the ambient PM10 loadings. Source contributions were estimated by applying the Positive Matrix Factorization (PMF) source apportionment model on a rich speciated PM10 dataset collected simultaneously at seven sites in Hong Kong over these eighteen years. Over 50 species including chemical elements, water-soluble ions, and elemental carbon and organic carbon were characterized for all samples. Nine sources were identified by PMF, and their relative and absolute contributions to the ambient PM10 were calculated. It was obviously found that local contributions from Hong Kong were consistently decreasing over these eighteen years, while non-local contributions, mostly from Mainland China, showed an initially increasing followed by a decreasing trend with a peak around 2011-2012. The impacts on source contributions from emissions and meteorological variations were identified by combining Kolmogorov-Zurbenko (KZ) filter and Principal Component Analysis (PCA) techniques. Results showed that the impacts from local emissions were consistently decreasing while those from non-local emissions showed maximum around 2011-2012. The impact from climatological factors was generally unfavorable for pollutant dispersion. With the continuous monitoring of PM10 compositions in Hong Kong, this study highlights the effectiveness of control measures in Hong Kong in the past decades and in Mainland China in the past several years, and shed light on future directions to make Hong Kong's particulate levels in line with WHO's air quality guidelines.

Electric field measurements of atmospheric discharges: coordination between ground based measurements in preparation of TARANIS space mission

Abstract ID : 439

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. SERAN Elena ,Elena.Seran@latmos.ipsl.fr ,(Scientist) ,France ,PARIS ,Not Presenting[1]

Dr. GODEFROY Michel ,Michel.Godefroy@latmos.ipsl.fr ,(Project Manager) ,France ,PARIS ,Not Presenting[1]

Dr. Coquillat Sylvain ,Sylvain.Coquillat@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[3]

Dr. Defer Eric ,Eric.Defer@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[3]

Dr. LAMBERT Dominique ,dominique.lambert@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[3]

Dr. PINTY Jean-Pierre ,jean-pierre.pinty@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[3]

Dr. PRIEUR Serge ,serge.prieur@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[3]

1 - LATMOS 2 - LATMOS 3 - LA 4 - LA 5 - LA 6 - LA 7 - LA

In frame of CNES micro-satellite TARANIS mission, we have developed two instruments to measure the electric field simultaneously in the ionosphere and at ground. The main objective of these measurements is the characterisation of the electric field perturbations induced by the atmospheric discharges.
The IME-BF instrument on-board the TARANIS consists of two spherical sensors accommodated on 4m-deployable booms and has the frequency range from DC to 1 MHz.
The SDA ground-based instrument is a mobile and autonomous sensor which covers the frequency range from DC to 60 kHz. Both instruments have the sensibility of ~$\mu V\ m^{-1}$ and data datation with absolute precision of ~µs.
With aim to prepare the coordinated observations of our instruments (TARANIS launch is expected to be at the end of 2018), we performed a preliminary campaign of SDA instrument in Corsica where it worked simultaneously with 12 antennas of the SAETTA network. Results and main findings of this campaign are reported.

Introducing the EXploiting new Atmospheric Electricity Data for Research and the Environment (EXAEDRE) project

Abstract ID : 1232

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Defer Eric ,Eric.Defer@aero.obs-mip.fr ,(None) ,France , ,Not Presenting[1]

Dr. Buguet Magalie ,magalie.buguet@onera.fr ,(None) ,France , ,Not Presenting[2]

Mr. Labrouche Gregory ,gregory.labrouche@ciele.fr ,(None) ,France , ,Not Presenting[3]

Mr. Pedeboy Stephane ,stephane.pedeboy@meteorage.com ,(None) ,France , ,Not Presenting[4]

Dr. Caumont Olivier ,olivier.caumont@meteo.fr ,(None) ,France , ,Not Presenting[5]

Dr. Lojou Jean-Yves ,sales@is2ws.com ,(None) ,France , ,Not Presenting[6]

Prof. Schwarzenboeck Alfons ,alfons.schwarzenboeck@opgc.univ-bpclermont.fr ,(None) ,France , ,Not Presenting[7]

Dr. Delanoe Julien ,julien.delanoe@latmos.ipsl.fr ,(None) ,France , ,Not Presenting[8]

1 - LA 2 - ONERA 3 - CIELE 4 - Météorage 5 - None 6 - IS2 7 - LaMP 8 - LATMOS

The EXAEDRE (EXploiting new Atmospheric Electricity Data for Research and the Environment; ANR-16-CE04-0005) project aims at consolidating the activities, which started during the HyMeX (HYdrological cycle in the Mediterranean EXperiment) field campaign by the French community on the research and operational exploitation of both observations and numerical simulations in relation with atmospheric electricity.
The EXAEDRE activities rely on innovative multi-disciplinary and state of the art instrumentation and modelling tools to provide a comprehensive description of the electrical activity in thunderstorms. The EXAEDRE observational part is based on i) existing lightning data collected during HyMeX Special Observation Period (SOP1), and permanent lightning observations provided by the research SAETTA and the operational Météorage lightning locating systems, ii) new lightning observations mapped with a brand new VHF interferometer especially developed within the EXAEDRE project, iii) a dedicated field campaign over Corsica combining ground-based lightning location detection (SAETTA, Météorage, interferometer), a suite of ground-based instruments sensitive to lightning component properties and cloud electrification, the new airborne electric field mills AMPERA, a suite of airborne microphysics probes and the airborne 95 GHz Doppler cloud radar RASTA onboard the French Falcon research aircraft, and operational weather radar and satellite imagers.

The modelling part of the EXAEDRE project relies on the electrification and lightning schemes developed in the French cloud resolving model MésoNH and on the Météo-France operational model AROME for innovative investigation of lightning data assimilation Through its rather comprehensive observational and modelling approach, the EXAEDRE project will improve our knowledge on lightning physics and on the links between lightning occurrence, electrification, dynamics and microphysics. First we will present an overview of the project. The first results at almost a year after the beginning of the project will then discussed. Finally the EXAEDRE airbor

Design and development of polarimetric phased array weather radar

Abstract ID : 1252

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Tomoaki Kida ,kida.tomoaki@comf5.comm.eng.osaka-u.ac.jp ,(2-1 Yamada-Oka,) ,Japan ,suita ,Not Presenting[1]

Dr. Hiroshi Kikuchi ,kikuchi.hiroshi@comf5.comm.eng.osaka-u.ac.jp ,(post doctor) ,Japan ,Suita ,Not Presenting[2]

Prof. Tomoo Ushio ,ushio@comm.eng.osaka-u.ac.jp ,(None) ,Japan ,None ,Not Presenting[2]

Mr. Fumihiko Mizutani ,fumihiko1.mizutani@toshiba.co.jp ,(None) ,Japan , ,Not Presenting[4]

Mr. Wada Masakazu ,masakazu.wada@dx.toshiba.co.jp ,(None) ,Japan , ,Not Presenting[4]

1 - Japan 2 - Osaka University 3 - Osaka University 4 - Toshiba Corporation 5 - Toshiba Corporation

Most of severe phenomena, such as heavy precipitations, a tornado, and a downburst, are caused by locally generated thunderstorms and sometimes cause severe disasters.?These phenomena are occurred in a short period of time (approximately several minutes). Therefore, it is difficult to predict the disasters. To observe the developing, mature, and dissipating stages of thunderstorms, a weather radar is one of the effective methods. At present, the X-band phased array weather radar (PAWR) that has high temporal resolution (30[sec] per volume scan) and high spatial resolution (100[m]) has been already developed and under operation in Osaka University. Although the PAWR is far superior in spatiotemporal resolution, the PAWR, which is a single polarization radar, has lower accuracy of observation than a parabolic type radar using dual polarized waves. Dual polarimetric radar observations provide multi-parameter measurements that reveal detailed microphysics of storms in addition to accurate precipitation estimation, and improve weather forecasts. As a next radar development project of the PAWR, a polarimetric phased array weather radar is currently under consideration. The under considering polarimetric phased array weather radar provides the polarimetric precipitation measurements in three-dimensional volume scanning in less than 10 or 30 seconds in a range of 20 or 60 km in real-time, respectively. However, it is difficult to maintain high accuracy of observation of polarimetric phased array radar because of the effect of deterioration of the antenna characteristics by digital beam forming and reduction of cross polarization discrimination which is performance to distinguish between horizontal pattern and vertical pattern. In this study, in order to solve such problems, we designed antenna elements and array antennas. And also, precipitation radar signal simulations are carried out assuming the specifications of an under considering polarimetric phased array weather radar. The observation accuracy of the radar is discussed.

Evaluation of ENTLN performance characteristics based on the natural and rocket-triggered lightning data acquired in Florida

Abstract ID : 1435

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Yanan Zhu ,lzandzyn@gmail.com ,(Research Assistant) ,United States ,Gainesville ,Not Presenting[1]

Prof. Vladimir Rakov ,rakov@ece.ufl.edu ,(None) ,United States , ,Not Presenting[2]

Mr. Manh Tran ,manhtran@ufl.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Douglas Jordan ,jordan@ece.ufl.edu ,(None) ,United States , ,Not Presenting[2]

Prof. Martin Uman ,uman@ece.ufl.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Jaime Caicedo ,jaime.caicedo@ufl.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Daniel Kotovsky ,dakotovsky@ufl.edu ,(None) ,United States , ,Not Presenting[2]

Mr. Felipe Lenz Carvalho ,fcarval1@ufl.edu ,(None) ,United States , ,Not Presenting[8]

Mr. Robert Wilkes ,rawilkes@ufl.edu ,(None) ,United States , ,Not Presenting[8]

Dr. Michael Stock ,mstock@earthnetworks.com ,(None) ,United States ,Germantown ,Not Presenting[10]

Dr. Stan Heckman ,SHeckman@whiskerlabs.com ,(None) ,United States , ,Not Presenting[10]

Dr. Charlie Liu ,CLiu@earthnetworks.com ,(None) ,United States , ,Not Presenting[10]

Mr. Christopher Sloop ,CSloop@earthnetworks.com ,(None) ,United States , ,Not Presenting[10]

1 - 2 - University of Florida 3 - University of Florida 4 - University of Florida 5 - University of Florida 6 - University of Florida 7 - University of Florida 8 - UF 9 - UF 10 - Earth Networks 11 - Earth Networks 12 - Earth Networks 13 - Earth Networks

The Earth Networks Total Lightning Detection Network (ENTLN) consists of more than 1500 wideband sensors deployed in more than 40 countries around the world. More than nine hundred are presently installed in the contiguous United States. By using the time-of-arrival technique, the ENTLN can report geolocation and time of each lightning-produced pulse. For each pulse, the polarity and type of discharge (either CG or IC) are determined based on the pulse polarity and waveshape. All

waveforms from ENTLN sensors are saved and can be used for reprocessing in the future. *Mallick et al.* [2015] evaluated the ENTLN performance in 2009 to 2012 by using as ground-truth rocket-triggered lightning data acquired in Florida. For the processor that was put in service in November 2012, the performance was evaluated by using the output from rerunning all the saved waveforms through the processor as if it was in service from 2009 to 2012. The stroke detection efficiency (DE) and classification accuracy (CA) were 67% and 48%. The medians of the location error and peak current estimation error were found to be 760 m and 19%, respectively.
In this study, the performance characteristics of the ENTLN were evaluated by using as ground-truth natural lightning data acquired at the Lightning Observatory in Gainesville (LOG) and rocket-triggered lightning data obtained at Camp Blanding, Florida, in 2014 and 2015. The performance of the latest processor (upgraded in August 2015) was evaluated. For natural lightning (219 flashes containing 608 strokes), the flash DE, flash CA, stroke DE, and stroke CA were 99%, 97%, 96%, and 91%, respectively. The stroke DE and stroke CA for first strokes are higher than those for subsequent strokes. For rocket-triggered lightning (36 flashes containing 175 strokes), the flash DE, flash CA, stroke DE, and stroke CA were 100%, 97%, 97%, and 86%. The median values of location error and absolute peak current estimation error were 215 m and 15%. For both natural and triggered lightning, strokes with higher peak currents were more likely to be both detected and correctly classified by the ENTLN.

Observations of Lightning using a Broadband Interferometer and a Lightning Mapping Array

Abstract ID : 1460

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. William Rison ,william.rison@nmt.edu ,(Research Professor) ,United States ,Socorro, New Mexico ,Not Presenting[1]

1 - New Mexico Tech

The Lightning Mapping Array (LMA) produces three-dimensional images of lightning flashes, typically with an 80 micosecond time resolution, and a three-dimensional range of about 200 km (e.g., Rison et al, 1999). A flash-continuous broadband lightning interferometer (INTF) produces two-dimensional (azimuth and elevation) images of lightning flashes, with sub-microsecond time resolution and a range of a few tens of kilometers (e.g., Stock et al, 2014). A newly developed technique allows us to combine the lower time resolution LMA data with the high time resolution INTF data to produce unparalleled high time resolution three-dimensional images of lightning flashes.

In the summer of 2016 we deployed a broadband interferometer with long (100 meter) baselines at the Kennedy Space Center to make make coordinated observations with the KSC LMA. Of particular interest are observations of the initial stages of lightning development, including the initiation process and the development from the initiation to the initial leader processes. We have found that most lightning flashes are initiated with a fast (~3 x 10^7 m/s) positive streamer breakdown, although a small fraction of flashes are initiated with a fast negative breakdown. We will also discuss how the use of long baselines has extended the useful range of the INTF. We will also compare LMA/INTF observations with those from the launched Geostationary Lightning Mapper on the newly launched GOES-16 satellite.

W. Rison, R.J. Thomas, P.R. Krehbiel, T. Hamlin and J. Harlin, A GPS-based three-dimensional lightning mapping system: initial observations in central New Mexico. Geophys. Res. Lett. 26, 3573-3576 (1999).

M. Stock, M. Akita, P. Krehbiel, W. Rison, H. Edens, Z. Kawasaki, and M. Stanley, Continuous Broadband Digital Interferometry of Lightning using a Generalized Cross Correlation Algorithm, J. Geophys. Res. 119, 3134-3165, 2014

Determination of the threshold value of lightning potential index (LPI) for identification of lightning activity regions

Abstract ID : 785

Conflict Declaration : None

Content Motivation : Dear Members of the Scientific Programme Committee, Joint Assembly 2017, Cape Town, South Africa, Respectfully, I started my work as an assistant professor in the Institute of Geophysics at the University of Tehran from 4 years ago. I intend to participate in Joint Assembly 2017 to meet the professors that have done researches in my field to improve my work. Some of my publications are as following: Gharaylou, Maryam, Payman Zawar-Reza, and Majid Mazraeh Ee Farahani. "A one-dimensional Explicit Time-dependent cloud Model (ETM): Description and validation with a three-dimensional cloud resolving model." Atmospheric Research 92, no. 4 (2009): 394-401. Gharaylou, Maryam, Peyman zavar-reza, Abbasali Aliakbari Bidokhti, and Majid Mazraeh Ee Farahani. "Implementation of a new cumulus parameterization scheme based on an explicit time-dependent tilting cloud model in ARPS model." Meteorology and Atmospheric Physics 122, no. 3-4 (2013): 145-158. Gharaylou, Maryam, Nafiseh Pegahfar, and Abbasali Aliakbari Bidokhti. "Electrical charge transfer modeling (lightning) in cloud and its implementation in a one-dimensional prognostic cloud model." Journal of the Earth and Space Physics 40, no. 1 (2014):137-148. Pegahfar, Nafiseh, and Maryam Gharaylou. "Implementation of three sets of electric charge transfer parameterization in a one-dimensional cloud model." Journal of the Earth and Space Physics 41, no. 1 (2015): 85-97. Gharaylou, Maryam, Samaneh Sabetghadam, and Sarmad ghader. "Feasibility study of lightning event prediction using WRF mesoscale model in Iran." Journal of the Earth and Space Physics 42, no. 1 (2016): 213-220. Alizadeh-Choobari, Omid, and Maryam Gharaylou. "Aerosol impacts on radiative and microphysical properties of clouds and precipitation formation." Atmospheric Research 185, no. - (2017): 53-64. I registered for" Joint Assembly 2017" and presenting an abstract "Comparison of Electric Field and LPI to Determine a threshold value of LPI for Prediction of Lightning ". Since my institute does not fully support applicants to attend the Joint Assembly 2017, it’s just your grate attention if you accept my grant application and give the possibility to me to attend the Assembly. Yours Sincerely, Maryam Gharaylou Assistant Professor, Institute of Geophysics, University of Tehran

Additional Information : None

Dr. Maryam Gharaylou ,gharaylo@ut.ac.ir ,(Assistant professor) ,Iran ,Tehran ,Presenting[1]

Mr. Morteza Hosseini Hosseini ,m.hosseini1369@ut.ac.ir ,(None) ,Iran , ,Not Presenting[1]

Dr. Majid Mazraeh Farahani ,mazraeh@ut.ac.ir ,(None) ,Iran , ,Not Presenting[1]

1 - Institute of Geophysics, University of Tehran 2 - Institute of Geophysics, University of Tehran 3 - Institute of Geophysics, University of Tehran

Lightning is one of the distinct characteristics of thunderstorms. Lightning Potential Index (LPI), suggested by Yair et al. (2010), recently has been used as the most promising indices in lightning

prediction. LPI is calculated within the charge separation region of convective clouds between isotherms of $0^{o}C$ and $-20^{o}C$, where the non-inductive electrification mechanism is most effective. Previous studies show that the maximum values of LPI are related to the lightning activity regions. This makes it possible to identify a threshold value of LPI as a criterion for the lightning occurrence. In this research, an analysis of the Lightning Potential Index (LPI) has been presented using the Weather Research and Forecasting (WRF) mesoscale model. For this purpose, the WRF model was run at 27, 9 and 3 km grid spacing for simulation of two thunderstorm events in Tehran area. These case studies (on 15th and 17th April 2012) have been chosen according to the observational data. The FNL data available every 6h at a spatial resolution of $1^{o}x1^{o}$ have been used to obtain initial and boundary conditions. The Kain-Fritsch scheme has been used to parameterize convection in the two outer domains and the Thompson scheme has been used for the microphysical processes. The other schemes have been considered the same as the default schemes of WRF model. Beside of the LPI, the potential difference (between the ground and cloud layer at a given altitude), based on Dementyeva et al. 2015, was also calculated to facilitate the extraction of the threshold values of LPI. Results show that LPI index is well predicted the time evolution of lightning activity in the studied area. Moreover, the potential difference outputs are also related to the region of lightning activity. The results indicate that LPI values more than 20 J/kg are likely to match with the lightning activity region. Therefore, it is suggested that this amount can be used as a threshold value for the LPI index in identification of lightning activity regions. It is noteworthy that the main features of the spatial distribution of the potential difference agree with the observational LIS data.

First results of high-speed video observation and electric field lightning flashes in Johannesburg, South Africa

Abstract ID : 1352

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Carina Schumann ,carina.schumann@gmail.com ,(None) ,Brazil , ,Not Presenting[1]

Mr. Hugh Hunt ,hugh.hunt@wits.ac.za ,(None) ,South Africa , ,Not Presenting[2]

Dr. Ken Nixon ,ken.nixon@wits.ac.za ,(None) ,South Africa , ,Not Presenting[3]

Dr. Marcelo Saba ,marcelosaba@inpe.br ,(None) ,Brazil , ,Not Presenting[4]

Mr. Tom Warner ,tom.alan.warner@gmail.com ,(None) ,United States , ,Not Presenting[5]

1 - INPE – National Institute for Space Research 2 - University of the Witwatersrand 3 - University of Witwatersrand 4 - INPE 5 - ZT Research

Abstract: This paper describes the project ideas and the first results of the investigation of lightning physics in Johannesburg, South Africa. In February of 2017, the first high-speed lightning videos in South Africa were filmed. The project shares support from international collaborators: ZT Research in South Dakota, USA and the National Institute for Space Research (INPE) in Brazil. Previous studies show a high activity of upward flashes in Johannesburg. Figure 1 shows a high-resolution gaussian density map based on SALDN data used to investigate points-of-interest in Johannesburg city and shows the Hillbrow and Brixton towers (Figure 1a) and the campus of University of the Witwatersrand also shows some distinguishing points (Figure1b).

[MISSING IMAGE: Description: FlashDensityJoburg, Description: FlashDensityJoburg][MISSING IMAGE: Description: FlashDensityCloser, Description: FlashDensityCloser]

Figure 1: Density map based on lightning location system data from 2007 - 2015. (a)The Brixton and Hillbrow towers are indicated in the image and can be distinguished by the "hotspots". (b) Gaussian smoothed lightning density map over Johannesburg, WITS University campus

Key words: Downward lightning, Electric field measurements, High-speed video, International Collaboration, Upward lightning.

The seasonality and spatiality of sixteen years of lightning discharges over the State of Parana, Brazil

Abstract ID : 1353

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Mauro Alves ,mauro.a.alves@gmail.com ,(None) ,Brazil ,Sao Jose dos Campos ,Presenting[1]

Dr. Inacio Martin ,martin@ita.br ,(None) ,Brazil , ,Not Presenting[1]

Dr. Alessandro de Abreu ,abreu.alessandro@gmail.com ,(None) ,Brazil , ,Not Presenting[1]

Dr. Cassia Lyra ,cassia@infinitetrans.com ,(None) ,Brazil , ,Not Presenting[4]

1 - Instituto Tecnologico de Aeronautica 2 - Instituto Tecnologico de Aeronautica 3 - Instituto Tecnologico de Aeronautica 4 - Infinite Technical

Sixteen years (2000 - 2015) of lighting discharges registered over the State of Parana, Brazil were analyzed to determine their spatial distribution, clustering and seasonal effects throughout the state. Additionally, the lightning discharge time series data were compared with time series of cosmic ray data proxies. The lightning discharges data were collected by Lightning Location System (LLS) and SIMEPAR in operation in southeastern Brazil. The LLS consists of an ELF/VLF electric field network that detects the occurrence of cloud-to-ground lightning discharges. Cosmic ray data were obtained from the network of neutron monitors of the Bartol Research Institute (Antarctica, and Newark, USA). The data were analyzed using spatial statistics tools and the time series using spectral and wavelet analysis to determine the presence of periodicities as well as the level of correlation between the time series. Seasonal and spatial effects in the distribution of lightning discharges were observed, but no noticeable correlation was detected between the time series of discharges and cosmic ray data.

Instability in Long DC Arcs in Air: Application to Lightning M-components in Continuing Current

Abstract ID : 1391

Conflict Declaration : None

Content Motivation : None

Additional Information : This talk has been submitted in response to Marcelo Saba and Joan Montanya both being organizers of this session

Dr. Earle Williams ,earlew@ll.mit.edu ,(Research Scientist) ,United States ,Cambridge ,Not Presenting[1]

Prof. Joan Montanya ,joan.montanya@gmail.com ,(None) ,Spain , ,Not Presenting[2]

Mr. Yakun Liu ,liuyakunhv@163.com ,(None) ,China , ,Not Presenting[3]

Mr. Robert Golka ,RobertGolka@comcast.net ,(None) ,United States , ,Not Presenting[4]

Mr. Mike Valente ,induction@comcast.net ,(None) ,United States , ,Not Presenting[4]

1 - Massachusetts Institute of Technology 2 - Polytechnic University of Catalonia 3 - Shanghai Jiao Tong University 4 - Golka Associates 5 - Golka Associates

A large DC power supply with +/-65 kV capability and current limit ~2 amperes has been used to study the evolution of DC arcs with lengths up to ~1 meter. High speed video is used to observe the arc geometry. The arcs are initiated with straight fuse wires and then become increasingly tortuous until single loops of the discharge arc over with a resultant shortening of the tortuosity. A similar phenomenon occurs in meandering river channels when 'oxbows' are abandoned in cutoffs-a process called avulsion in hydrology. Evidence from the lightning literature, in high resolution observations, will be shown that avulsion occurs in lightning channels. Further evidence will be shown that this instability may account for M-components with modest brightness variations.

"APEC Blue" Association with Emission Control and Meteorological Conditions Detected by Multi-scale Statistics

Abstract ID : 417

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ping Wang ,pwang@camscma.cn ,(None) ,China , ,Not Presenting[1]

Prof. Xin-Gang Dai ,daixg@tea.ac.cn ,(None) ,China ,Beijing ,Presenting[2]

1 - Institute of Air Condition, Chinese Academy of Meteorological Sciences, Beijing 100081, 2 - RCE-TEA, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029

The term "APEC Blue" has been created to describe the clear sky days since the Asia-Pacific Economic Cooperation (APEC) summit held in Beijing during November 5-11, 2014. The duration of the APEC Blue is detected from November 1 to November 14 (hereafter Blue Window) by moving t test in statistics. Observations show that APEC Blue corresponds to low air pollution with respect to PM2.5, PM10, SO2, and NO2 under strict emission-control measures (ECM) implemented in Beijing and surrounding areas. Quantitative assessment shows that ECM is more effective on reducing aerosols than the chemical constituents. Statistical investigation has revealed that the window also resulted from intensified wind variability, as well as weakened static stability of atmosphere (SSA). The wind and ECM played key roles in reducing air pollution during November 1-7 and 11-13, and strict ECM and weak SSA become dominant during November 7-10 under weak wind environment. Moving correlation manifests that the emission reduction for aerosols can increase apparent wind cleanup effect, leading to significant negative correlations of them, and the period-wise changes in emission rate can be well identified by multi-scale correlations basing on wavelet decomposition. In short, this case study manifests statistically how human interference modified air quality in the mega city through controlling local and surrounding emissions in association with meteorological condition.

The role of aerosol and clouds on spectral biologically effective UV irradiances

Abstract ID : 465

Conflict Declaration : None

Content Motivation : None

Additional Information : Acknowledgements: We thank Fundación Carolina (Spain) and the Foundation of Support Research of the State of Minas Gerais - Fapemig (Brazil) for the financial support.

Dr. Marcelo de Paula Correa ,mpcorrea@unifei.edu.br ,(Associate Professor) ,Brazil ,Itajuba ,Not Presenting[1]

Dr. Roberto Roman ,robertor@ugr.es ,(None) ,Spain , ,Not Presenting[2]

Dr. Manuel Anton ,manantonr@unex.es ,(None) ,Spain , ,Not Presenting[3]

Dr. Lucas Alados-Arboledas ,alados@ugr.es ,(None) ,Spain , ,Not Presenting[2]

1 - Federal University of Itajuba 2 - Universidad de Granada 3 - Universidad de Extremadura 4 - Universidad de Granada

The purpose of this study is to identify particular influences of clouds and aerosols on the direct and global spectral UV irradiances weighted by 16 different biological responses as the erythema, vitamin D synthesis, skin elastosis, and eyes diseases, among others. For this, we propose the exam of different events such as urban and desert dust intrusions, and cloud variability over Granada city, located at southern Spain. A spectral UV data set collected by a spectroradiometer (Bentham "Dmc-150" double monochromator) between 2008 and 2012 has been analysed and compared against spectral UV calculations using the UVSPEC radiative transfer model included in the LibRadtran package. Our calculations were based on aerosol optical properties provided by an AERONET Cimel CE318-1 sun-photometer, 5-minute cloud cover observations performed by a sky camera, and daily total ozone content supplied by OMI/NASA satellite measurements. In this preliminary step, not-weighted UV overall data under cloud-free conditions were analysed. As the direct beam measurements are more sensitive to aerosols, these simulations were used for filtering discrepancies in the data set. Mean bias error (MBE) ranges from -4 to +4% for measurements performed solar zenith angles (SZA) below 60°. As expected, the precision of the model is also smaller for shorter wavelengths. Global simulations showed good accuracy for SZA < 55° (MBE ranges from -2 to 0%), but the model overestimates above this angle, probably because some high clouds are difficult to be observed in these conditions. For the biological weighted-UV irradiances, larger MBE can be expected in some cases. For example, vitamin D synthesis biological response covers smaller wavelengths (280-330 nm) and comparisons have showed larger MBE (~ - 8% for < 300 nm). Next steps will be concentrated in the study cases. The goal is to provide a new scenario for weighted-UV irradiance, its dependencies and better approximations for forecast models.

The Universal Cloud and Aerosol Sounding System (UCASS) - an open path optical particle counter for dropsonde or balloon-borne measurements

Abstract ID : 528

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Helen Smith ,h.smith20@herts.ac.uk ,(Instrument Scientist) ,United Kingdom ,Hatfield ,Not Presenting[1]

Prof. Paul Kaye ,p.h.kaye@herts.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Edwin Hirst ,e.hirst@herts.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Joseph Ulanowski ,z.ulanowski@herts.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Warren Stanley ,w.stanley@herts.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Christopher Stopford ,c.stopford@herts.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Hertfordshire 2 - University of Hertfordshire 3 - University of Hertfordshire 4 - University of Hertfordshire 5 - University of Hertfordshire 6 - University of Hertfordshire

The Universal Cloud and Aerosol Sounding System (UCASS) is an open geometry instrument, which uses wide-angle elastic light scattering for the high precision sizing of particles in the range 0.3µm to 40µm. Particles passing through an optically defined sensing zone are counted, and the magnitude of the optical response is used to calculate the size. Modelled results using T-Matrix and Lorenz-Mie theory show that, for the optical set up utilized in the UCASS, the instrument response is largely independent of particle shape and refractive index. Therefore, the system is suitable for the measurement of both spherical and none-spherical particles, and particles with unknown optical properties.

The UCASS has been used in a number of field studies, early versions were tested as dropsondes for the vertical profiling of mineral dust and volcanic ash over Germany. The more recent, open geometry system has been used for balloon-borne measurements of aerosol and clouds at the Chilbolton observatory, and during the large-scale international campaigns ICE-D, PRE-TECT and A-LIFE. Laboratory based inter-comparison studies have also been conducted at the Puy de Dome observatory, using both the research platform and wind-tunnel facilities. This presentation describes the operating principles and specifications of the UCASS, and also discusses comparative data from a number of in-situ and remote sensing instrumentation from a collection of field and laboratory based studies.

Studies of sea spray aerosol production of ice nucleating particles

Abstract ID : 973

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Paul DeMott ,Paul.Demott@colostate.edu ,(Senior Research Scientist) ,United States ,Fort Collins ,Not Presenting[1]

Dr. Thomas Hill ,Thomas.Hill@colostate.edu ,(None) ,United States , ,Not Presenting[1]

Ms. Christina McCluskey ,mccluscs@atmos.colostate.edu ,(None) ,United States , ,Not Presenting[1]

Dr. Gregory Schill ,gpschill@atmos.colostate.edu ,(None) ,United States , ,Not Presenting[1]

Mr. Gavin Cornwell ,gavinccornwell@gmail.com ,(None) ,United States , ,Not Presenting[5]

Ms. Charlotte Beall ,cbeall@ucsd.edu ,(None) ,United States , ,Not Presenting[5]

Mr. Mitchell Santander ,msantand@ucsd.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Dale Stokes ,dstokes@ucsd.edu ,(None) ,United States , ,Not Presenting[8]

Dr. Francesca Malfatti ,f.malfatti@gmail.com ,(None) ,Italy , ,Not Presenting[9]

Ms. Camille Sultana ,camillesultana@gmail.com ,(None) ,United States , ,Not Presenting[5]

Dr. Kim Prather ,kprather@ucsd.edu ,(None) ,United States , ,Not Presenting[5]

Mr. Jonathan Trueblood ,jotruebl@ucsd.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Vicki Grassian ,vhgrassian@ucsd.edu ,(None) ,United States , ,Not Presenting[5]

Dr. Michael Harvey ,Mike.Harvey@niwa.co.nz ,(None) ,New Zealand , ,Not Presenting[14]

Dr. Alain Protat ,alain.protat@bom.gov.au ,(None) ,Australia , ,Not Presenting[15]

Dr. Ruby Leung ,Ruby.Leung@pnnl.gov ,(None) ,United States , ,Not Presenting[16]

1 - Colorado State University 2 - Colorado State University 3 - Colorado State University 4 - Colorado State University 5 - University of California, San Diego 6 - University of California, San Diego 7 - University of California, San Diego 8 - Scripps Institution of Oceanography 9 - OGS 10 - University of California, San Diego 11 - University of California, San Diego 12 - University of California, San Diego 13 - University of California, San Diego 14 - NIWA 15 - Bureau of Meteorology 16 - Pacific Northwest National Laboratory

The nature and abundance of oceanic ice nucleating particles (INPs) produced in sea spray aerosol (SSA) are important to characterize since ocean emissions could provide the primary source of INPs to cold clouds in remote ocean regions, and these INPs have far different activation properties than terrestrial INPs (DeMott et al., Proc. Natnl. Acad. Sci., 113, 5797-5803, 2016). The INP temperature spectra characteristic of ocean regions typically show lower abundance of INPs active at moderately supercooled cloud conditions, and this may have consequences for supercooled cloud persistence and cloud radiative properties in regions like the Southern Ocean.

We have applied online and offline methods to measure the number concentrations of INPs in air at coastal sites, on ships in both hemispheres, and in laboratory mesocosm studies of SSA produced from bubble-bursting of seawater. Online processing using a continuous flow diffusion chamber permits selection of activated INP for direct physical and chemical analyses (SEM, Raman spectroscopy). Time-integrated aerosol collections onto filters are used for offline measurements of the immersion freezing temperature spectra of particles dispersed into liquid volumes, and permit inference to INP source compositions via screening for particle size, heat lability, chemical reactivity, and the presence of known biological INPs. Similar measurements are made on collections of bulk seawater and the sea surface microlayer (SML). Finally, we have explored atmospheric processing impacts on INP activation properties.

Laboratory studies reveal two basic INP populations, one of a microbial nature and one composed of smaller organic components produced from biological processing. Emissions depend on the strength and timing of blooms, and the properties of the SML can exert a large control on INP emissions. Atmospheric oxidation over typical marine boundary layer lifetimes appear to degrade the subsequent activity of both INP types in mixed phase cloud conditions.

Field studies confirm greater than an order of magnitude variability in space and time of INP number concentrations in marine air that is expected on the basis of physical, chemical and biological factors affecting emissions, and the failure of simple relations between total organic matter content of aerosols and INPs in predicting INP concentrations.

Latent heating and surface fluxes in baroclinic development: Analytical and idealised numerical solutions

Abstract ID : 431

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Kristine Flacké Haualand ,kristine.haualand@uib.no ,(PhD Candidate) ,Norway ,Bergen ,Not Presenting[1]

Prof. Thomas Spengler ,thomas.spengler@uib.no ,(None) ,Norway ,None ,Not Presenting[1]

1 - University of Bergen 2 - University of Bergen

We investigate the effect of diabatic processes, including latent heat conversion and surface fluxes, on baroclinic development in a linear quasi-geostrophic framework. Previous studies have shown that latent heating alters the intensification rate and structure of baroclinic cyclones. Case studies from areas with strong surface fluxes, such as near the western boundary currents where the gradient of sea surface temperature is large, show an important contribution from surface fluxes on storm development. However, our understanding of the complex interactions of diabatic and baroclinic effects in marine cyclones remains limited. Furthermore, few studies have looked at the influence of latent cooling associated with the evaporation below a cloud layer. Such a cooling layer affects the baroclinic instability by enhancing the vertical gradient between the latent heating and cooling layer, intensifying the diabatically forced potential vorticity anomalies at this interface.
Our work is based on an analytical extension of the Eady model, as well as idealised two-dimensional numerical simulations, where the diabatic effects are parametrised using vertical velocity and surface temperature. The influence of latent heating and surface fluxes is consistent with previous studies using similar heating parametrisations. Increasing these diabatic effects shifts the instabilities toward shorter wavelengths and results in shallower structures of the unstable waves. We also present the effects of a low-level evaporation layer on the dynamics of baroclinic waves in the presence of latent heating aloft. Our findings shed light on how diabatic processes interact and influence baroclinic development.

Formation and Maintenance Mechanisms of the Western Hemisphere Circulation Pattern: Roles of Stationary waves versus Synoptic waves

Abstract ID : 769

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ming Bao ,baom@nju.edu.cn ,(Associate Professor) ,China ,Nanjing ,Presenting[1]

Dr. Paulo Ceppi ,ceppi@uw.edu ,(None) ,United Kingdom , ,Not Presenting[2]

Mr. Xin Tan ,mg1528018@smail.nju.edu.cn ,(None) ,China , ,Not Presenting[1]

Prof. Dennis Hartmann ,dhartm@washington.edu ,(None) ,United States , ,Not Presenting[4]

1 - Nanjing University 2 - Reading University 3 - Nanjing University 4 - University of Washington

The formation mechanism of a recurrent, low-frequency flow regime-the Western Hemisphere (WH) atmospheric circulation pattern-is investigated in this study. Patterns in observed stream function, Rossby wave activity flux anomalies associated with the observed WH pattern in 500-hPa height fields are defined through regression and composite analysis. The results indicate the stationary Rossby wave propagation from the subtropical central Pacific through North America and from the subtropical North Atlantic to western Europe.
The role of synoptic waves in the formation and maintenance of the WH pattern is further investigated. Persistent WH events are characterized by the propagation of quasi-stationary Rossby waves across the North Pacific-North America-North Atlantic regions and by associated storm track anomalies. The eddy-induced low-frequency height anomalies maintain the anomalous low-frequency ridge over the Gulf of Alaska, which induces more equatorward propagation of synoptic waves on its downstream side. The eddy forcing favors the strengthening of the mid-latitude jet and the deepening of the mid-high latitude trough over the North Atlantic, whereas the deepening of the trough over eastern North America mostly arises from the quasi-stationary waves propagating from the North Pacific. A case study for the 2013/14 winter is examined to illustrate the downstream development of synoptic waves.

A comparative study between bulk and bin microphysical schemes of a simulated squall line in East China

Abstract ID : 952

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Fan Ping ,pingf@mail.iap.ac.cn ,(Professor) ,China ,Beijing ,Not Presenting[1]

Miss. Lei Yin ,yinlei@mail.iap.ac.cn ,(None) ,China , ,Not Presenting[1]

Mr. Jiahua Mao ,maojh90@163.com ,(None) ,China , ,Not Presenting[1]

1 - Institute of Atmospheric Physics, Chinese Academy of Sciences 2 - Institute of Atmospheric Physics, Chinese Academy of Sciences 3 - Institute of Atmospheric Physics, Chinese Academy of Sciences

A squall line occurred in East China during 12 July 2014 was simulated with the Weather Research and Forecasting (WRF) model using spectral bin and two-moment bulk microphysical parameterization scheme, respectively. Comparative study showed that significant differences existed in the dynamic, thermodynamic and microphysical structures of squall line between bulk and bin simulation results. The bulk scheme produced a well-organized but shorter radar structure while bin scheme simulated scattered but stronger radar echo which was more consistent with observation. Bulk scheme had a better performance in predicting the strong rainfall areas and amount. The strong rear-to-front (RTF) inflow and convective updrafts were identified in bulk scheme by comparison with weak RTF and updrafts in bin scheme. In addition, bulk simulated a deeper cold pool than bin. Much higher cloud droplet number concentration was simulated by bulk scheme, while higher raindrop mass and number concentration was generated by bin scheme. Detailed analysis and sensitivity tests are needed in future to further investigate the possible mechanisms that responsible for the distinctive results.

Linking Hadley circulation and storm tracks in a conceptual model of the atmospheric energy balance

Abstract ID : 1101

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Cheikh Mbengue ,c.mbengue@wolfson.oxon.org ,(Postdoctoral Researcher) ,Saint Lucia ,Castries ,Not Presenting[1]

Prof. Tapio Schneider ,tapio@caltech.edu ,(None) ,United States , ,Not Presenting[2]

1 - University of Oxford 2 - California Institute of Technology

Midlatitude storm tracks shift in response to climate change and natural climate variations such as ENSO, but the dynamical mechanisms controlling these shifts are not well established. Here an energy balance model is developed that shows how shifts of the Hadley cell terminus and of the meridional energy flux out of the Hadley cell can drive shifts of storm tracks, identified as extrema of the atmospheric meridional eddy energy flux. The distance between the Hadley cell terminus and the storm tracks is primarily controlled by the energy flux out of the Hadley cell. Because tropical forcings alone can modify the Hadley cell terminus, they can also shift extratropical storm tracks, as demonstrated through simulations with an idealized GCM. Additionally, a strengthening of the meridional energy flux out of the Hadley cell can reduce the distance between the Hadley cell terminus and the storm tracks, enabling storm-track shifts that do not parallel shifts of the Hadley cell terminus. Thus, with the aid of the energy balance model and supporting GCM simulations, a closed theory of storm-track shifts emerges.

Multi-scale Structure between Cut off Upper Low and Tornados

Abstract ID : 1115

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Kasuga Satoru ,b36217489@gmail.com ,(None) ,Japan ,Niigata ,Not Presenting[1]

Mr. Meiji Honda ,meiji@env.sc.niigata-u.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Prof. Ukita Jinro ,jukita@env.sc.niigata-u.ac.jp ,(None) ,Japan , ,Not Presenting[3]

Dr. Katsushi Iwamoto ,katsu.iwamoto@gmail.com ,(None) ,Japan , ,Not Presenting[4]

1 - Japan 2 - Niigata Univ. / Jpapan 3 - Niigata Univ. / Japan 4 - Mombetsu City / Japan

Associated with the passing of a cut off upper low (COL) over Japan on 15 April 2015, two tornados occurred with a sharp rain-band at Chubu district, Japan. COL is identified as an upper-tropospheric synoptic scale (>2000km) cold vortex derived from the North Pole region. Until recently, multi-scale structures between COL and tornados have been hardly discussed. To investigate interactions of multi-scale phenomena of this case, we used analysis data of the Meso Scale Model (MSM) of the Japan Meteorological Agency (JMA). A high value of EHI (Energy Helicity Index) evaluating occurrence of supercells was scored relatively high value nearly overlapped the location of the meso-beta scale (20~200km) rain-band. Around this rain-band, some mid-tropospheric low equivalent potential temperature air streams (derived from the COL) overrode surface meso-alpha scale (200~2000km) moist frontal region. That structure created strong vertical wind shear and decreased static stability, and made a favorable condition for tornado. It is suggested that the COL provided a favorable condition for the occurrence at the rain-band.

Stratospheric gravity waves produced by asymmetric TC Soudelor (2015) near Taiwan

Abstract ID : 1257

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Fabrice Chane Ming ,fchane@univ-reunion.fr ,(Assistant Professor) ,Reunion ,St Denis ,Not Presenting[1]

Dr. Samuel Jolivet ,bohux@yahoo.fr ,(None) ,Switzerland , ,Not Presenting[2]

Prof. Yuei-An Liou ,yueian@csrsr.ncu.edu.tw ,(None) ,Taiwan , ,Not Presenting[3]

Dr. Fabrice Jegou ,Fabrice.jegou@cnrs-orleans.fr ,(None) ,France , ,Not Presenting[4]

1 - University of La Réunion 2 - Meteobooking 3 - Center for Space and Remote Sensing Research 4 - Laboratoire de Physique et Chimie de l'Environnement et de l'Espace Orléans Cedex 2 (France)

Predicting the structure and dynamics of tropical cyclone (TC) inner core remains a major operational challenge today, especially in the rapid changes of TC intensity. TC intensification is mainly controlled by internal dynamics and external forcing from the environmental flow. In particular, during intensification phase and extra-tropical transition, TC vortex experiences asymmetric instabilities during its lifecycle resulting from interactions between the TC and its environment. The wavenumber-1asymmetry is involved in rapid TC intensity change with convective bursts and induces intense stratospheric gravity waves (GWs).

The present study describes the intensification of TC Soudelor (2015) before its landfall over Taiwan in the West-Pacific Ocean through observations and WRF modeling. The asymmetric structure of TC Soudelor is well observed on satellite images and on the distribution of horizontal wind intensity derived from operational ECMWF analyses on 7 August at 1200 UTC at 4-km heights near Taiwan. The vertical wind speed field reveals concentric mesoscale GWs in the upper troposphere and propagating upward in the lower stratosphere. FORMOSAT-3/COSMIC radio occultation temperature profiles support the presence of mesoscale GWs with vertical wavelengths of 2-3 km in the lower stratosphere. Numerical simulations enable us to reproduce the TC asymmetry as well as stratospheric GWs.

Research on Transverse Shear Lines and Heavy Rainfalls over the Tibetan Plateau during Boreal Summer

Abstract ID : 340

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Xiuping Yao ,yaoxp@cma.gov.cn ,(Professor) ,China ,Beijing ,Not Presenting[1]

1 - China Meteorological Administration

Based on the ERA-Interim dataset and 2474 stations precipitation dataset ranging from May to October in china during the 33-yr period of 1981-2013 , the transverse shear lines (shorten as TSLs) were identified , and the TSLs climatic characteristics and the relationship with the heavy rainfalls over the Tibetan Plateau and the adjacent eastern region during the boreal summer were analysed statistically by the 3 criteria, namely the meridional shear of the zonal wind, the relative vorticity and the zero contour line of the zonal wind.
It was shown that the TSLs generally dominated west-east orientation through the Tibetan Plateau in the boreal summer, with the most occurrence frequency in June, at least in October. The high frequency axis of the TSL paralled to the Tibaten Plateau terrain, shifting southward from May to August and then northward from September to October slightly. The annual average frequency of the TSL was 65.3 days. There existed an obvious interannaual and interdecadal variation characteristics for the TSLs. The annual fluctuation of the TSL's frequency was most distinct in 1980s and the second in 21th century, while the average frequency appeared during 1995-2000.
It could be found that the occurrence frequency of the TSL and the heavy rainfall was stable during the 33-yr period of 1981-2013. However, the occurrence frequency of the heavy rainfall caused from the TSL was decreasing. More than 50% of the TSLs could lead to the heavy rainfalls, while 40% of the heavy rainfalls were caused by the TSLs. The close relationship between the TSLs and the heavy rainfalls in the flooding season ranging from June to August was explored in this paper.

Vanda Grubisic : VG: Recommend for a poster presentation.

Effects of the topography on the atmospheric variables in the Southeastern Brazil

Abstract ID : 1312

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Michelle Reboita ,reboita@gmail.com ,(researcher) ,Brazil ,Itajuba ,Not Presenting[1]

Dr. Rosmeri da Rocha ,rosmeri@model.iag.us.br ,(None) ,Brazil , ,Not Presenting[2]

Miss. Débora Martins ,deboramartins.atm@gmail.com ,(None) ,Brazil , ,Not Presenting[1]

1 - Unifei 2 - USP 3 - Unifei

General Circulation Models (GCM) have coarse horizontal resolution and for this reason they are not able to represent realistically regional orographic forcing of weather and climate. In this context, the purpose of this study is to evaluate the influence of the topography in the climate (precipitation, air temperature and atmospheric circulation) of southeastern Brazil (Serra da Mantiqueira) through two simulations with the Regional Climate Model (RegCM4). This model was nested in the NCEP-NCAR reanalysis, which has a coarse resolution (2.5^{o} x 2.5^{o}), and executed with 12 km of horizontal grid spacing. The first simulation was the control (CTRL) and was evaluated by comparing it with data from meteorological stations. In the second simulation, the topography was removed (WTOPO), i.e., all southeastern of Brazil was at sea level in the simulation. Both simulations extended from November 2008 to February 2009 and the first month was not included in the analysis (spin-up period). The period studied corresponds to the rainy season over the southeastern Brazil. CTRL simulation underestimates about 2^{o} the air temperature at 2 meters high. Overall, CTRL simulation overestimates the precipitation, from 4 to 40%, when compared with the meteorological stations and underestimates it when compared with TRMM satellite data. In WTOPO simulation there is a precipitation increase in almost the domain. Although in the WTOPO simulation the mountain-valley breeze is suppressed, acting negatively to orographic rain, it is suggested that the moisture transport from the Atlantic Ocean (by the subtropical anticyclone) and from the Amazonia (by the low level jet eastern the Andes) can interact with a more unstable atmosphere without topography (that is warmer than in the CTRL simulation) and produce more precipitation.

Vanda Grubisic : VG: Recommend for an oral presentation.

role of large-scale tropospheric circulation and energetics in the latitudinal distribution of the tropical cyclone lifecycle

Abstract ID : 107

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Joshua Studholme ,studholme@sail.msk.ru ,(Research Scientist, Ph.D. Student) ,Russia ,Moscow ,Presenting[1]

Dr. Sergey Gulev ,gul@sail.msk.ru ,(None) ,Russia , ,Not Presenting[1]

1 - Russian Academy of Sciences, Shirshov Institute of Oceanology 2 - Russian Academy of Sciences, Shirshov Institute of Oceanology

Trends can be identified in the latitudinal distribution of tropical cyclone (TC) activity throughout the cyclone lifecycle. Notably for example, the latitude of lifetime maximum intensity (LMI) has been shown to be migrating poleward in both hemispheres and has been linked to an expansion in the tropical atmosphere. In this study, observed trends in both hemispheres at tropical cyclogenesis, LMI and lysis are computed and decomposed to investigate the role of the mean bulk horizontal tropospheric circulation (the so-called steering flow), vertical circulation and ocean-atmosphere enthalpy fluxes (latent and sensible heat). Extreme interannual modulations (as expected) are largely determined by ENSO, while some interdecadal changes are shown to be associated with zonally homogenous patterns in enthalpy fluxes, convective available potential energy (CAPE), and intensified Hadley circulation. Patterns of variability are significantly more coherent in the Northern Hemisphere. These results suggest that, since differing large-scale conditions conspire to effect TC lifecycle points differently, the overall latitudinal distribution of the TC lifecycle does not modulate in a wholesale fashion.

Ventilation Index during a super-intense tropical cyclone

Abstract ID : 259

Conflict Declaration : None

Content Motivation : Dear Members of the Scientific Programme Committee, Joint Assembly 2017, Cape Town, South Africa, With this letter I hereby would like to state my motivation to attend " Joint IAPSO-IAMAS-IAGA Assembly " organized in < Cape Town, South Africa, 27 Auguest-1September 2017>. The assembly theme is especially relevant to my professional expertise, and therefore I would high appreciate to be given an opportunity to attend this event gathering professional from all over the World. As a special added value of this event I find the opportunity to network with other professional from the World, which is an exceptional opportunity for horizontal exchange of experience. I perceive this also as an occasion to familiarize with good practices as a channel for my personal development. Also I am filling the application form for grant. Since I am from Iran, It would be highly appreciated if my request for grant be accepted. Sincerely, Nafiseh Pegahfar, Assistant Professor, Iranian International Institute for oceanography and Atmospheric Science

Additional Information : None

Dr. Nafiseh Pegahfar ,pegahfar@inio.ac.ir ,(Faculty member) ,Iran ,Tehran ,Not Presenting[1]

Dr. Maryam Gharaylou ,gharaylo@ut.ac.ir ,(Assistant professor) ,Iran ,Tehran ,Not Presenting[2]

1 - INIOAS 2 - Institute of Geophysics, University of Tehran

The most of increasing vulnerability to tropical cyclones (TCs), which are causing the most devastating of all natural catastrophes, is related to the intense and super-intense tropical cyclones. This resulted in forming hypothesized mechanism to investigate some environmental factors' constrains on tropical cyclone's intensity. Following, various empirical quantities and indices have been introduced to provide evidence for the defined hypothesizes. In this approach, using thermodynamical variables, such as entropy and its derivatives have been highly focused. Recently, the ventilation index has been defined to assess the degree to which ventilation controls global TC genesis and intensity statistics.

In the current work, the framework resulted in Tang and Emanuel (2010) has been used to numerically calculate the ventilation index during an intense tropical cyclone (November 2013) has been studied which was the strongest TC to 2014. Also, a dynamical downscaling with a high resolution limited-area model (Weather Research and Forecasting, WRF) has been done using analysis data provided by National Centers for Environmental Prediction Global Forecast System with 0.5 degree by 0.5 degree horizontal resolution at 26 pressure levels in 6-h intervals.

Following, bulk environmental vertical wind shear between 850 and 200 hPa, non-dimensional entropy deficit, potential intensity, saturation entropy at 600 hPa in the inner core of the TCH, environmental entropy at 600 hPa, the saturation entropy at the sea surface temperature and the entropy of the boundary layer have been computed during 3-11 November 2013.

Our derived results indicated that the trend of ventilation index maximized four times. The largest value was 100 and occurred during the selected TC dissipation period (0000 UTC 11 November 2013). Also, the second large maximum value (around 20) has been detected at TCH peak activity time (0000 UTC 8 November 2013). Also, one maximum value (less than 5) occurred before TCH maximum intensity time and the other one appeared at the beginning of TCH lifetime (0000 UTC 4 November 2013), respectively.

Assessment of track and precipitation of tropical cyclone Dineo using global ensenble forecast

Abstract ID : 900

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Celio Matuele ,celiomatuele@gmail.com ,(Student) ,Japan ,Kyotanabe ,Not Presenting[1]

1 - Doshisha University

The southeast region of the African continent is often affected by tropical cyclones, particularly during the period of October to May. Generally, the tropical cyclones form in the southern Indian Ocean basin and move westward affecting Madagascar Island and parts of southeastern Africa bringing intense precipitation, high winds, sea level rise and huge waves. Sometimes, cyclones form in the Mozambique Channel and most of them move eastward. In February 2017, tropical cyclone Dineo was generated in the Mozambique Channel. Dineo reached category 1 and moved westward, made landfall in Inhambane province, Mozambique on 15 February and crossed through to South Africa and Botswana. In this study, we made an assessment of the predicted track and precipitation distribution of Dineo using global ensemble forecast and observed data. The forecast data provided by ECMWF, NCEP, JMA and UKMO were downloaded from Thorpex Interactive Grand Global Ensemble (TIGGE). The positions of MSLP local minima and the horizontal distributions of 6-hour accumulated precipitation related to Dineo predicted in the ensemble forecast for the period of 13 - 17 February were compared with the observed track and satellite precipitation products (GSMaP produced by JAXA). The results showed that the observed Dineo track was predicted well by the NCEP ensemble forecast with little spread. The UKMO ensemble forecast showed a good representation of the tropical cyclone shape while the ECMWF ensemble forecast predicted well and showed more confidence in extreme weather occurrence in a longer-range forecast.

STUDY OF VARIATION OF LOW-LEVELS JET IN SOUTH AMERICA

Abstract ID : 976

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Dejanira Ferreira Braz ,dejanira.braz@iag.usp.br ,(Estudante de doutorado) ,Brazil ,São Paulo ,Not Presenting[1]

Dr. Raquel Nieto ,rnieto@uvigo.es ,(None) ,Spain , ,Not Presenting[2]

Dr. Tércio Ambrizzi ,ambrizzi@model.iag.usp.br ,(None) ,Brazil , ,Presenting[3]

Prof. Rosmeri Porfírio da Rocha ,rosmerir@model.iag.usp.br ,(None) ,Brazil , ,Not Presenting[4]

1 - Universidade de São Paulo 2 - University of Vigo, Spain 3 - USP/São Paulo 4 - University of São Paulo

An increasing number of surveys of the Low-Level Jet (JBN) have been showing their importance in influencing weather and climate. A fundamental factor that is directly related to the JBNs is the transport of heat and humidity from the Amazon basin and the Atlantic Ocean to the South, Southeastern Brazil and northern Argentina, in which it contributes to the precipitation distribution of these regions. The JBNs are wind systems with speeds above 10ms-1, located between one and two kilometers above the surface and with a horizontal structure of approximately 500km. The JBNs are of extreme importance for the local climate, playing a relevant role in the latent heat balance, angular momentum and kinetic energy. Although there are several studies on the JBN, there is still a lack of understanding about the nocturnal jet. Thus a better knowledge of this system will aid in the interpretation of abnormalities in the transport of moisture during extreme climatic events (droughts or heavy rains). For this study we used the Era-interim reanalysis data (ECMWF), with spatial resolution of 1,5º x 1,5º for the period 1979-2013. An analysis of the nocturnal JBNs (JBNN) was made based on the vertical structure of the time variation that is defined in local time (00UTC, 06UTC, 12UTC and 18UTC). In this way, it was possible to identify through this index the maximum peak of the jet in several points of South America for the months of January and July. The analysis done through the index maps, shows the locations where the jet is already known, but also reveals a new location that is in northeastern Brazil. In addition, the JBNN was observed more frequently at this point for both months. Having the most detailed knowledge about the transport of moisture bound to the JBNN, it will be possible to improve understanding of precipitation distribution, contributing to improve forecasting models and to understand how global warming may affect this system in the future.

The structure and variability of Indian monsoon depressions

Abstract ID : 1084

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Kieran Hunt ,k.m.r.hunt@reading.ac.uk ,(Research Scientist) ,United Kingdom ,Reading ,Not Presenting[1]

1 - University of Reading

ERA-Interim reanalysis data from the past 35 years have been used with a newly-developed feature tracking algorithm to identify Indian monsoon depressions originating in or near the Bay of Bengal. These were then rotated, centralised and combined to give a fully three-dimensional 106-depression composite structure -- a considerably larger sample than any previous detailed study on monsoon depressions and their structure.
Many known features of depression structure are confirmed, particularly the existence of a maximum to the southwest of the centre in rainfall and other fields, and a westward axial tilt in others. Additionally, the depressions are found to have significant asymmetry due to the presence of the Himalayas; a bimodal mid-tropospheric potential vorticity core; a separation into thermally cold- (-1.5 K) and neutral- (0 K) cores near the surface with distinct properties; and that the centre has very large CAPE and very small CIN.
Variability as a function of background state has also been explored, with land/coast/sea, diurnal, ENSO, active/break and Indian Ocean Dipole contrasts considered. Depressions are found to be markedly stronger during the active phase of the monsoon, as well as during La Nina. Depressions on land are shown to be more intense and more tightly constrained to the central axis.
A detailed schematic diagram of a vertical cross-section through a composite depression is also presented, showing its inherent asymmetric structure.

ACTIVE METEOROLOGICAL SYSTEMS DURING THE GOAMAZON EXPERIMENT AND IMPACTS IN ATTO TOWER DATA

Abstract ID : 1202

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Paola Bueno ,paola.gbueno@gmail.com ,(Master Degree Student) ,Brazil ,São Paulo ,Not Presenting[1]

Dr. Tércio Ambrizzi ,ambrizzi@model.iag.usp.br ,(None) ,Brazil , ,Not Presenting[2]

1 - IAG-USP 2 - USP/São Paulo

The Amazon has great importance for the climate, both regionally and globally, so it is necessary to understand its climatology and the major weather systems that have an influence on it. For this purpose, there are large scientific projects operating in the region, as the latest GOAmazon, that had a number of sites of instrumental weather observations around the city of Manaus in addition to data collection made from aircraft, radar and soundings, during the years of 2014 and 2015. This study has the general objective to evaluate the variability of daily weather data during the GOAmazon experiment and associate the anomalies found with atmospheric systems operating in the region and large-scale systems, in order to determine their influence during the data collection. For a first analysis, the daily precipitation data of ATTO tower (2.146 ° S, 59 005 ° W), located 150 km northeast of Manaus, were used for these two years. To detect anomalies in the precipitation data the rainy and dry percentiles were calculated (90% and 20% respectively) of the climatological series of CHIRPS (Climate Hazards Group InfraRed Precipitation with Station date) and then select the rainy and dry cases of the collected series by ATTO. Later, some of these cases were selected to see which weather systems were acting and that could be associated with the detected anomaly. In the anomalies detected is possible to see the influence of El Niño, which was intense during the year of 2015, by the amount of days that are equal to or below the daily dry percentile. Also, it was observed that the rainiest days were associated with events of South Atlantic Convergence Zone (SACZ) and Humidity Convergence Zone, other events were also related to the presence of a extratropical frontal system.

The relationship between the southern African heat low, circulation and rainfall in coupled model and reanalyses

Abstract ID : 1378

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Callum Munday ,callum.munday@seh.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Prof. Richard Washington ,richard.washington@ouce.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - University of Oxford 2 - Oxford University

Coupled general circulation models (GCMs) tend to simulate excessive rainfall over the normally arid Kalahari region, particularly in the austral summer season. For some models, Kalahari rainfall is overestimated by a factor of 4 compared to satellite/rain-gauge products, associated with a westward shift of their land based convergence zone (the South Indian Convergence Zone; SICZ). The Kalahari region is characterised by the formation of a heat low, in association with high mean surface temperatures (>25°C) and the overlying mid-level Botswana High pressure. The aim of the present study is to evaluate whether model deficiencies in capturing the seasonal cycle of the heat low are associated with their misrepresentation of rainfall in the region. Using daily model and reanalyses data, we find large variation between models in their representation of the heat low and quite considerable differences between models and reanalyses. The most severe biases occur in December to February (DJF), when some models underestimate the frequency of heat low formation by 50% compared to reanalysis estimates. The implications of these biases are explored in terms of their influence on circulation and rainfall in models.

Enhanced Predictability of SSW Events for Select Phases of the MJO

Abstract ID : 438

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Chen Schwartz ,chen.schwartz1@mail.huji.ac.il ,(M.Sc student) ,Israel ,Petah Tiqwa ,Not Presenting[1]

1 - Hebrew university of Jerusalem

The effect of the Madden-Julian Oscillation (MJO) on the Northern Hemisphere wintertime stratospheric polar vortex in meteorological reanalysis dataset and in S2S (subseasonal to seasonal prediction project) data. In both data sources, the MJO influences the tropospheric North Pacific, and in particular it modulates the heat flux that is in-phase with the climatological planetary waves in both the troposphere and stratosphere. The phase of the MJO in which convection is propagating into the tropical central Pacific immediately precedes a weakened vortex, while suppressed MJO convection in this region precedes a stronger vortex. While previous work has shown that SSW events are generally not predictable beyond two weeks in advance, the MJO can be used to enhance the timescale of predictability to beyond three weeks. Namely, members of the reforecast ensemble that maintain a stronger MJO event also simulate a weaker vortex for start dates three weeks before historical SSW events.

Climatological structure of planetary waves and mean flows in the Northern Hemisphere middle atmosphere during winter

Abstract ID : 481

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Koki Iwao ,iwao@kumamoto-nct.ac.jp ,(Associate professor) ,Japan ,Yatsushiro ,Presenting[1]

Prof. Toshihiko Hirooka ,hirook@geo.kyushu-u.ac.jp ,(Professor) ,Japan ,Fukuoka ,Not Presenting[2]

1 - National Institute of Technology, Kumamoto College 2 - Department of Earth and Planetary Sciences, Kyushu University

Importance of traveling planetary waves has been reported for the onset and/or the recovery periods of sudden stratospheric warming (SSW) events (e.g., Tomikawa et al., 2012; Iida et al., 2014); the traveling planetary waves could be generated in the middle atmosphere due to barotropic and/or baroclinic instability to bring about significant impacts on the mean flow through their generation and dissipation. However, detailed understandings for it seems to be still insufficient. Hence, we investigate observational features of the mean flow and the planetary wave propagation in the Northern Hemisphere (NH) winter by using TIMED/SABER satellite data. The time series of the SABER data includes tidal variations, because the satellite orbit is not perfectly sun-synchronous and the local time of observation is gradually decreased at a specific latitude. Therefore, after eliminating diurnal variations, daily 3-dimensional data is constructed from SABER data for geopotential heights and temperatures. Horizontal winds and EP-fluxes, potential vorticities are derived from these variables. As a result, it is found that climatological EP-flux convergence has two peaks in the NH middle atmosphere around the stratopause (50N, 50km) and in the polar mesosphere (65N, 80km). The former convergence is associated with stationary planetary waves propagating from the troposphere, while the latter convergence might be associated with traveling planetary waves generated in the middle atmosphere. Detailed features will be shown in the presentation.

ARCTIC STRATOSPHERE DYNAMICAL RESPONSE TO GLOBAL WARMING

Abstract ID : 656

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Alexey Yu. Karpechko ,Alexey.Karpechko@fmi.fi ,(None) ,Finland , ,Not Presenting[1]

Dr. Elisa Manzini ,elisa.manzini@mpimet.mpg.de ,(None) ,Germany ,Hamburg ,Not Presenting[2]

1 - Finnish Meteorological Institute 2 - MPIM

The role of stationary planetary waves in the dynamical response of the Arctic winter stratosphere circulation to global warming is here investigated by analysing simulations performed with atmosphere-only Coupled Model Intercomparison Project Phase 5 (CMIP5) models driven by prescribed sea surface temperatures (SSTs). Climate models often simulate dynamical warming of the Arctic stratosphere as a response to global warming in association with a strengthening of the deep branch of the Brewer-Dobson circulation; however until now, no satisfactory mechanism for such a response has been suggested. We focus on December-February (DJF) because this is the period when the troposphere and stratosphere are strongly coupled. When forced by increased SSTs, all the models analysed here simulate Arctic stratosphere dynamical warming, mostly due to increased upward propagation of quasi-stationary wave number 1, as diagnosed by the meridional eddy heat flux. We propose a mechanism which relates stratospheric warming and increased wave flux to the stratosphere with the strengthening of the zonal winds in subtropics and mid-latitudes near the tropopause. Evidences presented in this paper corroborate climate model simulations of future stratospheric changes and suggest a dynamical warming of the Arctic polar vortex as a more likely response to global warming.

An empirical model of nitric oxide in the upper mesosphere and lower thermosphere based on 12 years of Odin-SMR measurements

Abstract ID : 734

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Joonas Kiviranta ,joonas.kiviranta@chalmers.se ,(43535) ,Sweden ,Mölnlycke ,Not Presenting[1]

Dr. Kristell Pérot ,kristell.perot@chalmers.se ,(None) ,Sweden , ,Not Presenting[1]

Prof. Donal Murtagh ,donal.murtagh@chalmers.se ,(None) ,Sweden , ,Not Presenting[1]

Dr. Patrick Eriksson ,patrick.eriksson@chalmers.se ,(None) ,Sweden , ,Not Presenting[1]

1 - Chalmers University of Technology 2 - Chalmers University of Technology 3 - Chalmers University of Technology 4 - Chalmers University of Technology

Joonas Kiviranta, Kristell Pérot, Patrick Eriksson, Donal Murtagh
Chalmers University of Technology, Department of Earth and Space Sciences, SE-412 96, Gothenburg, Sweden
Nitric oxide (NO) is produced by energetic particle precipitation (EPP) and soft solar X-rays in the lower thermosphere. This NO can be transported down to lower atmospheric regions during polar winter, where it can interact with ozone and thus affect the chemical, thermal and dynamical structure of the atmosphere. A reliable model for the amount of thermospheric NO is needed, for instance to constrain chemistry climate models. This would help to reproduce the effects of solar activity variations on climate variability more accurately. Such an empirical model, called NOEM, was developed by Marsh and Solomon (2004) based on 2.5 years of measurements from the Student Nitric Oxide Explorer (SNOE). However, neither validation nor competition for NOEM has taken place since its release.

This work presents and discusses the technique used for the new empirical model, the SMR Acquired Nitric Oxide Model Atmosphere (SANOMA). It is based on 12 years of Odin Sub Millimeter Radiometer (SMR) measurements, covering more than one solar cycle from 2003 to 2015 in both day- and nighttime conditions. The model predicts the amount of NO as a function of altitude between 85-115 km, magnetic latitude, as well as time. Principle component analysis of daily zonal mean number density of NO constitute the basis for SANOMA, much like in the older model, NOEM. SANOMA only requires the Kp-index, the solar declination, and the F10.7 cm flux for a given day as input.

References

Marsh, D.R., Solomon, S.C.: Empirical model of nitric oxide in the lower thermosphere, Journal of Geophys.
Res., 109, A07301, doi:10.1029/2003JA010199, 2004.

Stratospheric ozone feedbacks under global warming in ICON

Abstract ID : 854

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Katharina Meraner ,katharina.meraner@mpimet.mpg.de ,(Postdoctoral Researcher) ,Germany ,Hamburg ,Not Presenting[1]

Dr. Hauke Schmidt ,hauke.schmidt@mpimet.mpg.de ,(None) ,Germany , ,Not Presenting[2]

1 - Max Planck Institute for Meteorology 2 - Max Planck Insitute for Meteorology

Most comprehensive Earth system models now include more processes than ever. However, atmospheric chemistry is still computationally expensive and hence, is often neglected in Earth system models. However, chemical feedbacks induced by a change in the radiative forcing may alter the equilibrium climate sensitivity (ECS). Nowack et al. (2014; Nature Clim. Change) and Marsh et al. (2016; GRL) found large changes in the tropical upper tropospheric and lower stratospheric ozone, when interactive chemistry was included in their models. However, their results regarding the equilibrium climate sensitivity are inconclusive. Whereas Nowack et al. (2014) showed a 1 K decrease in ECS with interactive ozone, Marsh et al. (2016) found no change in ECS.
Here, we analyze the impact of stratospheric ozone feedbacks on the equilibrium climate sensitivity. We use the comprehensive Earth system model ICON with a linear ozone photochemistry parameterization. I will show the importance of the vertical model resolution in the tropical upper troposphere and lower stratosphere.

The Importance of a Properly Represented Stratosphere for Northern Hemisphere Surface Variability in the Atmosphere and the Ocean

Abstract ID : 923

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Katja Matthes ,kmatthes@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[1]

Mrs. Sabine Haasse ,shaase@geomar.de ,(None) ,Germany , ,Not Presenting[2]

1 - GEOMAR Helmholtz Centre for Ocean Research Kiel 2 - GEOMAR

Major Sudden Stratospheric Warmings (SSWs) are extreme events during Northern Hemisphere winter which do not only impact tropospheric weather for up to three months, but can also influence the oceanic circulation through wind stress and turbulent heat flux anomalies. In the North Atlantic, these anomalies have the potential to modulate deep convection in the Labrador Sea and thereby the strength of the Atlantic Meridional Overturning Circulation. In the North Pacific, which lacks deep water formation, these wind stress anomalies could directly influence the oceanic gyre circulation, which is important for redistributing heat in the Pacific basin.
To investigate the potential impact of stratospheric events on the ocean circulation in the Northern Hemisphere, the surface response of early- to mid-winter major SSWs is evaluated in two coupled climate model configurations: a stratosphere resolving (high-top) and a non-stratosphere resolving (low-top) one. In both model configurations, we detect a robust link between the occurrence of SSWs and shallower than normal mixed layer depths, an estimate for deep convection, in the North Atlantic one month after the stratospheric event. In the Pacific, significant differences between both model configurations in the months following SSWs occur in the strength of the Aleutian Low. In the low-top configuration, spuriously strong planetary wave reflection at the model lid leads to an unrealistic deep Aleutian Low after SSWs, whereas in the high-top model the Aleutian Low weakens similar to observations. Our results underline the importance of a proper representation of the stratosphere in a coupled climate model for a consistent surface response in both, the atmosphere and the ocean.

Preliminary results of the observation for whole atmosphere with the atmospheric profiling synthetic observation system(APSOS)

Abstract ID : 955

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Daren Lu ,ludr@mail.iap.ac.cn ,(None) , , ,Not Presenting[1]

Dr. Weilin Pan ,weilinpan@mail.iap.ac.cn ,(None) ,China , ,Not Presenting[2]

Dr. Yinan Wang ,wangyinan@mail.iap.ac.cn ,(None) ,China , ,Not Presenting[2]

Prof. Jinli Liu ,jliu@mail.iap.ac.cn ,(None) ,China , ,Not Presenting[2]

1 - None 2 - Institute of Atmospheric Physics, Chinese Academy of Science 3 - Institute of Atmospheric Physics, Chinese Academy of Science 4 - Institute of Atmospheric Physics, Chinese Academy of Science

To understand the whole neutral atmosphere and the coupling from lower to upper atmosphere, a synthetic system called "Atmospheric Profiling Synthetic Observation System (APSOS)" has been funded by the National natural Science Foundation of China (NSFC) since 2012. It is a system mainly consisted of five lidars devoting to observe the vertical structure of atmospheric temperature, wind, air density, water vapor, ozone, CO_2, SO_2, NO_2, aerosol, cirrus cloud, and sodium layer with high vertical and temporal resolution, a W-band Doppler dual polarized radar, a THz radiometer, and a composite optical receiving telescope with equivalent diameter of 2-meter. Seven research institutes and universities have been engaged in this project.

Since late 2016 APSOS has been completed the development of each unit. In 2017, APSOS will fulfill the system tests and the whole system will begin operating. In this paper, we will present the system techniques, data and retrieval system, preliminary results of the atmospheric vertical structure of temperature, water vapor, GHGs, high clouds, ozone, aerosols, as well as wind profiles from the troposphere to mesopause.

The South Georgia Gravity Wave Experiment (SG-WEX): investigating the small island problem

Abstract ID : 681

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Tracy Moffat-Griffin ,tmof@bas.ac.uk ,(Scientist) ,United Kingdom ,Cambridge ,Not Presenting[1]

Dr. Corwin Wright ,c.wright@bath.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Prof. Nicholas Mitchell ,N.J.Mitchell@bath.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. John King ,jcki@bas.a.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr. Steve Colwell ,src@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Andrew Moss ,andrew.moss@bath.edu ,(None) ,United Kingdom , ,Not Presenting[2]

1 - British Antarctic Survey 2 - Bath University 3 - Bath University 4 - British Antarctic Survey 5 - British Antarctic Survey 6 - Bath University

Recent studies have shown that isolated mountainous islands in regions of strong winds can be intense sources of gravity waves that can have climatologically-significant effects on atmospheric circulation. However, most climate and numerical weather prediction models cannot accurately model waves from such small, intense island sources because the islands are too small compared to the resolution of the models - this is the "small island problem".

The South Georgia Gravity Wave Experiment (SG-WEX) is a NERC funded observational and modelling experiment to determine the nature and impacts of gravity waves generated by South Georgia (a small mountainous island in the Southern Ocean). It is a collaboration between Bath University, BAS, Leeds University and the Met Office.
Two month-long radiosonde campaigns were conducted from South Georgia in 2016 to examine the gravity wave field in the troposphere and lower stratosphere. The results from these two campaigns are presented in this talk alongside model results.
The radiosonde results show a marked increase in gravity wave activity in the wintertime compared to summertime in terms of gravity wave energy density and momentum fluxes. There is also a marked difference in the proportion of upward and downward propagating waves seen in the two campaigns. The reasons for these differences are explored and the results explained in reference to the likely different sources for gravity waves in these two seasons.

A sensitive study of net solar irradiance at the surface in the presence of distinct cloud types

Abstract ID : 752

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Marcia Yamasoe ,marcia.yamasoe@iag.usp.br ,(Associate Professor) ,Brazil ,São Paulo ,Presenting[1]

Mr. Jorge Rosas ,jrosas43@gmail.com ,(None) ,Brazil ,São Paulo ,Presenting[2]

1 - Universidade de São Paulo 2 - IAG-USP

Sensitive study of global and diffuse solar irradiance variations at the surface in São Paulo city due to variations of surface, cloud and aerosol properties for different cloud types was performed. Cloud properties retrieved by CloudSat and the 1D radiative transfer model LibRadtran were used. Profiles of cloud r_e (effective radius) and LWC/ IWC (Ice or Liquid Water Content) as well as cloud height basis and vertical extension from 17 UTC overpasses were analyzed for five cloud types (Ci, As, Ac, Sc and Cu). Data from overpasses with a maximum distance of 100 km to a reference point placed at the University of São Paulo were considered. Mean climatological values for aerosol optical properties, surface albedo and ozone and water vapor column integrated data obtained for São Paulo were also used as input to the model. One of the tests consisted in adopting a homogeneous layer of cloud constituted by mean values of r_e and LWC or IWC against using the observed profile. Differences of about 15 % between irradiances modeled considering a homogeneous layer and irradiances modeled using the observed cloud profile were observed. The shortwave cloud effect at the surface for each cloud type showed higher cooling effect for Sc and Cu, with a mean deficit of -450 W/m^2 and -600 W/m^2, respectively. Higher clouds presented the minimum effect, of about -25 W/m^2 for Ci cloud type. These estimates were performed using median values of the cloud properties as input to the radiative transfer code.

Shortwave Aerosol Direct Radiative Effect at the Surface for São Paulo City – Comparison of Modeling and Measurement Results

Abstract ID : 756

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Marcia Yamasoe ,marcia.yamasoe@iag.usp.br ,(Associate Professor) ,Brazil ,São Paulo ,Presenting[1]

Prof. Nilton do Rosário ,niltoncvbr@gmail.com ,(None) ,Brazil , ,Presenting[2]

1 - Universidade de São Paulo 2 - Universidade Federal de São Paulo

Downward solar global irradiance measurements at the surface are continuously performed at São Paulo city (-23.55°, -46.73°), since 2004, every minute. AERONET (Aerosol Robotic Network) provides retrievals of aerosol optical depth (AOD), size distribution, complex refractive index, asymmetry parameter and single scattering albedo (ssa), since 2000. AOD retrievals are available at least every 15 minutes in cloud free conditions. Intensive properties, by contrast, are available only when the solar zenith angle is around 60°. For ssa, retrievals are available for measurements performed under AOD at 440 nm above 0.4. Such restrictions limit the atmospheric optics characterization to numerically estimate the aerosol direct effect at the same time resolution as the irradiance measurements. In order to verify our ability to numerically estimate the shortwave aerosol direct radiative effect using AERONET fully and partially available optical properties retrievals as input to a radiative transfer code, simulations performed with LibRadtran are compared with downward irradiance measurements. Three sets of data were compared separately: instants when all aerosol properties from AERONET and irradiance measurements were available; cases when only ssa was unavailable and mean values of the refractive index were used as input to a Mie code to estimate ssa; cases when both AOD was interpolated and mean values of the aerosol intensive properties were used as input to the code. When all aerosol optical properties from AERONET were available, a least square linear fit between measured versus calculated data resulted in a slope of 1.002(8), an offset of -12.3(2.1) Wm^{-2}, a coefficient of determination equal 0.99, bias of 6.2 Wm^{-2} and root mean squared error of 13.4 Wm^{-2}. Values in parentheses represent the uncertainty of the parameters. For the second analysis, ssa mean values were estimated using monthly mean values of the complex refractive index and the retrieved size distribution. In this case, the slope was 0.991(4), the offset -16.0 (1.2) Wm^{-2}, the bias 19.2 Wm^{-2}, the root mean squared error 23.4 wm^{-2} and the coefficient of determination was also 0.99. Results for the third set of comparison are still preliminary.

Comprehensive Dam Rehabilitation Assessment in South Korea for Considering Climate change

Abstract ID : 351

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Young-Il Moon ,ymoon@uos.ac.kr ,(Professor) ,South Korea ,Seoul ,Not Presenting[1]

Mr. Ji-Hyeok Choi ,chjh0212@uos.ac.kr ,(None) ,South Korea ,Seoul ,Not Presenting[2]

Mr. Min-Seok Kim ,sharpkms@uos.ac.kr ,(None) ,South Korea , ,Not Presenting[3]

Mr. Ho-Young Kang ,yain@uos.ac.kr ,(None) ,South Korea , ,Not Presenting[3]

1 - Univ. of Seoul 2 - None 3 - Urban Flood Research Institute 4 - Urban Flood Research Institute

The fluctuation of water quantity entering dams have grown recently, due to the increase of intensity and frequency of torrential rain along with the growing scale of typhoons. More frequent cases of extreme flooding or drought has been reported by cause of the growth of water entering the dams. Such changes have produced more difficulties in managing the water. Therefore, the need of preparing countermeasures is urgent. Unfortunately, there hasn't been enough studies that address dam rehabilitation that take climate change into consideration. Acknowledging the overall conditions along with the stalled development of new water resources and the aging of dams, there must be a full scale rehabilitation review on existing dam facilities. In order to prepare for complex safety issues that could arouse from such circumstances, this study consists the development of evaluating equipment for the rehabilitation of dams adapting to climate change; and the comprehensive dam rehabilitation assessment of South Korea.

Heat stress projections for South America based on CMIP5 Earth System Models

Abstract ID : 511

Conflict Declaration : None

Content Motivation : None

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Dr. Marcelo de Paula Correa ,mpcorrea@unifei.edu.br ,(Associate Professor) ,Brazil ,Itajuba ,Not Presenting[1]

Mr. Plinio Marcos pliniobsouza@yahoo.com.br ,pliniobsouza@yahoo.com.br ,(None) ,Brazil , ,Not Presenting[1]

Dr. Roger Rodrigues Torres ,torres.fisico@gmail.com ,(None) ,Brazil , ,Not Presenting[1]

1 - Federal University of Itajuba 2 - Federal University of Itajuba 3 - Federal University of Itajuba

Higher temperatures, water availability scarcity and changes on atmospheric patterns are likely consequences of the climate changes throughout this century. The variations on these parameters will probably contribute to worsen heat stress scenarios that are directly related to the health conditions and work performance. In this work, we evaluate the behaviour of nine heat stress indicators (HSI) based on air temperature, humidity, wind velocity and solar radiation conditions. In order to compare the HSI, we classified each indicator in 5 categories of heat stress level: c0 (no stress), c1 (low), c2 (medium), c3 (high), and c4 (extreme). The last two categories indicate worry conditions for the human health. Eight climate models of the Coupled Model Intercomparison Project Phase 5 (CMIP5) have provided historical (1950-2006) and future (2071-2100) climate information. We also used observations of the present climate (1979-2005) that were used to validate the CMIP5 historical simulations. Our study has performed a sensibility analysis of each model and index. Results show a significant decrease of c0, with a consequent increase of c1 to c4 conditions at the end of this century, mainly in central part of the South American continent. The c3 and c4 conditions were observed in almost 25% of the simulations for the Amazon region by the end of this century. On the other hand, western side of South America, including Andean sites, should show an increase of c1 and c2 categories. Despite the uncertainties of the climate models and the necessary care to conduct a multidisciplinary study of this nature, this study can be an important tool for mitigation and adaptation policies.

Influence of atmospheric model resolution on numerical representation of Maputo province gale on October of 2016

Abstract ID : 671

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Luis Chongue ,chongue.chongueluis@gmail.com ,(Undergraduate student) ,Japan ,Kyotanabe ,Not Presenting[1]

Dr. Shozo Yamane ,syamane@mail.doshisha.ac.jp ,(None) ,Japan , ,Not Presenting[1]

1 - Doshisha University 2 - Doshisha University

Mozambique is located in the southeast in the African Continent and have been suffering from the effects of severe weather events such as, heavy rain, strong wind and thunderstorm, which generally occur in summer or rainy season (October to March), most likely bringing severe damages to the country. Recently, on October 24, 2016, Maputo city and province, the southern part of Mozambique, were affected by very strong wind (up to 50km/h) accompanied by rain and thunderstorm, where about 22460 people, 4492 families, 4018 houses, 65 schools and 7 hospitals were strongly affected, 117 people were injured, 4 died, and 474 houses were completely destroyed. This event and many similar extreme phenomena such as gale, were not well predicted by Nacional Institute of Meteorology of Mozambique (INAM), particularly the maximum wind speed. The Mozambicans weather forecasters have been making effort to find out the reason why these events were frequently missed, starting by questioning the horizontal resolution of atmospheric model used at INAM. The main objective of this study is to investigate the linkage between atmospheric instability and wind speed, and find out how far the quality of weather forecast depends on the horizontal resolution of atmospheric model in Mozambique. In this regard, numerical simulations for the Maputo province gale on October 24, 2016 were conducted with WRF (The Weather Research & Forecasting Model) in three different resolutions (18km, 6km and 2km), and CAPE, Total Totals, K-index and wind speed were analyzed. The JRA-55 (Japanese 55-year Reanalysis data) were also used for the comparison. The results have shown the strong dependence of the wind speed on the atmospheric instability which means that the indices of instabilities are possible to detect the occurrence of gale. The higher resolution is required to predict more accurately extreme meteorological phenomena such as gales in Mozambique, since the experiments have shown that the accuracy of gale detection decreases drastically when the resolution is decreased.

Investigation the Bias Correction of Satellite Data in Regional Numerical Weather Simulation

Abstract ID : 1039

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Shen-Cha Hsu ,weiny1992@gmail.com ,(None) ,Taiwan , ,Not Presenting[1]

Prof. Chian-Yi Liu ,cyliu@csrsr.ncu.edu.tw ,(Associate Professor) ,Taiwan ,Taoyuan ,Not Presenting[2]

1 - National Central University 2 - National Central University, TAIWAN

The numerical weather prediction (NWP) model help people to understand atmospheric phenomenon and avoid disasters losses. The accuracy of NWP forecast performance is sensitive to its initial and boundary conditions. It is known that satellite observations can provide the observation in remote area such ocean and polar regions. Therefore, the use of satellite data in NWP model is expected to improve its forecast skills.

On the other hand, the satellite data, for example the retrieved profiles, may exist a various degree of uncertainties. It is critical to address the bias issue before the use of them in NWP model. In this study, we adopt the Weather Research and Forecasting (WRF) model and the community Gridpoint Statistical Interpolation (GSI) data assimilation system to evaluate the use of microwave and infrared retrieved sounding for severe precipitation case at Taiwan. The preliminary results indicate a positive impact when the bias information is handling properly. The quantitative precipitation forecasts (QPFs) skills are also improved due to the implement of new bias correction method.

Analysing the projected change of climate extremes using regional model simulation results

Abstract ID : 1459

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Judit Bartholy ,bartholy@caesar.elte.hu ,(None) ,Hungary , ,Presenting[1]

Dr. Rita Pongracz ,pongracz.rita@gmail.com ,(Assistant professor) ,Hungary ,Budapest ,Not Presenting[1]

Dr. Ildiko Pieczka ,pieczka@nimbus.elte.hu ,(None) ,Hungary , ,Not Presenting[1]

Ms. Karolina Szabone Andre ,karol@nimbus.elte.hu ,(None) ,Hungary , ,Not Presenting[1]

1 - Eotvos Lorand University 2 - Eotvos Lorand University 3 - Eotvos Lorand University 4 - Eotvos Lorand University

The simulations of model RegCM are used to evaluate the past and future trends of extreme temperature and precipitation conditions in the MED-44 CORDEX area including the extended Mediterranean region of Europe (30°-50°N, 10°W-45°E). In addition to the past historical period (1951-2005), simulations continue to 2006-2100 with two very different scenarios (RCP4.5 and RCP 8.5 - based on the radiative forcing change by 2100) using HadGEM2 global model outputs as initial and lateral boundary conditions (ICBC). First, RegCM4.3 is run using 50 km as horizontal resolution. Then, on the basis of these 50 km RegCM runs we aim to provide detailed regional scale climate projection results for Central/Eastern Europe. For this purpose, further downscaling is necessary using 10 km as horizontal resolution for a smaller domain. These experiments can serve as the basis of the national climate and adaptation strategies for detailed regional scale analysis and specific impact studies.

Our analysis compares the estimated temperature and precipitation changes with special focus on extreme conditions for the following 10 subregions of the MED-44 CORDEX area: Iberian Peninsula, Apennine Peninsula, Balkan Region, Asia Minor, East European Plain, Middle European Plain, Carpathian Basin, Carpathian Mountains, Alps, Western Europe.

Radiative Effects on Heavy Rainfall during a Landfall of Typhoon Fitow (2013)

Abstract ID : 39

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Xiaofan Li ,xiaofanli@zju.edu.cn ,(Professor) ,China ,Hangzhou ,Not Presenting[1]

1 - None

The three-dimensional Weather Research and Forecasting (WRF) model is used to conduct sensitivity experiments of Typhoon Fitow in 2013 during its landfall. Surface rainfall and heat budgets as well as the vertical profiles of stability and vertical velocity are analyzed to examine physical processes responsible for radiative effects on rainfall. The inclusion of radiative effects of liquid clouds suppresses radiative cooling in liquid cloud layers via reducing outgoing radiation to ice cloud layers, whereas it enhances radiative cooling in ice cloud layers through trapping less radiation from liquid cloud layers. The enhanced radiative cooling decreases from ice cloud layers to liquid cloud layers. The suppressed stability and vertical mass convergence increase. Thus, heat divergence is weakened to warm the atmosphere, which reduces net condensation and rainfall. The inclusion of radiative effects of ice clouds suppressed radiative cooling by reducing outgoing radiation. The suppressed radiative cooling reduces from ice cloud layers to liquid cloud layers and the suppressed instability and vertical mass convergence decreases when radiative effects of liquid clouds are present. As a result, heat divergence is strengthened to cool the atmosphere, which increases net condensation and rainfall. The suppressed radiative cooling increases temperature and reduces net condensation and rainfall when radiative effects of liquid clouds are absent.

A Three-Dimensional WRF Modeling Study of Convective-Stratiform Rainfall during a Landfall of Typhoon Fitow (2013)

Abstract ID : 41

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Guoqing Zhai ,zhaigq@zju.edu.cn ,(Professor) ,China ,Hangzhou ,Not Presenting[1]

1 - Zhejiang University

EmptIn this study, convective-stratiform rainfall separation scheme is developed based on a three-dimensional surface precipitation budget equation using the WRF model simulation of Typhoon Fitow (2013). The results show that water vapor convergence moistens local atmosphere and support hydrometeor divergence, and maximum rainfall corresponds to water vapor and hydrometeor convergence and local atmospheric drying. The separation results are verified by analyzing vertical velocity and cloud microphysical budgets. Mean ascending motions are prevailing throughout the troposphere over convective rainfall regions, whereas mean descending motions occur below 5 km and mean ascending motion occur above over stratiform rainfall regions. The frequency distribution of vertical velocity shows that vertical velocity has a wide distribution with the maximum values up to 13 m s-1 over convective regions, whereas it has a narrow distribution with absolute values confined within 7 m s-1 over stratiform region. Liquid cloud microphysics is dominant over convective regions whereas ice cloud microphysics is dominant over stratiform regions. The physical characteristics of the convective-stratiform rainfall in the three-dimensional framework conform generally to those from the two-dimensional framework.y

Catastrophic heavy rains that forming floods in the South of Ukraine

Abstract ID : 64

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Valeriya Ovcharuk ,valeri.o@mail.ru ,(None) ,Ukraine ,Odessa ,Not Presenting[1]

Mr Nataliya Kichuk ,kichuknatali@ukr.net ,(None) ,Ukraine , ,Not Presenting[2]

Mr Eugene Gopchenko ,gidro@odeku.edu.ua ,(None) ,Ukraine , ,Not Presenting[2]

1 - Odessa State Environmental Universuty 2 - Odessa State Environmental University 3 - Odessa State Environmental University

In terms of climate change in recent years in Ukraine there is a significant decrease in the rate of cyclones, especially in the south, changing areas of their formation, the trajectory of the movement, which leads to a redistribution of precipitation in the territory, including an increase in the probability of torrential rainfall.
One of the most important components forming the hydrological regime of rivers it is precipitation. The area of study is characterized by insufficient moisture. Annual precipitation decreases from east to south of 510 to 441 mm. Precipitation variability differ significantly for years. In dry years the annual amount ranging from 174 mm (Kherson, 1921) to 273 mm (Zaporozhye, 1951). Maximum rainfall for the year may reach 783 mm (Ismail, 1966). During the year, the largest amount of rainfall occurs in June and July, when their average values ??are 61-85 mm, reaching in some years up to 154-220 mm; the lowest - in March and October (22-36 mm). In certain periods could be observed drought. Forming the catastrophic flood of rain origin associated with the heavy rains. In regulatory documents forming storm floods associated with maximum values ??of precipitation per day. In territory South of Ukraine its values ??fluctuate quite widely - from 52 mm (Korotne) to 164 mm (Caushani). The analysis shows that most daily maxima observed within 80-100 mm (56.7%). But the peaks are also observed and for various years. Most daily highs observed in the time interval 1961-1990 years. (84.4%). In the last twenty years of outstanding daily precipitation occurred only in 12% of the total number.
To analyze and generalization of values of daily maximum of precipitation was used the data of observations of 72 meteorological stations located in the study area. Maximum daily rainfall and runoff layers 1% probability of exeedance obtained by applying the method recurrence of extrema and refined through method of collective analysis As a result for calculation of runoff the small rivers of the South of Ukraine it is recommended to accept maximum daily rainfall 1% probability of exeedance equal 95mm.

Verification of Probabilistic Quantitative Precipitation Forecast on Different Type Typhoons in Taiwan

Abstract ID : 119

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Hsu-Feng Teng ,spursteg@nat.as.ntu.edu.tw ,(None) ,Taiwan ,Taipei ,Presenting[1]

Dr. Cheng-Shang Lee ,cslee@ntuedu.tw ,(None) ,Taiwan , ,Not Presenting[1]

1 - None 2 - None

Typhoon forecast techniques, particularly for mesoscale convective features, are critical to rainfall forecast and disaster management. To consider the influence of topographical lifting on the typhoon circulation, a typhoon rainfall climatology model had been developed and used in real-time operation practice. However, the mesoscale convective features could not be captured well in the typhoon rainfall climatology model. An ensemble meteorological modeling system has been developed after the Morakot (2009) disaster. This system is one-way coupled with a hydrological model to predict typhoon rainfall and flood responses in a mountainous watershed. In addition, the ensemble meteorological model framework includes perturbations of the initial conditions, data analysis methods, and physical parameterizations. Conversely, to quantify the uncertainty of the ensemble precipitation forecast, the probabilistic quantitative precipitation forecast (PQPF) is developed. In this study, the reliability diagram, relative operating characteristic, Brier score, and ranked probability score are used to verify the probabilistic rainfall forecast. The PQPFs of different type typhoons, including the different tracks, intensities, sizes, and motion speeds, are analyzed by the probabilistic verifications. As a result, the PQPF of the typhoon with smaller radius during 2011-2016 is usually overestimated for high probability value. Because the track uncertainty of the northward typhoon is more significant, the averaged error of PQPF for the northward typhoon is larger than the westward typhoon. The different motion speeds of typhoon cause a west-east dipole pattern of the probabilistic error distribution in Taiwan. However, the influence of typhoon intensity on the PQPF is non-significant in this ensemble system.

Case study of the cause and the dynamic structure for a small-scale snowstorm event associated with a cyclone

Abstract ID : 247

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Cheng fang Yang ,cf_yang70@hotmail.com ,(None) ,China , Jinan ,Shandong Province ,Not Presenting[1]

1 - Shandong Metereological Observatory

Abstract: This study investigates the cause and dynamitic structure on a small-scale snowstorm event occurred in Shandong peninsula, east China with Doppler radar, profile, automatic station, routine sounding and surface observation data. The results are as follows. (1) Precipitation occurred in two stages: the first weak precipitation was typical snowstorm caused by Huanghe cyclone with the characteristic of weak snowfall and north-east radar echo, and the second strong precipitation one behind the cyclone was ocean-effect snowstorm with character of strong snowfall and south-west radar echo.(2) Favorable synoptic situation led to the occurrence of the first stage snow, such as obvious trough, cyclonic circulation, southwestern low-level jet and surface cyclone. Its vapor came from the South China Sea. The snowfall was distributed to ahead of southwestern low-level jet on the right and eastern side of surface cyclone. (3) By contrast, the second precipitation occurred after trough passed Shandong peninsula and cyclone passed through Bohai straight to Huanghai sea. Cold air intruded into Shandong peninsula from Bohai straight and Huanghai sea. North-east wind was prevailing and its speed was stronger than north-west wind, which brought rich water vapor and heat. Snowfall distributed within north-east wind.(4) the structure of wind field in the lower troposphere was different during ocean-effect snowstorm. There was mid-γ scale low circulation beside north coastal area in Shandong peninsula, and radar radial velocity shows a meso-βvortex in low level. Meanwhile, there was a shear between the south-east wind and north-west wind near the east coastal area. During strong snowfall, a shear between the north-east and north-west wind was found in boundary layer. Both the low circulation and shear are the favorable dynamic factors.
As a result, the case implies that remarkable difference between Bohai straight/ Huanghai Sea and Bohai Sea ocean-effect snowstorm, the former is behind Huanghe cyclone, and the latter is common and typical, in terms of wind field structure, motion of radar echo and precipitation distribution.
Key words: Huanghe cyclone, Snowstorm, Ocean-effect, Analysis of observation data

Analysis on the Variation Characteristics of Summer–Autumn Precipitation over the Surrounding Regions of Southwest China and the Corresponding Circulation

Abstract ID : 358

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Xiuhua Zhou ,xiuxiu000945@163.com ,(None) ,China ,Nanning ,Presenting[1]

Mr. Ziniu Xiao ,xiaozn@lasg.iap.ac.cn ,(None) ,China , ,Not Presenting[2]

Ms. Hong Lu ,luhong0908@163.com ,(None) ,China , ,Presenting[3]

1 - Guangxi Climate Center, CHINA 2 - State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), Institute of Atmospheric Physics, Chinese Academy of Sciences 3 - Guangxi Climate Center

The temporal and spatial characteristics of precipitation over Southwest China and the surrounding regions were analyzed using observation data from 124 stations in Yunnan Province and high-resolution Climatic Research Unit precipitation data. The precipitation was analyzed for summer and autumn. The relationship between precipitation and monsoon activity, and the circulation background during drought and flood periods were also analyzed to investigate the possible mechanisms affecting the decadal variabilities. The results show that the spatial distribution of precipitation in these areas evolve with the seasons, with a relatively small value over Southwest China. Precipitation in all seasons has obvious interannual variability and interdecadal oscillation characteristics. By further analyzing the decadal-scale period of precipitation in summer and autumn, this study shows that the continuous drought that has occurred in Southwest China in recent years is likely caused by the decadal-scale periodic negative phase cooperation of precipitation in summer and autumn. In addition, the precipitation reduction is associated with the weaker summer monsoon activity and its shorter duration. There are significant differences in the atmospheric circulation during drought periods and flood periods in summer and autumn, respectively. Anomalous northerly winds appear in the lower troposphere during the drought period, and anomalous anticyclonic circulation occurs around the Tibetan Plateau in the upper troposphere, and vice versa.

Sensitivity of simulated summer monsoonal precipitation in Langtang Valley, Himalaya to cloud microphysics schemes in WRF

Abstract ID : 377

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Andrew Orr ,anmcr@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Pranab Deb ,prab@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Walter Immerzeel ,w.w.immerzeel@uu.nl ,(None) ,Netherlands , ,Not Presenting[3]

Dr. Emily Collier ,emily.collier@fau.de ,(None) ,Germany , ,Not Presenting[4]

Dr. Constantino Listowski ,constantino.listowski@latmos.ipsl.fr ,(None) ,France , ,Not Presenting[5]

Dr. Maugaux Couttet ,margaux.couttet@gmail.com ,(None) ,Switzerland , ,Not Presenting[6]

Dr. Dan Bannister ,danban70@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - British Antarctic Survey 2 - British Antarctic Survey 3 - University of Utrecht 4 - Friedrich-Alexander University (FAU) Erlangen-Nürnberg 5 - Laboratoire Atmosphères, Milieux, Observations Spatiales 6 - École Polytechnique Fédérale de Lausanne 7 - British Antarctic Survey

A better understanding of regional-scale precipitation patterns in the Himalayan region is required to increase our knowledge of the impacts of climate change on glaciers, snowpacks, and downstream water availability. This study examines the impact of four cloud microphysical schemes (Thompson, Morrison, WRF Single-Moment 5-class (WSM5), and WRF Double-Moment 6-class (WDM6)) on summer monsoon precipitation in the Langtang Valley, Himalayas, as simulated by the Weather Research and Forecasting (WRF) model at 1 km grid spacing for a ten-day period. The model results are evaluated through a comparison with precipitation and radiation measurements made at two observation sites located on the Langtang Valley floor and on the adjacent mountain slopes. Additional understanding is gained from a detailed examination of the microphysical characteristics simulated by each scheme, which are compared with measurements of cloud properties from the DARDAR (raDAR/liDAR) satellite product, and the roles of large and small-scale forcing.

The choice of microphysics scheme has a strong influence on simulated precipitation in the Langtang Valley, with large inter-model differences and significantly different day-to-day variability compared to measurements. Overall, the Morrison scheme showed the best agreement in terms of both precipitation and radiation over the ten-day period (consistent with its double-moment prediction of every ice-phase hydrometeor). Analysis of hydrometeors from each of the schemes suggests that 'cold-rain processes' are a key precipitation formation mechanism, which is also best represented by

the Morrison scheme. As well as microphysical structure, both large-scale and localised forcing is also important.

Impact of resolution on the representation of precipitation variability associated with the ITCZ

Abstract ID : 409

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Marc De Benedetti ,marc.debenedetti@mail.utoronto.ca ,(Graduate Student) ,Canada ,Mississauga ,Not Presenting[1]

Prof. G.W.K. Moore ,gwk.moore@utoronto.ca ,(None) ,Canada , ,Not Presenting[1]

1 - University of Toronto 2 - University of Toronto

The intertropical convergence zone (ITCZ) is a band of precipitation that oscillates seasonally about the equator and is mainly caused by the convergence of trade winds. The ITCZ is responsible for the majority of the weather and climate in the equatorial region, as well as contributing to tropical-midlatitude interactions through the forcing of planetary waves. Therefore, being able to better determine its location, variability, and structure is important for describing atmospheric processes on a local and global scale. Being a primarily oceanic phenomenon, data on its structure and evolution is limited, and much of our knowledge regarding it has been derived from models including reanalysis datasets. The precipitation associated with the ITCZ is convective in origin, and thus it is unclear how model resolution impacts its representation. Here we use a novel technique that involves the calculation of the decorrelation length scale (DCLS) for precipitation to assess the role that model resolution plays in the representation of the ITCZ's structure. The technique was applied to the ERA-I Reanalysis (resolution ~80km), as well as a set of hindcasts, known as the Athena datasets, performed with the same model but with resolutions ranging from 16 km to 160 km. All datasets were able to represent the mean structure and seasonal evolution of the ITCZ. The DCLS analysis for the ERA-I not only resolves the mean structure but also reveals topographical effects around Hawaii as well as a noticeable effect that the upwelling cold water in the region where marine stratocumulus clouds (MSC) form along the west coast of South America have on the scale of the precipitation. The lowest resolution Athena dataset was not able to resolve these structures. The DCLS analysis for the higher resolution Athena datasets demonstrated a significant increase in fine-scale structures and was able to capture many topographical effects that are unseen in the lower resolutions, such as those associated with the MSC. The DCLS technique demonstrated a remarkable ability to provide information about the variability and structure of the precipitation, while providing insight into the role that model resolution plays in the representation of the ITCZ.

Rainfall monitoring based on the time-varying attenuation of microwave

Abstract ID : 544

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Min-Seong Kim ,givemeasong@naver.com ,(Full Time Researcher) ,South Korea ,Busan ,Presenting[1]

Prof. Byung Hyuk Kwon ,bhkwon@pknu.ac.kr ,(None) ,South Korea , ,Not Presenting[2]

Mr. Park Sa Kim ,withlord56@naver.com ,(None) ,South Korea , ,Not Presenting[2]

Mr. Sang Jin Kim ,sjgreat373@gmail.com ,(None) ,South Korea , ,Not Presenting[2]

Mr. Won Gi Jo ,sgm999@naver.com ,(None) ,South Korea , ,Not Presenting[2]

Mr. Daeil Seo ,sdi1588@naver.com ,(None) ,South Korea , ,Not Presenting[2]

Mr. Kyung Hun Lee ,dwdw1678@nate.com ,(None) ,South Korea , ,Not Presenting[2]

Mr. Kwang-Ho Kim ,goodss777@naver.com ,(None) ,South Korea , ,Not Presenting[8]

1 - Geo-Science Institute / Pukyong National University 2 - Pukyong National University 3 - Pukyong National University 4 - Pukyong National University 5 - Pukyong National University 6 - Pukyong National University 7 - Pukyong National University 8 - Pukyong National University

In many countries, the study on the precipitation is being conducted because frequent droughts and floods are a major threat to the economy and population. Especially in many African countries, even though rainfall monitoring needs are very high, the number of rain gauge is decreasing and the weather radar is too expensive to operate. On the other hand, as the microwave links for the communication network is increasing, the rainfall estimation based on the microwave link will be a very useful technology. Using the rainfall-induced attenuation of the microwave, the path-average rainfall intensity can be accurately estimated in the microwave link section. Among Korea Telecom repeater networks with more than 50 links, which was built in the Seoul metropolitan area, we estimated the path-average rainfall intensity and the time-varying attenuation baseline of 10 links with a distance of 5-30 km, a frequency of 6-11 GHz and a time resolution of 15 seconds. In four cases of weak rainfall from April to December 2016, the accuracy of the time-varying attenuation baseline was 80%, and 93% in 7 cases with strong rainfall. This baseline information plays important role to detect very weak rain which is not recorded in the rain gauge. The RMSE of the 1-minute average between the path-average rainfall intensity and the rain gauge was 2.3 mm/h. The high temporal resolution data made good agreement with the surface rain gauge data when compared with the RMSE of 15-minute average reported in Europe.

Investigation of riming within mixed-phase stratiform clouds using Weather Research and Forecasting (WRF) model

Abstract ID : 561

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Zhaoxia Hu ,huzx@mail.iap.ac.cn ,(Associate Prof.) ,China ,Beijing ,Not Presenting[1]

Dr. Tuanjie Hou ,houtj@mail.iap.ac.cn ,(None) ,China , ,Not Presenting[2]

Prof. Hengchi Lei ,leihc@mail.iap.ac.cn ,(None) ,China , ,Not Presenting[2]

1 - Institute of Atmospheric Pyhsics, CAS, P.R.China 2 - Institute of Atmospheric Physics, Chinese Academy of Sciences 3 - Institute of Atmospheric Physics, Chinese Academy of Sciences

In this study, we investigated stratiform precipitation associated with an upper-level westerly trough and a cold front over northern China between 30 Apr. and 1May 2009. We employed the Weather Research and Forecasting (WRF) model (version 3.4.1) to perform high-resolution numerical simulations of rainfall. We also conducted simulations with two microphysics schemes and sensitivity experiments without riming of snow and changing cloud droplet number concentrations (CDNCs) to determine the effect of snow riming on cloud structure and precipitation. Then we compared our results with CloudSat, Doppler radar and rain gauge observations. The comparison with the Doppler radar observations suggested that the WRF model was quite successful in capturing the timing and location of the stratiform precipitation region. Further comparisons with the CloudSat retrievals suggested that both microphysics schemes overestimated ice and liquid water contents. The sensitivity experiments without riming of snow suggested that the presence or absence of riming significantly influenced the precipitation distribution, but only slightly affected total accumulated precipitation. Without riming of snow, the changes of updrafts from the two microphysics schemes were different due to a different consideration of ice particle capacitance and latent heat effect of riming on deposition. While sensitivity experiments with three different CDNC values of 100, 250 and 1000 cm^{-3} suggested variations in snow riming rates, changing CDNC had little impact on precipitation.

Climate Indices as indicators of desertification in Argentina

Abstract ID : 822

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Moira Doyle ,doyle@cima.fcen.uba.ar ,(Scientist) ,Argentina ,Buenos Aires ,Presenting[1]

Miss. Giselle Marincovich ,gisellemarincovich93@gmail.com ,(None) ,Argentina , ,Not Presenting[2]

1 - Dto Ciencias de la Atmósfera y los Océanos- University of Buenos Aires 2 - University of Buenos Aires

One of the UNCCD priorities is the necessity to create indices to help identify potential desertification risk. Root causes of desertification include climatic fluctuation and adaptation of drylands ecosystems due to limited fresh water supplies, and erratic rainfall leading to seasonal variability, annual and decadal fluctuations that may cause droughts and flooding events. Drylands cover a large extension of Argentina and 75% of the country is affected by a desertification process. Dry periods have increased in the arid diagonal crossing the country from northwest to southeast and extreme precipitation events have become more frequent and intense to the east. These droughts could further intensify in 21st century under scenarios of increased evapotranspiration, decreased precipitation or a combination of both. These factors indicate there is a high probability of an acceleration of processes leading to desertification. Precipitation seasonality and the Aridity Index are among the climatic indicators used to monitor desertification. CMIP5 global climate model results for historical 1900-2010 time period are used to validate the ability of models to represent the present distribution of drylands and potential areas to be affected by desertification processes. The Precipitation Seasonality Index and the Aridity Index are calculated for 20 models and CRU data used as observations to validate the models. Decadal variations and differences between the beginning and the end of the 20th century are studied to understand the degree and extent of advance of desertification due to climate factors in the country and which is the contribution of climate change, in particular how changes in temperature have contributed and to what point changes in precipitation modify the desertification process.

Dynamics of the Northern East Asian Monsoon Precipitation

Abstract ID : 963

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Jun-Hyeok Son ,j-hson@pusan.ac.kr ,(Student) ,South Korea ,Busan ,Presenting[1]

Prof. Kyong-Hwan Seo ,khseo@pusan.ac.kr ,(None) ,South Korea , ,Not Presenting[1]

1 - Pusan National University 2 - Pusan National University

This work provides a new perspective on the major factors controlling the East Asian summer monsoon (EASM). Dominant modes of the EASM are revealed from the variability of large-scale air masses discerned by equivalent potential temperature, and are found to be dynamically connected with the anomalous sea surface temperatures (SSTs) over the three major oceans of the world and their counterparts of prevailing atmospheric oscillation or teleconnection patterns. Precipitation over Northeast Asia (NEA) during July is enhanced by the tropical central Indian Ocean warming and central Pacific El Niño-related SST warming, the northwestern Pacific cooling off the coast of NEA, and the North Atlantic Ocean warming.

Impacts of Convective Triggering on the Coupling of Convection and Diurnal Propagating Systems over the Southern Great Plains in CAM5

Abstract ID : 1413

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Yi-Chi Wang ,yichiwang@gate.sinica.edu.tw ,(Postdoctoral Research Fellow) ,Taiwan ,Taipei city ,Not Presenting[1]

1 - Research Center for Environmental Changes

In this study, we investigated the impacts of the triggering function of the deep convection scheme on diurnal precipitating systems on the South Great Plains with the Community Atmospheric Model (CAM) version 5 (Neale et al., 2010). CAM5, like many other up-to-date climate model, has not been able to correctly capture the diurnal convection over the islands and those propagating seaward from the island edges.
To reduce this bias, we adopted the idea from the analysis in Wang et al. 2015. In that study, we found that the parameterized convective triggering in CAM5 needs to recognize the low-level inhomogeneity in the troposphere to simulate the diurnal precipitating system over the Southern Great Plains of the United States. In this study, we apply the improved parameterized triggering to the default cumulus parameterization - Zhang-Mcfarlane (ZM) scheme of CAM5 and run global-domain simulations driven by fixed sea surface temperature.
We found that the diurnal precipitating systems over the Southern Great Plains becomes the dominant diurnal mode in the simulations. We examined and validate the performance of CAM in reproducing the nocturnal convection. Large-scale circulations suggested important from the observations and mesoscale models such as the low-level jets, mountain-plains solesoid, and mid-tropospheric disturbances are validated. This study suggests the key features for cumulus parameterization to capture the diurnal nocturnal rainfall.

Analysing projected precipitation-induced flood events on a small catchment scale

Abstract ID : 1451

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Rita Pongracz ,pongracz.rita@gmail.com ,(Assistant professor) ,Hungary ,Budapest ,Not Presenting[1]

Prof. Judit Bartholy ,bartholy@caesar.elte.hu ,(None) ,Hungary , ,Not Presenting[1]

Ms. Anna Kis ,kisanna@nimbus.elte.hu ,(None) ,Hungary , ,Not Presenting[1]

Mr. Janos Adolf Szabo ,janos.szabo@hydroinform.hu ,(None) ,Hungary , ,Not Presenting[4]

1 - Eotvos Lorand University 2 - Eotvos Lorand University 3 - Eotvos Lorand University 4 - HYDROInform

Precipitation evidently plays a driving role in the entire hydrological cycle as the main water input to the surface, which might infiltrate through the soil, or flow on the surface following the topographical constrains and ending in a large water body, such as sea or ocean. In this study, simulated runoff values are analysed in order to estimate the future local changes on a Central/Earstern European catchment, namely, the Upper-Tisza basin (with an area of 9707 km^2), which rises in the Ukrainian Carpathians and drains southwest into Hungary. For this purpose, the distributed, physically-based DIWA (DIstributed WAtershed) hydrological model is coupled with the RegCM4 regional climate model, thus providing the simulated precipitation input with a horizontal resolution of 10 km to DIWA. First, calibration and validation of DIWA distributed hydrological model are completed for the target catchment using historical meteorological and runoff data. After that, characteristics of extreme hydrological events in past and future (using new RCP scenarios) time periods for 30 years are analyzed. Finally, statistical analysis based comparison of observed-past, modelled-past and modelled-future runoff data is evaluated for the Upper-Tisza catchment. The results can be used to provide recommendations for decision makers in order to mitigate climate change induced hydrological hazards in the region.

The Effect of Climate Change on Ocean-Atmosphere Interactions in the Atlantic Basin: "New Climate" Warmed, "New Atmospheric Circulation" and "Extreme" Meteorological Phenomena

Abstract ID : 38

Conflict Declaration : None

Content Motivation : 1- To present the novelties of this work: the new forcing exerted by the atmospheric ocean warming and their interactions, 2- The evolution of the "New Climate" reheated planetary, which induces a "New Distribution" of meteorological phenomena, mainly "Extreme" phenomena. 3- To present a methodological "New Approach", enabling the scale of prediction to be extended beyond 72 hours (meteorology), and to shorten the climatological scale within 50-100 years (numerical models), To allow the decision-maker to act politically: the scale of the week, the month and the season. 4- To enrich may experiences with those of colleagues from other laboratories, which will enable us to develop a global science action.

Additional Information : None

Prof. Mohammed-Said KARROUK ,ClimDev.Morocco@gmail.com ,(Professor / Researcher) ,Morocco ,Casablanca ,Not Presenting[1]

1 - Université Hassan II

Cumulating ocean-atmospheric thermal energy caused by global warming has resulted in the reversal of the energy balance towards the poles. This situation is characterized by a new ocean-continental thermal distribution: over the ocean, the balance is more in excess than in the mainland, if not the opposite when the balance is negative inland.
Thanks to satellite observation and daily monitoring of meteorological conditions for more than ten years, we have observed that the positive balance has shifted more towards the poles, mainly in the northern hemisphere. Subtropical anticyclones are strengthened and have extended to high latitudes, especially over the Atlantic and Pacific oceans. This situation creates global peaks strengthened in winter periods, and imposes on cosmic cold the deep advection toward the south under the form of planetary valleys "Polar Vortex".
This situation imposes on the jet stream a pronounced ripple and installs a meridional atmospheric circulation in winter, which brings the warm tropical air masses to reach the Arctic Circle, and cold polar air masses to reach North Africa and Florida.
This situation creates unusual atmospheric events, characterized by hydrothermal "extreme" conditions: excessive heat at high latitudes, accompanied by heavy rains and floods, as well as cold at low latitudes and the appearance of snow in the Sahara!
The populations are profoundly influenced by the new phenomena. The socioeconomic infrastructures can no longer assume their basic functions and man when unprotected is weak and hence the advanced vulnerability of all the regions especially those belonging to poor and developing countries

This is why climate sciences must deal nowadays with short term prediction of phenomena: weekly, monthly, or seasonly a bit more advanced than meteorology (72 hours) but less advanced than climate models (50-100 years) to allow the policy makers enough time to intervene efficiently in order to protect the populations from extreme meteorological phenomena and to benefit from the opportunities of the new meteorological conditions These are the characteristics of "New Meteorological Events" resulting from the "New Atmospheric Circulation", caused by the "New planetary Climate" consequence of "Global Warming".
It is the new global challenge.

The role of air-sea interaction in regulating the Tibetan-Iranian Plateau heating effect on the Asian summer monsoon

Abstract ID : 289

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Bian He ,heb@lasg.iap.ac.cn ,(None) ,China ,Beijing ,Presenting[1]

Prof. Guoxiong Wu ,gxwu@lasg.iap.ac.cn ,(Professor) ,China ,Beijing ,Not Presenting[2]

Dr. Qing Bao ,qbao@lasg.iap.ac.cn ,(None) ,China , ,Not Presenting[1]

Dr. Yimin Liu ,lym@lasg.iap.ac.cn ,(None) ,China ,Beijing ,Not Presenting[4]

Dr. Ziqian Wang ,wangziq5@mail.sysu.edu.cn ,(None) ,China , ,Not Presenting[5]

1 - LASG/IAP 2 - LASG, Institute of Atmospheric Physics, CAS 3 - LASG/IAP 4 - LASG, Institute of Atmospheric Physics, CAS 5 - SYU

Using both Atmosphere General Circulation Model (AGCM) and Coupled General Circulation Model (CGCM), the thermal effects of the Tibetan-Iranian Plateau (TIP) on the Asian summer monsoon (ASM) are studied. The role of air-sea interaction over the IO in regulating the TIP impacts is also explored. Results suggested that through generating a low- layer cyclonic circulation and a monsoonal meridional circulation, the TIP thermal forcing can produce precipitation over northern South Asian and East Asia and reduce precipitation over the tropical IO. In CGCM, the TIP heating effect causes the sea surface temperature (SST) decrease over the north of Arabian Sea and Bay of Bengal which is due to the decrease of the surface radiation and the mixed layer horizontal advections, while the decrease of SST over the western coast of Indonesia is due to local upwelling. The SST increases over the tropical IO due to the decrease of the latent heat fluxes and over South IO due to the increase of radiation fluxes. Furthermore, the monsoon precipitation in response to the TIP heating is weaker over IO in CGCM than in AGCM due to the air-sea interactions. The air-sea interaction as a whole is to counteract the topographical heating effect via inducing a local anti-monsoonal meridional circulation, which produce more precipitation over the tropical IO and less precipitation over the south slope of Himalaya, Arabian Sea, Bay of Bengal and Sumatra. Results from numerical experiment also demonstrate that due to the air-sea interaction, the response of SST to the TIP thermal forcing presents an IO Dipole (IOD)- like pattern, which also exists in the extreme TIP thermal forcing years in the observation.

Representation of the Indian summer monsoon in an atmosphere–ocean-mixed-layer GCM

Abstract ID : 508

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Simon Peatman ,s.peatman@reading.ac.uk ,(NCAS Research Scientist) ,United Kingdom ,Reading ,Not Presenting[1]

Dr. Nicholas Klingaman ,nicholas.klingaman@ncas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

1 - NCAS Climate, University of Reading 2 - NCAS, University of Reading

The BoBBLE (Bay of Bengal Boundary Layer Experiment) project exists to investigate the impact of air-sea interactions and ocean dynamics in the Bay of Bengal on intra-seasonal variability in the Indian summer monsoon. In this study we assess the performance of a GCM, MetUM-GOML2, at representing the summer mean state and intra-seasonal propagation events. The UK Met Office Unified Model, representing the atmosphere and land surface, is coupled to a one-dimensional mixed layer ocean employing a KPP parametrization, which uses a vertical mixing scheme but has no horizontal or vertical transport. As such the ocean columns are mutually independent, meaning that coupling can be employed with relatively low computational expense and can be switched on or off by region. Pre-computed temperature and salinity increments can be applied to constrain the ocean mean state. These features make the model ideal for investigating the effect of regional coupling and resolution on the representation of the monsoon. The model mean state exhibits a robust pattern of biases in precipitation with dry biases over India and the Maritime Continent, and wet biases over the equatorial Indian Ocean and western tropical Pacific Ocean. These biases are improved by using a higher resolution: they reduce significantly when changing from 200km to 90km grid spacing, and reduce again (although less significantly) when changing from 90km to 40km spacing. Perhaps surprisingly, switching off coupling in the Indian Ocean causes the biases to improve. However, no resolution or coupling configuration is able to remove the biases completely. Switching on coupling in the Indian Ocean, however, does improve the representation of intra-seasonal northward propagating convection over the Indian Ocean and India, especially in terms of the speed of propagation. This is likely due to the negative feedback between convection and SST. An increase in resolution also improves the speed of propagation, provided that the Indian Ocean is coupled.

Influence of the Gulf Stream Sea Surface Temperature Front on the Evolution of Storms

Abstract ID : 577

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Leonidas Tsopouridis ,leonidas.tsopouridis@uib.no ,(Ph.D. Candidate) ,Norway ,Bergen ,Presenting[1]

Mr. Simon Millet ,simon.millet.17@gmail.com ,(None) ,France , ,Not Presenting[2]

Mr. Lukas Papritz ,lukas.papritz@uib.no ,(None) ,Norway , ,Not Presenting[3]

Prof. Thomas Spengler ,thomas.spengler@uib.no ,(None) ,Norway ,None ,Not Presenting[4]

1 - Geophysical Institute /University of Bergen(UiB) 2 - University of Toulon, Seatech 3 - Geophysical Institute 4 - University of Bergen

There are complex dynamic and thermodynamic air-sea interactions in the Northern Hemisphere midlatitude western boundary currents such as the Gulf Stream and Kuroshio. The sharp sea surface temperature (SST) gradients along these currents strongly influence the atmosphere through enhanced latent and sensible heat fluxes. Furthermore, the lower tropospheric baroclinic zones associated with these SST fronts can play a significant role in the evolution of mid-latitude storms. While previous climatological studies have shown a clear relationship between SST fronts and storm tracks, the actual mechanisms influencing storm development on synoptic time scales remain unclear. We focus on storms in the vicinity of the Gulf Stream SST front in the North-West Atlantic using ERA-Interim data for the period 1979-2015. The position of the North-West Atlantic SST front is defined by the location of the maximum meridional gradient of SST, zonally averaged between 290-310E. Storm tracks are compiled using a cyclone tracking algorithm for the same period. Each storm track is then classified by its trajectory with respect to the position of the SST front, where trajectories can either be north, south, or crossing the SST front in either northward or southward direction. We find that northward crossing storms intensify most rapidly, accompanied by the most vigorous precipitation, while storms remaining south of the SST front are associated with the highest surface fluxes. We also present the influence of intra-annual to decadal variability of the gradient of SST on these findings.

Case study on impact propagation of radiosonde data assimilation over the Kuroshio and Kuroshio Extension

Abstract ID : 590

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Yoshimi Kawai ,ykawai@jamstec.go.jp ,(Senior Scientist) ,Japan ,Yokosuka ,Presenting[1]

Dr. Qoosaku Moteki ,moteki@jamstec.go.jp ,(None) ,Japan , ,Not Presenting[1]

Dr. Akira Kuwano-Yoshida ,akiray@jamstec.go.jp ,(None) ,Japan , ,Not Presenting[1]

Dr. Atsuyoshi Manda ,am@bio.mie-u.ac.jp ,(None) ,Japan , ,Not Presenting[4]

Dr. Takeshi Enomoto ,eno@dpac.dpri.kyoto-u.ac.jp ,(None) ,Japan , ,Not Presenting[5]

Dr. Hisashi Nakamura ,hisashi@atmos.rcast.u-tokyo.ac.jp ,(Professor) ,Japan ,Tokyo ,Not Presenting[6]

1 - JAMSTEC 2 - JAMSTEC 3 - JAMSTEC 4 - Mie University 5 - Kyoto University 6 - University of Tokyo

The authors investigated how impacts of the inclusion of radiosonde observations conducted locally in the early summer of 2012 over the Kuroshio and Kuroshio Extension (KE) can spread over time across the North Pacific basin to influence the predictability of synoptic and large-scale tropospheric circulation. For that purpose, observing system experiments (OSEs) were performed where each of two extra sets of radiosonde data, one obtained over the East China Sea in mid-May and the other over the KE in early July, was added to an atmospheric ensemble data assimilation system for comparison with the corresponding analyses without those data. Although these experiments do not directly deal with the impacts of the warm western boundary currents on the atmosphere, they are expected to be useful for gaining insight into the processes through which signals induced by the Kuroshio/KE can propagate into far fields. The experiments show that the impact of the extra data assimilated propagates eastward mainly due to advection by the subtropical jet (STJ) in both May and July. The strong STJ in May allows the upper-tropospheric impact to travel across the basin only within two days. On the other hand, the corresponding impact in July tends to remain within the western Pacific because of the weaker STJ, until it eventually reaches the eastern portion of the basin. Assimilation of the extra radiosonde data over the Kuroshio or KE can lead to a decrease of pressure over the Gulf of Alaska in both May and July. Additional forecast experiments based on the OSEs for May revealed that the pressure decrease over the Gulf of Alaska can be traced back to the west of the Alaska Peninsula and to the east of Japan over three days. The impacts that originate on different dates via different paths merge over the central North Pacific, reinforcing the cyclone over the Gulf of Alaska. This study presents examples where the impacts of atmospheric observations over

the western boundary current can propagate across the ocean basin through the westerlies to influence the forecast skill in distant regions.

Modelling the influence of tropically-excited poleward propagating rossby waves on recent trends in circulation over north Canada and Greenland

Abstract ID : 600

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Michelle McCrystall ,michmcr@bas.ac.uk ,(None) ,United Kingdom ,Cambridge ,Presenting[1]

Mr. Scott Hosking ,jask@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Ms. Amanda Maycock ,a.c.maycock@leeds.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Mr. John Pyle ,john.pyle@atm.ch.cam.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

1 - British Antarctic Survey/University of Cambridge 2 - British Antarctic Survey 3 - University of Leeds 4 - University of Cambridge

With recent rapid changes of Arctic climate widely evident, identifying the key drivers is essential for understanding these changes and their mechanisms. Previous studies have indicated that remote sea-surface temperatures (SSTs) have contributed to patterns of increased surface and mid-tropospheric warming and circulation change in the Arctic, specifically over north Canada and Greenland (Ding et al. 2014).
This work aims to further investigate the Tropical-Arctic teleconnection through assessing the role of tropical SSTs in exciting planetary scale Rossby waves and determining their effect on circulation anomalies over North Canada and Greenland. Using the Met Office HadGEM3 atmospheric model, we analyse a series of sensitivity experiments forced by changes in SSTs between the periods 1979-1988 and 2003-2012 imposed for; [i] the entire tropics, [ii] the tropical Pacific ocean [iii] the tropical Atlantic Ocean and [iv] the global extratropical oceans.
The spatial patterns of the Z200 anomalies in these experiments are quantitatively compared to Z200 trends from ERA-Interim reanalysis data and model results of Ding et al. (2014). In contrast to these results, we found a significant negative Z200 anomaly over NCG in boreal winter in response to tropical SST forcing. Further analysis found that tropical SST forcing from the Atlantic sector contributed more to the negative anomaly than the other tropical ocean basins and that extratropical SSTs further enhanced this anomaly. The direct tropical influence, assessed through wave flux anomalies as derived by Plumb (1985), displays weak propagation on to north Canada and Greenland from the tropical Pacific. This wave train is enhanced and strengthened when the additional forcing of extratropical SSTs are included. These results do suggest that tropical SSTs can affect regional Arctic climate however from these experiments it appears that this process has not contributed to the recent observed positive trends over north Canada and Greenland.
References:

Ding, Q.; Wallace, J.M.; Battisti, D.S.; Steig, E.J.; Gallant, A.,J.,E.; Kim, H-J.;Geng, L.: 2014: Tropical forcing of the recent rapid Arctic warming in northeastern Canada and Greenland: Nature: 509: pp 209-212
Plumb, A.: 1985: On the Three-Dimensional Propagation of Stationary Waves: Journal of Atmospheric Sciences: 42: pp 217-22

Possible Mechanisms for the Synchronization of the North Atlantic Oscillation with the Solar Cycle

Abstract ID : 655

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Annika Drews ,adrews@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[1]

Prof. Katja Matthes ,kmatthes@geomar.de ,(None) ,Germany ,Kiel ,Not Presenting[1]

1 - GEOMAR Helmholtz Centre for Ocean Research Kiel 2 - GEOMAR Helmholtz Centre for Ocean Research Kiel

Recent studies suggest an influence of the 11-year solar cycle on Northern Hemisphere winter climate. Specifically, a peak in solar irradiance induces a surface pattern resembling a positive phase of the winter North Atlantic Oscillation (NAO) with a delay of a few years. This lag has been attributed to ocean-atmosphere feedbacks as the atmosphere itself does not hold any long-term memory. However, the underlying mechanisms are still unclear. Here, we examine two simulations of the same coupled atmosphere-ocean general circulation model with atmospheric chemistry (CESM-WACCM). One simulation includes 11-year solar cycle variability, while the other keeps the solar forcing constant. For this set of experiments, it has been shown recently that quasi-decadal variability in Northern Hemisphere winter climate is found in both simulations. In the simulation with variable solar forcing this quasi-decadal variability of the NAO is synchronized with the solar cycle. The signal propagates downward from the stratosphere to the surface where atmosphere-ocean feedback takes place to delay the signal. Here, we seek further insights into the oceanic processes associated with quasi-decadal variability as well as feedback mechanisms causing the delayed NAO-response to the solar signal. We investigate surface variables important for air-sea interaction such as sea level pressure, wind stress, and surface temperature, as well as oceanic variables, e.g., the barotropic streamfunction, the Atlantic Meridional Overturning Circulation (AMOC), and oceanic heat content.

The effect of the 18.6 year lunar nodal cycle on decadal temperature trends

Abstract ID : 661

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Manoj Joshi ,m.joshi@uea.ac.uk ,(Senior Lecturer) ,United Kingdom ,Norwich ,Presenting[1]

Dr. Rob Hall ,robert.hall@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Ed Hawkins ,e.hawkins@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Prof. David Stevens ,D.Stevens@uea.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of East Anglia 2 - University of East Anglia 3 - University of Reading 4 - University of East Anglia

The lunar nodal cycle is an oscillation in tidal amplitude with an 18.6 year period, and is associated with slight changes in the orbit of the Moon around the Earth. Its effects on the circulation and state of the ocean can be parameterised in global circulation models by a small oscillatory component added to the background diffusion term that represents tides and other small-scale oscillations. To date, research using both ocean and coupled ocean-atmosphere models has shown that the lunar nodal cycle can have an effect on large scale modes of variability such as the Pacific-Decadal-Oscillation (PDO). Here we show that the lunar nodal cycle can have a small, but measurable, effect on global temperature trends in the context of warming planet; indeed, given the actual phase of the cycle, we suggest that it may have played a role in reducing temperature trends in the 1st decade of this century, and may also act to slightly accelerate temperature trends at other times. The effect of the lunar nodal cycle on sea surface temperatures (SST) is globally non-uniform for two reasons: first- tidal strength can vary geographically; second- the modulation of vertical mixing by the nodal cycle will warm or cool SSTs by an amount which depends on thermocline stability, and hence location. The nonuniformity may also help to explain observed geographical variations in warming trends.

Comparison of recent physically-based stochastic subgrid modelizations

Abstract ID : 675

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Jonathan Demaeyer ,jodemaey@meteo.be ,(Post-doctoral fellow) ,Belgium ,Brussels ,Presenting[1]

Dr. Stephane Vannitsem ,svn@meteo.be ,(None) ,Belgium , ,Not Presenting[1]

1 - Royal Meteorological Institute of Belgium 2 - Royal Meteorological Institute of Belgium

We consider some recent methods of stochastic subgrid-scale parameterization used in the context of climate models. These methods are developed to take into account subgrid processes playing an important role in the correct stochastic modeling of the atmospheric and climate variability.
Since the start of the century, various physically-based reduction methods have been developed. This multiplicity of available stochastic parameterization approaches illustrates how fruitful was the seminal work of Hasselmann about it in the 1970s. However, in this perspective, one might wonder about their relative efficiency in different situations. Indeed, depending on the specific purpose that it needs to fulfill, some parameterizations might perform better than others. The present work aims to shed some light on these questions by illustrating these methods in simple systems for which analytical expressions can be deduced, as well as in a coupled ocean-atmosphere low-order model.

Role of tropical Atlantic SST in the El Niño decaying phase

Abstract ID : 1100

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Wei Chen ,chenwei@mail.iap.ac.cn ,(Associate Researcher) ,China ,Beijing ,Not Presenting[1]

Prof. Riyu Lu ,chenwei@lasg.iap.ac.cn ,(None) ,China , ,Not Presenting[1]

1 - Institute of Atmospheric Physics, Chinese Academy of Sciences 2 - Institute of Atmospheric Physics, Chinese Academy of Sciences

The El Niño event varies from case to case in terms of its decaying phase: some El Niño events terminated in the subsequent summer are identified as short decaying El Niño, and other ones persisted until the following autumn or winter are identified as long decaying El Niño. The two types of El Niño evolution have been suggested by previous studies, but the reason responding to the different decaying phase remains unclear. In this study, we find a robust connection between the sea surface temperature (SST) anomalies over the tropical Atlantic (TA) and the El Niño decaying phase. A positive (negative) TA SST anomaly corresponds to the short (long) decaying of El Niño. This connection is not only obtained from the composite result, but also applicable to individual El Niño case in observations. Further analysis suggests a significant leading correlation between springtime tropical Atlantic SST anomaly and El Niño evolution, indicating an important contribution of TA SST to the El Niño decaying. The positive TA SST anomaly in spring induces anomalous descent motion over the central and eastern tropical Pacific, driving westward wind anomalies over equatorial Pacific. This wind anomaly increases the east-west thermocline slope and results in the emergence of negative SST anomaly over central and eastern tropical Pacific, and therefore terminates the El Niño event in the following summer. The same mechanisms act for the negative TA SST anomaly but with opposite sign, and thus favors the El Niño persistence. Given the active role of TA SST in the El Niño decaying phase, the TA SST anomaly may contribute to the predictability in El Niño evolution.

Role of local ocean-atmosphere interaction in determining tropical Pacific Climate

Abstract ID : 1189

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Noel Keenlyside ,noel.keenlyside@uib.no ,(None) ,Norway ,None ,Not Presenting[1]

Dr. Mao-Lin Shen ,maolin.shen@uib.no ,(None) ,Norway , ,Not Presenting[2]

Dr. Gregory Duane ,Gregory.Duane@colorado.edu ,(None) ,Norway , ,Not Presenting[2]

Dr. Bhuwan Bhatt ,Bhuwan.Bhatt@uni.no ,(None) ,Norway , ,Not Presenting[2]

1 - Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research 2 - Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research 3 - Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research 4 - Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research

The factors determining the tropical Pacific climatology remain poorly understood, and climate models remain challenged in simulating this region. Here we apply a novel super modelling strategy to study the role of local processes. In particular, two versions of an atmospheric model differing only in their convection scheme are coupled to a single ocean model. The ocean model receives a weighted combination of the momentum and heat fluxes. Optimal weights can produce a super model with a basic state similar to observations: a single intertropical convergence zone (ITCZ), with a western Pacific warm pool, and an equatorial cold tongue. This is in stark contrast to the erroneous double ITCZ pattern simulated by the two stand-alone coupled models. Through exploring different weights and using a diagnostic box model, we show how differences in the momentum and heat fluxes of the two different atmospheric models can be transformed by local feedbacks to determine the basic state; the Bjerknes feedback and the shallow-tropical cells are key in this respect. Our results provide insight to observed and modelled tropical Pacific climate.

Does South Atlantic Convergence Zone modify sea surface temperature?

Abstract ID : 1194

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Luciano Pezzi ,lppezzi@gmail.com ,(None) ,Brazil ,São Jose dos Campos ,Presenting[1]

Dr. Mario Quadro ,mquadro95@gmail.com ,(None) ,Brazil , ,Not Presenting[2]

Ms. Eliana Rosa ,elianaocn@gmail.com ,(None) ,Brazil , ,Not Presenting[3]

Dr. Ronald Souza ,ronald.buss@inpe.br ,(None) ,Brazil , ,Not Presenting[1]

1 - INPE 2 - Instituto Federal de Santa Catarina (IFSC) 3 - National Institute for Space Research 4 - INPE

Extreme climatic fluctuations severely affect natural resources, human life and the economy in various regions of Brazil. This is true both in the tropics, where the extreme time interval is not so great as in the extra-tropics, where meteorological systems produce large variations in precipitation, pressure, wind and temperature. However, a change in tropical rainfall can be devastating. Particular attention should be paid to the coastal region, which is usually punished by extreme weather events. Phenomena such as seagrasses, floods and coastal erosion can be generated by these events, which pose a threat to life and property and can cause great damage to the affected regions. Due to these climatic impacts it is necessary to include the state of the ocean in studies and forecasts of weather and climate, specifically in southeastern Brazil, where the Atlantic also plays an important role in atmospheric phenomena. There is a strong motivation and need to study and understand these issues that are related to the sea, with the atmosphere with their interactions, both large-scale (global impact) and regional scales. This is the motivation to deepen studies on the so-called South Atlantic Convergence Zone (SACZ), which directly influence precipitation indices in the southeastern region of Brazil. So far, it is believed that the presence of SACZs can modify sea surface conditions. The persistence for a few days (3-7) of the cloud band will reduce the sea surface temperature by blocking shortwave radiation. However, there is evidence that the convergence of surface wind will affect the dynamics and thermodynamics of the surface and sub-surface ocean, which will contribute to this surface cooling. For these reasons, it is extremely important to better understand this weather system when it happens over the Southwest Atlantic Ocean. The present work will show and discuss preliminary results of a series of numerical simulations performed using a regional coupled modeling system. The main objective is to understand a little more about the processes of air-sea interaction when the SACZ is present on the South-West Atlantic. In this study we used the Coupled Ocean-Atmosphere-Waves-Sediment (COAWST), which is a regional coupled modeling system.

Global Warming Attenuates the Tropical Atlantic-Pacific Teleconnection

Abstract ID : 1245

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Fan Jia ,jiafan@qdio.ac.cn ,(RESEARCH ASSOCIATE) ,China ,QINGDAO ,Presenting[1]

Prof. Lixin Wu ,lxwu@ouc.edu.cn ,(None) ,China , ,Presenting[2]

Dr. Bolan Gan ,gbl0203@ouc.edu.cn ,(Scientist) ,China ,Qingdao ,Not Presenting[3]

Prof. Wenju Cai ,Wenju.Cai@csiro.au ,(None) ,China , ,Not Presenting[4]

1 - Institute of Oceanology, Chinese Academy of Sciences 2 - Ocean University of China/Qingdao National Laboratory for Marine Science and Technology 3 - Ocean University of China/ Qingdao National Laboratory for Marine Science and Technology 4 - Qingdao National Laboratory for Marine Science and Technology

Changes in global sea surface temperature (SST) since the end of last century display a pattern of widespread warming intercepted by cooling in the eastern equatorial Pacific and western coasts of the American continent. Studies have suggested that the cooling in the eastern equatorial Pacific may be partly induced by warming in the North Atlantic. However, it remains unknown how stable this inter-tropical teleconnection will be under global warming. Here we show that the inter-tropical teleconnection from the tropical Atlantic to Pacific weakens substantially as the CO2 concentration increases. This reduced impact is related to the El Ni?-like warming of the tropical Pacific mean state, which leads to limited seasonal migration of the Pacific inter-tropical convergence zone (ITCZ) and weakened ocean heat transport. A fast decay of the tropical Atlantic SST anomalies in a warmer climate also contributes to the weakened teleconnection. Our study suggests that as greenhouse warming continues, the trend in the tropical Pacific as well as the development of ENSO will be less frequently interrupted by the Atlantic because of this attenuation. The weakened teleconnection is also supported by CMIP5 models, although only a few of these models can capture this inter-tropical teleconnection.

Impact of Gulf Stream SST biases on the global atmospheric circulation

Abstract ID : 1310

Conflict Declaration : Project PI Tim Woollings is co-convenor of session

Content Motivation : I am nearing the end of an important research project which is highly relevant to this session. The research I wish to present I am immenantly about to submit as a paper for peer review in a scientific journal and this research might be accepted by the time of the conference.

Additional Information : I am part of the institute: National Centre for Atmospheric Science (NCAS)

Dr. Robert Lee ,r.w.lee@reading.ac.uk ,(Research Scientist) ,United Kingdom ,Reading ,Presenting[1]

Dr. Tim Woollings ,Tim.Woollings@physics.ox.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Keith Williams ,keith.williams@metoffice.gov.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Prof. Brian Hoskins ,b.j.hoskins@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Reading 2 - University of Oxford 3 - Met Office 4 - University of Reading

The role of winter Gulf Stream biases are examined with a focus on the tropospheric response. The UK Met Office Unified Model in the Global Coupled 2 (GC2) configuration has a warm bias of up to 6 K, which is associated with surface heat flux biases and linked to eddy-driven jet biases in the North Atlantic. To test the tropospheric response to the Gulf Stream bias, three sensitivity experiments were performed. These imposed the SST biases on the atmosphere-only version of the model over three different-sized regions, to cover a small and medium section of the Gulf Stream, and the wider North Atlantic. The dynamical response to this anomalous Gulf Stream heating is to further enhance deep vertical ascent over the Gulf Stream, rather than balance the heating with a meridional wind or storm track response. This deep ascent is already stronger in the control versions of the model relative to ERA-Interim reanalysis. Together with the imposed Gulf Stream heating bias, the response affects the troposphere not only locally but also in remote regions of the Northern Hemisphere via a planetary Rossby wave response. The wave response, as opposed to storm track changes, appears to provide a pathway to the North Atlantic eddy-driven jet biases. These pathways may have implications for the ability of the model to respond correctly to variability or changes in the Gulf Stream.

Role of Air-Sea-Land Interactions in the Tropical Atlantic Seasonal Cycle

Abstract ID : 1330

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Lander R. Crespo ,lander.crespo@gfi.uib.no ,(PhD fellow) ,Norway ,Bergen ,Presenting[1]

Prof. Noel Keenlyside ,noel.keenlyside@uib.no ,(None) ,Norway ,None ,Not Presenting[2]

Mr. Shunya Koseki ,shunya.koseki@uib.no ,(None) ,Norway , ,Not Presenting[3]

1 - Geophysical Institute, University of Bergen and Bjerknes Center fro Climate Research 2 - Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research 3 - Geophysical Institute, University of Bergen, Norway

State-of the art climate models poorly represent the seasonal cycle in the tropical Atlantic, to a large extent due to the lack of understanding of the ocean-atmosphere and land-atmosphere couplings. In this study, we investigate the role of the SST seasonality in driving the seasonal cycle of the atmosphere in the tropical Atlantic basin. We run two sensitivity experiments for the historical period 1982-2013 using the atmospheric general circulation model CAM4, to try to isolate the impact of the seasonal cycle of the SST. One experiment is forced with observed climatological SST and the other one with time-independent SST. We statistically compare the two runs in terms of surface winds and precipitation, and use a Maximum Covariance Analysis (MCA) statistical technique to isolate and quantify the separate contributions of ocean- and land-processes to the atmospheric variability. Our results suggest that the land-processes are the main driver of the monsoonal precipitation over west Africa. However, ocean variability contributes to the northward shift of the ITCZ. Ocean processes are relevant for determining the seasonal cycle of the atmosphere in the eastern tropical Atlantic, explaining around 30% of the variance of precipitation during the monsoon season. The co-variability patterns show that the SST seasonal variability controls the low-level wind circulation over equatorial western Atlantic throughout the whole year. The model only explains 10% of the surface winds variance in absence of seasonality in the SST.

The dynamical coupling of sea-ice in Variable-Resolution Earth System Model and its feedback on the SH seasonal to inter-annual climate variability

Abstract ID : 1395

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Asmerom Beraki ,ABeraki@csir.co.za ,(Senior Researcher) ,South Africa ,Pretoria ,Presenting[1]

Dr. Francois Engelbrecht ,FEngelbrecht@csir.co.za ,(None) ,South Africa , ,Not Presenting[2]

1 - CSIR 2 - CSIR/NRE

The predictive skill of extratropical climate on seasonal to interannual time-scales has historically been very low. Interactions between the ocean, ice, atmosphere and land on these time-scales can be complex, and representing the relevant feedbacks and teleconnections in climate models is challenging. Notwithstanding, the realistic representation of these coupled phenomena and their teleconnections may offer a source of predictability for the extratropics. Sea-ice has not only a noticeable importance in the Earth's energy and water budget but also has a considerable effect on local and remote atmospheric and oceanic circulations. As previous studies noted, the Antarctic Dipole temperature anomalies present the largest El Niño-Southern Oscillation (ENSO) signal outside of the tropical Pacific and represents the largest interannual variability in the Antarctic sea ice field. The changes of the basin-scale meridional circulation in the South Pacific and South Atlantic and stationary Rossby wave propagation associated with the ENSO variability might be the main mechanisms for the tropical/polar teleconnection. In addition, sea-ice extent and drift velocities were reportedly found to be sensitive to the main modes of southern hemisphere variability, including the PSA (Pacific South America), SAM (Southern Annular Mode), SAO (Semi-Annual Oscillation) and the wave number 3 pattern. The main objective of this ongoing study is therefore to investigate the contribution and downstream feedback of the sea-ice on SH (Southern Hemisphere) seasonal to interannual climate variability using the first African based Earth System Model (ESM) referred to as the "Variable-resolution Earth System Model (VRESM)". The VRESM has been developed through collaborative research between the Council for Scientific and Industrial Research (CSIR) in South Africa and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) In Australia. The model employs ocean, atmosphere, land-surface and dynamic sea-ice models all cast on a cube-based grid and can be applied either at quasi-uniform horizontal resolution to function as a global climate model, or in stretched-grid mode to function as a high-resolution regional climate model.

The role of the ocean and atmosphere model resolution in the generation of the warm bias in the Angola-Benguela Frontal Zone

Abstract ID : 1402

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Dmitry Sein ,Dmitry.Sein@awi.de ,(None) ,Germany , ,Presenting[1]

Dr. William Cabos ,william.cabos@gmail.com ,(None) ,Spain , ,Not Presenting[2]

Dr. Dmitry Sidorenko ,dmitry.sidorenko@awi.de ,(None) ,Germany , ,Not Presenting[3]

Dr. Nikolay Koldunov ,nikolay.koldunov@awi.de ,(None) ,Germany , ,Not Presenting[3]

Prof. Thomas Jung ,thomas.jung@awi.de ,(None) ,Germany , ,Not Presenting[3]

1 - Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research 2 - University of Alcala 3 - Alfred Wegener Institute for Polar and Marine Research 4 - Alfred Wegener Institute for Polar and Marine Research 5 - Alfred Wegener Institute for Polar and Marine Research

We study the impact of the horizontal resolution of the atmospheric and oceanic components of a coupled atmosphere-ocean system in the simulation of the Sea Surface Temperature in the Angola-Benguela Frontal Zone region (ABFZ). It is well known that state of the art ESM models typically show strong warm biases in that region. Experiments with the regional atmospheric model REMO, the ocean model MPIO-OM and the regionally coupled model REMO-MPIOM (ROM) show that the biases are both of oceanic and atmospheric origin, and are influenced by ocean-atmosphere interactions in coupled runs. Our simulations with ROM and the global coupled AWI Climate Model (AWI-CM) suggests that better resolved upwelling system and coastal winds could contribute to a weakening of the strong coastal warm bias in the ABFZ. In simulations where at least one of the components of the coupled system has low resolution, the biases, albeit of lesser extent (almost negligible in the oceanic component of AWI-CM) are already present in the forced oceanic simulations and are exacerbated by the coupling. AWI-CM simulations with a very high resolution ocean (~10 km) and low resolution atmosphere (~100 km) in the region show biases in the ABFZ similar to our results obtained with the regionally coupled model ROM, where the atmosphere resolution is higher (~50 km) and the ocean lower (~20 km) than in AWI-CM. We further explore the impact of horizontal resolution on the ABFZ bias by a comparison of coupled and uncoupled simulations with higher resolution REMO (~25 km) and MPI-OM (~5 km) setups. These resolutions currently are not attainable in coupled global simulations.

Observed and Simulated Summer Rainfall Variability in Southeastern South America

Abstract ID : 1528

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Leandro Diaz ,ldiaz@cima.fcen.uba.ar ,(None) ,Argentina ,Buenos Aires ,Not Presenting[1]

Dr. Carolina Vera ,carolina@cima.fcen.uba.ar ,(None) ,Argentina , ,Not Presenting[2]

Prof. Ramiro Ignacio Saurral ,saurral@cima.fcen.uba.ar ,(None) ,Argentina , ,Not Presenting[3]

1 - None 2 - Centro de Investigaciones del Mar y la Atmósfera. UBA-CONICET 3 - Centro de Investigaciones del Mar y la Atmósfera (CIMA/CONICET-UBA)

The evolution of precipitation during the last 150 years exhibits in Southeastern South America (SESA) considerable multi-decadal variations that have been identified in previous works as forced by the tropical ocean variability. Therefore, in order to better understand the influence of the observed large-scale interannual variability of the sea surface temperatures (SST) on austral summer rainfall in SESA in a global warming context, a singular value decomposition analysis was performed over the 1902-2010 period. The leading mode (SVD1) shows a clear global warming signal, mainly related to warming in the Pacific and Indian Oceans, in association with a rainfall increase in SESA. The temporal series of the mode exhibits significant variability ranging from the interannual scale to long-term trends. In particular, the decadal variability signal is remarkable, with a particular phase shift at around the middle 1970s. After detrending the series, the spatial distribution of both SST anomalies and precipitation anomalies in SESA associated with the first mode resembles that typically related with El Niño-Southern Oscillation. Moreover, the mode temporal evolution has a remarkable variability on decadal scales, which shows that the relationship between SST anomalies, especially in the Tropical Pacific Ocean, and SESA precipitation is non stationary.
Historical and Decadal simulations simulations included in the Fifth phase of the World Climate Research Program-Coupled Model Intercomparison Project (WCRP/CMIP5) are considered in order to make a preliminary evaluation of the representation of austral summer rainfall variability and trends in SESA and its connection with ocean variability. Models are able to represent a significant positive trend over SESA in agreement with the observations, although weaker than observed. The model representation of the SVD1 was also assessed. Preliminary results using short-term climate predictions show that some models are able to reproduce the main spatial features associated with the mode, on both SST anomalies and precipitation anomalies in SESA. In particular, these models are able to reproduce the teleconnections linking the tropical Pacific-Indian Ocean sector with SESA. An assessment of the temporal evolution of this mode provided by those simulations will be also presented in the Conference.

MJO Prediction and Teleconnections in sub-seasonal forecasts

Abstract ID : 274

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Frederic Vitart ,Frederic.Vitart@ecmwf.int ,(Principal Scientist) ,United Kingdom ,Reading ,Not Presenting[1]

1 - ECMWF

The Madden Julian Oscillation (MJO) is the dominant intra-seasonal mode of organized convective activity in the Tropics,
with also a considerable impact in the middle and high latitudes. The skill of sub-seasonal forecasting systems to predict
the MJO has improved significantly over the past decade thanks mostly to changes in the convective parameterization, although most models still have difficulties propagating the MJO across the Maritime continent. The MJO predictive skill and teleconnections in the high latitudes have been diagnosed in 10 operational sub-seasonal prediction models from the WWRP/WCRP Sub-seasonal to Seasonal Prediction (S2S) database. Results suggest that the S2S models display skill to predict the MJO between 2 and 4 weeks, although the majority of S2S models tend to produce a too weak and slow propagating MJO in the extended forecast range. All the S2S models produce MJO extratropical teleconnections which are too weak over the Euro-Atlantic sector, which suggests that they do not fully exploit the predictability associated to the MJO in the Northern Extratropics, particularly over Europe. The impact of model resolution and ocean-atmosphere coupling on
the MJO prediction skill and teleconnections will be discussed.

Iracema F.A. Cavalcanti : The author asked poster presentation

Relative Role of the MJO and Stratospheric Variability in North Atlantic Climate Patterns During Boreal Winter

Abstract ID : 430

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Chen Schwartz ,chen.schwartz1@mail.huji.ac.il ,(M.Sc student) ,Israel ,Petah Tiqwa ,Not Presenting[1]

1 - Hebrew university of Jerusalem

European and eastern U.S wintertime weather is strongly influenced by large-scale modes of variability in the Northern Hemisphere such as the AO and NAO. Improved predictability of these modes can help improve forecasts of extreme weather events across the midlatitude northern hemishpere.
Both the MJO phase 6 and 7 and stratospheric sudden warmings have been shown to lead to the negative phase of the AO, but the relative role of each phenomena is not clear, and the two phenomena are themselves linked. In our work, we evaluate the relative roles of MJO phase 6/7 and stratospheric variability for northern hemisphere surface weather during boreal winter by using MERRA reanalysis data. We show that stratospheric variability leads to significantly different north Atlantic anomalies if it is preceded by MJO phase 6/7. Furthermore, MJO phase 6/7 leads to robust negative AO pattern only if it modulates the stratosphere first. Hence, proper attribution of their respective influence on surface weather needs to take into consideration the nonlinear linkages between these two phenomena. A similar analysis will be presented but for 5 Subseasonal-to-Seasonal (S2S) operational models.

Calibration and Combination of CHFP precipitation forecasts over South America using Ensemble Regression

Abstract ID : 705

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Marisol Osman ,osman@cima.fcen.uba.ar ,(PostDoctoral Fellowship) ,Argentina ,Ciudad Autónoma de Buenos Aires ,Not Presenting[1]

Dr. Carolina Vera ,carolina@cima.fcen.uba.ar ,(None) ,Argentina , ,Not Presenting[2]

1 - Centro de Investigaciones del Mar y la Atmósfera (CIMA).Instituto Franco-Argentino del Clima y sus Impactos (IFAECI-UMI3351)/CNRS. Universidad de Buenos Aires - CONICET 2 - Centro de Investigaciones del Mar y la Atmósfera. UBA-CONICET

In this study we calibrate the climate predictions available at the Climate Historical Forecast Project of the World Climate Research Program to develop seasonal precipitation forecast tools over South America. Forecasts made with initial conditions of November and May and valid at December-January-February (DJF) and June-July-August (JJA), respectively (Lead 1) over the period 1982-2006 are considered. A Multi-Model Ensemble (MME) using 11 models with around 10 ensemble members, was constructed and its performance was evaluated against CMAP database. The domain of application spans [15°N-60°S;275°E-330°E] and it is also divided in two subdomains: tropical South America and extratropical South America.
The Ensemble Regression technique (EREG) applies a regression equation developed for the ensemble mean to each ensemble member to obtain a probability density function (PDF) which represents the ensemble prediction. EREG is first applied to each model and its ensemble members to calibrate them. Then, two approaches are used to obtain the consolidated PDF. The first one consists in using the weighted MME in a new ensemble regression, resulting in a weighted super-ensemble regression (WSEREG) to get the consolidated PDF. The other technique consists in obtaining the consolidated PDF computing the normalized summing of the weighted models' PDF (weighted kernels, WKERNELS). The consolidated PDFs obtained are used to forecast the three equally probable categories below, near and above normal. These forecast are confronted against those obtained counting the proportion of ensemble members of the MME falling in each category (counting estimate technique, CE).
Results show that both WKERNELS and WSEREG outperform CE in terms of the Ranked Probabilistic Skill Score (RPSS) and Brier Skill Score (BSS) in both seasons. However, only in northern South America the performance of both consolidation techniques is slightly better than the climatological values of the predictand (three categories equally probable). In extratropical South America both RPSS and BSS values change from less than -0.5 for CE to near 0 for both WKERNELS and WSEREG.On the other hand, reliability diagrams computedover the entire domain

shows that WKERNELS and WSEREG substantially improve the forecast in terms of reliability respect to than obtained with CE.

A comparison of two intraseasonal cold events in 2007/08 and 2015/16 winter: the roles of Arctic sea ice loss and ENSO

Abstract ID : 823

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Shuanglin Li ,shuanglin.li@mail.iap.ac.cn ,(None) ,China , ,Presenting[1]

Ms. Mingyue Win ,qinmingyue@mail.iap.ac.cn ,(None) ,China , ,Not Presenting[2]

1 - Nansen-Zhu International Research Centre and Climate Change Research Center, Institute of Atmospheric Physics, Chinese Academy of Sciences 2 - University of Chinese Academy of Sciences

The 2015/16 winter climate in East Asia exhibits a resemblance to that in the 2007/08 winter, with an intraseasonal shift in surface air temperature (SAT) from a substantial warmth in early winter to a coldness in late winter. In the lower boundary a common feature in the two cases is an evident reduction in Arctic sea ice in the preceding autumn. A difference is the opposite phase of ENSO, in that the former is accompanied with a super strong El Niño event and the latter with a strong La Nina. Intensified middle-and-high latitudinal blocking activity and the intensified Siberian High are found in both the cases, but the blocking high in the 2015/16 case shifted further north and east. Besides, the northwestern Pacific subtropical high was further north than normal in the 2015/16 case, which explains the coolness primarily confined in the north. Although the two intraseasonal spectral variability (ISV), one with the periodicity of 10~20d and the other with the periodicity of 30-60d, were common in both the cases, the 30-60d one seems stronger in the 2007/08 case. Finally the underlying mechanism particularly the potential impacts of Arctic sea ice and ENSO responsible for the difference in ISV in the two cases is explored by ECHAM5 AGCM sensitive experiments.

Madden-Julian Oscillation prediction skill of the Subseasonal-to-Seasonal (S2S) models

Abstract ID : 827

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Yuna Lim ,jennifer125@snu.ac.kr ,(None) ,South Korea ,Seoul ,Not Presenting[1]

Prof. Daehyun Kim ,daehyun@uw.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Seok-Woo Son ,seokwooson@snu.ac.kr ,(Associate Professor) ,South Korea ,Seoul ,Presenting[1]

1 - Seoul National University 2 - University of Washington 3 - Seoul National University

The Madden-Julian Oscillation (MJO), the dominant mode of tropical intraseasonal variability, provides a primary source of predictability not only in the tropics but also in the extratropics. To understand the current status of MJO prediction, this study assesses the MJO prediction skill in the ten operational models, which participated in the Subseasonal-to-Seasonal (S2S) prediction project. In terms of bivariate anomaly correlation coefficient of 0.5, the S2S models produce useful MJO forecasts up to 2-5 weeks, with an enhanced skill when initial MJO amplitude is strong. For most models, MJO prediction skill is insensitive to the initial MJO phase without a symptom of the Maritime Continent MJO prediction barrier, although two models show notable sensitivity. The prediction skill and its inter-model spread are further related to the horizontal distribution of total column water and the strength of cloud-radiation feedbacks. All models, which provide sufficient data, exhibit dry biases in the tropics especially near the Maritime Continent and rather weak cloud-radiation feedbacks in comparison to observation. These biases are highly correlated with MJO prediction skill, suggesting that the improvement in the mean moisture field and cloud-radiation feedbacks are necessary for better predicting MJO in the operational models.

Changes of frontal activity under climate change scenarios in Brazil

Abstract ID : 1134

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Simone Ferraz ,simonetfe@ufsm.br ,(Associated Professor) ,Brazil ,Santa Maria ,Not Presenting[1]

Prof. Tercio Ambrizzi ,tercio.ambrizzi@iag.usp.br ,(None) ,Brazil , ,Not Presenting[2]

Mr. Diego Pedroso ,diegopedroso1@gmail.com ,(None) ,Brazil , ,Not Presenting[3]

Dr. Ernani Nascimento ,ernani.nascimento@ufsm.br ,(None) ,Brazil , ,Not Presenting[4]

1 - Federal University of Santa Maria 2 - University of Sao Paulo 3 - DHN 4 - UFSM

The performance of frontal systems modulates the rainfall and temperature behavior of large regions, and the climate models must correctly simulate it. In addition, these systems have a transient nature, therefore, they modify the conditions of time by promoting the distribution of energy between the equator and the poles before, during and after their passage. They occur throughout the year, with greater intensity and frequency in winter and spring. Its detection is due to the combination of several factors: a) temperature, humidity, wind and vorticity gradients more intense than those typically observed in the synoptic scale; b) relative minimum pressure and negative minimum of vorticity; c) confluence zone along the front; d) strong wind turning; e) rapid change in -nebulosity. Thus, in this work we analyzed how frontal systems are represented by climate models and how they are projected in climate change scenarios using RegCM4 simulations nested to the HadGEM2-ES global model from the reference period 1975 to 2004 (RF) and for 2020 -2049 period in RCP4.5 and 8.5 scenarios. Additionally, five regions of frontal systems performance were analyzed from the South to the Southeast of Brazil. The average number of found fronts agrees with the observed one, with a constant distribution throughout the year in the further south area and an increase in the number of fronts of the end of winter and beginning of spring in the other areas more than to the southeast of the Brazilian continent. In general, in both scenarios an increase in the average number of fronts in relation to the RF period is observed, except in the further south area, where this increase is observed only in the spring of scenario 4.5 and winter of scenario 8.5. One possible explanation would lie on what most climate change models show, indicating that strengthening the low-level jet would increase the moisture flow from the Amazon Basin region to the south of South America. And the presence of warmth and humidity would also be in agreement with the highest accumulated rainfall.

Teleconnections between the Madden Julian Oscillation (MJO) and extratropical weather patterns as a source of predictability

Abstract ID : 1356

Conflict Declaration : Project PI Frederic Vitart is convenor of session

Content Motivation : None

Additional Information : I am part of the institute: National Centre for Atmospheric Science (NCAS)

Dr. Robert Lee ,r.w.lee@reading.ac.uk ,(Research Scientist) ,United Kingdom ,Reading ,Presenting[1]

Dr. Steve Woolnough ,s.j.woolnough@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Frederic Vitart ,Frederic.Vitart@ecmwf.int ,(Principal Scientist) ,United Kingdom ,Reading ,Not Presenting[3]

Dr. Andrew Charlton-Perez ,a.j.charlton-perez@reading.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Reading 2 - University of Reading 3 - ECMWF 4 - University of Reading

The MJO, acting as a Rossby-wave source, can provide teleconnections to the extratropics including: the NAO; the strength of the Northern Hemisphere winter polar stratospheric vortex including the occurrence of Sudden Stratospheric Warmings; and Arctic sea-ice. This tropical sub-seasonal variability and correctly represented teleconnections may provide a source of predictability for sub-seasonal variability in extra-tropical polar regions. The ERA-Interim reanalysis is used to analyze the MJO-extratropical teleconnections on sub-seasonal to seasonal timescales, and their dependence on slowly varying basic state. This includes the dependence of these teleconnections on interannual and longer timescale modes of variability. The ability of climate and seasonal prediction models to capture these dependencies are explored using data from the WMO Sub-seasonal to Seasonal Prediction Project (S2S) database.

IAGA

Use of harmonic splines to investigate the evolution of the South Atlantic Anomaly over southern Africa between 2005 and 2010

Abstract ID : 47

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Emmanuel Nahayo ,enahayo@sansa.org.za ,(PhD student) ,South Africa ,Hermanus ,Not Presenting[1]

Prof. Susan J. Webb ,susan.webb@wits.ac.za ,(None) ,South Africa ,Johannesburg ,Not Presenting[1]

Dr. Pieter B. Kotze ,pkotze@sansa.org.za ,(SA IAGA delegate) ,South Africa ,Hermanus ,Not Presenting[3]

1 - University of the Witwatersrand 2 - University of the Witwatersrand 3 - South African National Space Agency (SANSA)

We use a harmonic spline core field model derived from CHAMP satellite and ground-based data recorded over southern Africa between 2005 and 2010 to investigate the evolution of the South Atlantic Anomaly in this region. The computed maps of main field show a steady decrease of the magnetic field intensity over the years during the study period, highlighting the evolution of the South Atlantic Anomaly over southern Africa. We show the relationship between the secular variation at Hermanus magnetic observatory and the influence of the South Atlantic Anomaly in the region.

late quaternary secular variation data from mexico: attempts for constructing a high resolution local secular variation curve

Abstract ID : 78

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Ahmed Nasser Mahgoub ,ahmednasser@geociencias.unam.mx ,(PhD student) ,Mexico ,None ,Not Presenting[1]

Mr Ann Cyphers ,cyphers@unam.mx ,(None) ,Mexico , ,Not Presenting[2]

Mr Angel Ramirez Luna ,rangel@geofisica.unam.mx ,(None) ,Mexico , ,Not Presenting[3]

Mr Erick Juarez ,erickja18@gmail.com ,(None) ,Mexico , ,Not Presenting[1]

Mr Claus Siebe ,csiebe@geofisica.unam.mx ,(None) ,Mexico , ,Not Presenting[3]

Dr. Linda Manzanilla ,lmanza2004@yahoo.com.mx ,(None) ,Mexico ,None ,Not Presenting[6]

Mr Katrin Sieron ,ksieron@gmail.com ,(None) ,Mexico , ,Not Presenting[7]

Mr Peter Schaaf ,pschaaf@geofisica.unam.mx ,(None) ,Mexico , ,Not Presenting[3]

Dr. Harald Böhnel ,hboehnel@geociencias.unam.mx ,(None) ,Mexico ,Queretaro ,Not Presenting[1]

1 - Centro de Geociencias, Universidad Nacional Autónoma de México 2 - Instituto de Investigaciones Antropológicas, Universidad Nacional Autónoma de México 3 - Departamento de Vulcanología, Instituto de Geofísica, Universidad Nacional Autónoma de México 4 - Centro de Geociencias, Universidad Nacional Autónoma de México 5 - Departamento de Vulcanología, Instituto de Geofísica, Universidad Nacional Autónoma de México 6 - nstituto de Investigaciones Antropológicas, Universidad Nacional Autónoma de México 7 - Centro de Ciencias de la Tierra, Universidad Veracruzana 8 - Departamento de Vulcanología, Instituto de Geofísica, Universidad Nacional Autónoma de México 9 - Centro de Geociencias, Universidad Nacional Autónoma de México

During the last decades an increasing number of paleomagnetic data from Mexican archaeological artifacts and lava flows mainly within the Trans-Mexican volcanic belt (TMVB) have been published for the past fifty thousand years. Nevertheless, scarcity, disparity and age uncertainties of these data made it difficult constructing a local secular variation (SV) curve for Mexico for the late Quaternary. It is intriguing that during this period of time the Mono Lake and the Laschamp geomagnetic excursions occurred. Their global coverage and temporal extent are still matter of debate. Moreover, over the past few thousand years short-lived periods of very high geomagnetic intensities (geomagnetic spikes) have been documented (Europe, The Levant, and Eastern Asia), which can not be explained

by the current geodynamo theories. We note here that counting on precise age data for the studied materials is the main restriction for contributing to the above mentioned geomagnetic excursions and jerks. In this study we compile data from a suite of fifty five volcanic lavas, forty eight pottery fragments, and four bricks which all are located within the TMVB. The volcanic materials were dated recently mainly by the radiocarbon dating (14C) and some of them by the thermoluminiscence (TL) methods, which places them into an age range between 45 Kyr to 1793 AD. The age range of the archeological pieces is based on archeological constraints, 14C and historical data which establish a time interval from ~ 1300 BC to 1800 AD. Our new dataset together with selected previously published data are used to establish a full vector regional secular variation curve for Mexico for the late Quaternary. To accomplish this, we have used the Spherical Harmonic Analysis technique (SHA) in space, and the penalized cubic B-splines in time (Pavón-Carrasco et al., 2014). Interestingly, the above mentioned phenomena of geomagnetic excursions and jerks will be discussed in the context of these new secular variation curves, as well as the relation between these curves and the most recent global geomagnetic field models.

Filling the Gap – optimal use of low degree main field models and core flows to predict secular variation

Abstract ID : 537

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Kathy Whaler ,kathy.whaler@ed.ac.uk ,(None) ,United Kingdom ,Edinburgh ,Not Presenting[1]

Dr. Ciaran Beggan ,ciar@bgs.ac.uk ,(None) ,United Kingdom ,Edinburgh ,Presenting[2]

1 - University of Edinburgh 2 - British Geological Survey

Between the de-orbiting of CHAMP in September 2010 and the launch of Swarm in November 2013, there were few satellite vector magnetic field measurements available to the field modelling community. Though some total field measurements from Oersted were collected, main field models relied heavily on ground-based observatory data. While the ground observatory data are of excellent quality, the spatial distribution of the network is heavily biased towards the northern hemisphere, leaving large regions without coverage, particularly over the oceans. During this three year period, main field models had larger errors than during the vector satellite era bracketing this 'gap' in measurements.

We firstly investigate these errors or differences compared to retrospectively constructed models constrained using Swarm data from 2014 onwards. We assess if it is possible to optimally recover the 'true' main field and secular variation during the 2010-2014 period using core surface flows derived from CHAMP data and main field models produced at the time using the more limited data available. We combine the information from both sets of models using an Ensemble Kalman Filter to work out the best combination of core flow SV forecast and main field model to assimilate.

Jerks in Geomagnetic and Rotational Data

Abstract ID : 614

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Richard Holme ,holme@liv.ac.uk ,(Professor) ,United Kingdom ,Liverpool ,Presenting[1]

Dr. Yan Feng ,frank_feng8848@163.com ,(None) ,China , ,Not Presenting[2]

Dr. Grace Cox ,gracecox@liverpool.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - University of Liverpool 2 - Nanjing University of Information Science & Technology 3 - University of Liverpool

Geomagnetic jerks are defined as discontinuities in the rate of change of geomagnetic secular variation, and are generally accepted as being the features with shortest time scale observable originating from the internal (core) field. Detailed models of variations in Earth rotation (Holme and de Viron, 2013) have provided evidence of a link between these jerks and changes in the rate of Earth rotation - so-called length-of-day. This is particularly clear in terms of a six-year variation seen in both signals. However, other features are also observed in length-of-day in addition to this 6-year variation. The changes in length of day are assumed to be associated with similar changes in core flow, which would imply that the jerks might also involve jumps in the secular variation itself. Initial examination of secular variation records (particularly for 2003.5) suggested that such changes were seen in geomagnetic data; however, many of these sharp changes may be of external origin. Here we revisit the correlation between geomagnetic and rotational jerks, to examine whether there are a range of different jerk types, and what these can tell us about the origin of the features, their timing, and structure and processes in the deep Earth.

R. Holme and O. de Viron, Nature, 499, 202-204, 2013.

Statistical forecasting techniques applied to observatory data for core field modelling

Abstract ID : 701

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. William Brown ,wb@bgs.ac.uk ,(Geomagnetic field modeller) ,United Kingdom ,Edinburgh ,Not Presenting[1]

Dr. Ciaran Beggan ,ciar@bgs.ac.uk ,(None) ,United Kingdom ,Edinburgh ,Not Presenting[1]

Dr. Susan Macmillan ,smac@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - British Geological Survey 2 - British Geological Survey 3 - British Geological Survey

Modelling of the geomagnetic field is a complex challenge, hindered by noisy and incomplete ground and satellite observations, and the extent to which we can separate the contributions of the various field sources in these data. Forecasting of the core field and its time variations (secular variation), an activity of key interest for academic and applied studies of geomagnetism and space weather, is further complicated by an incomplete knowledge of the physics controlling magnetic field generation. Predictive core field models often rely on simple mathematical extrapolation to produce short term (<5 year) forecasts, but this technique can struggle when rapid variations known as geomagnetic jerks cause distinctly non-linear secular variation to occur. More advanced physics-based forecasting techniques such as core flow advection and geodynamo data assimilation also currently struggle to capture such short timescale variations.
We discuss the applicability of common statistical forecasting techniques to ground observatory time series and compare the results of models based on such data forecasts to those of simple field model extrapolation and core flow advection forecasts.

On the frequency spectra of the magnetic field Gauss coefficients

Abstract ID : 1016

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Vincent Lesur ,lesur@ipgp.fr ,(Head of magnetic observatories) ,France ,Paris ,Presenting[1]

Dr. Ingo Wardinski ,ingo.wardinski@univ-nantes.fr ,(None) ,France , ,Not Presenting[2]

Prof. Matthias Holschneider ,matthias.holschneider@gmail.com ,(None) ,Germany , ,Not Presenting[3]

Mr. Julien Baerenzung ,baerenzung@gmx.de ,(Postdoc) ,Germany ,Berlin ,Not Presenting[4]

1 - Institut de Physique du Globe de Paris 2 - LPG Nantes 3 - Uni Potsdam 4 - None

From monthly mean observatory data spanning 1957 to 2014, geomagnetic field secular variation values were calculated by annual differences. Estimates of the spherical harmonic Gauss coefficients of the field variations were then derived by applying a correlation based modelling. Finally, a Fourier transform was applied to the time series of the Gauss coefficients. This process led to reliable temporal spectra of the Gauss coefficients up to spherical harmonic degree 5 or 6, and down to periods as short as 1 or 2 years depending on the coefficient. We observed that a k^{-2} slope, where k is the frequency, is an acceptable approximation for these spectra, with possibly an exception for the dipole field. The monthly estimates of the core field secular variation at the observatory sites also show that large and rapid variations of the latter happen. This is an indication that geomagnetic jerks are frequent phenomena and that significant secular variation signals at short time scales - i.e. less than 2 years, can still be extracted from data to reveal an unexplored part of the core dynamics.

Ice Giant Dynamo Models with Radially Varying Electrical Conductivity

Abstract ID : 1219

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Krista Soderlund ,krista@ig.utexas.edu ,(Research Associate) ,United States ,Austin ,Presenting[1]

Dr. Nicholas Featherstone ,nicholas.featherstone@colorado.edu ,(None) ,United States , ,Not Presenting[2]

Dr. Moritz Heimpel ,mheimpel@ualberta.ca ,(None) ,Canada , ,Not Presenting[3]

Dr. Jonathan Aurnou ,aurnou@ucla.edu ,(None) ,United States , ,Not Presenting[4]

1 - The University of Texas at Austin, Institute for Geophysics 2 - University of Colorado 3 - University of Alberta, Edmonton 4 - UCLA

The internal dynamics of giant planets are controlled primarily by the interaction of convection, stratification, rotation, and magnetic fields. Within Uranus and Neptune, the ice giants, convection in the ionic ocean generates the planets' magnetic fields through dynamo action, while convection in the molecular envelope may generate the planets' zonal winds. Previous work has hypothesized the influence of rotation on convection to be relatively weak compared to that of buoyancy, leading to fluctuating fluid motions that are characterized by three-dimensional turbulence instead of columns aligned with the rotation axis (Aurnou et al., Icarus 190, 110-126, 2007; Soderlund et al., Icarus 224, 97-113, 2013). In this regime, convection generates a multipolar dynamo and zonal flows with a retrograde equatorial jet and a prograde high latitude jet in each hemisphere that look similar to those observed on the ice giants. However, the magnetic field strength and zonal wind speeds are overestimated in our models with constant electrical conductivity. Towards resolving this discrepancy, we hypothesize that incorporation of an electrically insulating outer molecular envelope will bring the magnetic field and zonal flows into quantitative agreement. We will present new simulations that include radial variations in electrical conductivity based on internal structure models in combination with material property estimates and will discuss the potential for coupling between dynamo action in the ionic ocean and zonal flow generation in the molecular envelope. In addition, we will highlight how these simulations will both contribute to and benefit from the next mission to an ice giant planet.

Environmental magnetism study for the determination of paleoclimates and paleoenvironmental conditions in Serdan Oriental Basin.

Abstract ID : 1285

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Kurt Heinrich Wogau ,kurtwogau@gmail.com ,(None) ,Mexico ,Queretaro ,Not Presenting[1]

Dr. Harald Böhnel ,hboehnel@geociencias.unam.mx ,(None) ,Mexico ,Queretaro ,Not Presenting[2]

Dr. Tripti Bhattacharya ,tripti@email.arizona.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Roger Byrne ,arbyrne@berkeley.edu ,(None) ,United States , ,Not Presenting[4]

Dr. Kenneth L Verosub ,klverosub@ucdavis.edu ,(None) ,Mexico , ,Not Presenting[5]

1 - UNAM 2 - Centro de Geociencias, Universidad Nacional Autónoma de México 3 - University of Arizona 4 - University of California, Berkeley 5 - University of California, Davis campus

Aljojuca lake is located in the Serdan Oriental basin in the state of Puebla, in the eastern part of the Transmexican Volcanic Belt. Three lake sediment cores were recovered for studying the magnetic mineralogy, in order to study the the paleo climate and paleo environmental conditions of the area. Core images and magnetic concentration dependent parameters were used to correlate the core sections and then build a compound core. The length of this core is 1171.2 cm and the maximum age is 5460 years according to fifteen C-14 ages. The core was subdivided into four zones with similar behavior of the magnetic concentration-dependent parameters. The results shows that the main magnetic minerals in Aljojuca lake are magnetite and titanomagnetite, with the rare presence of hematite and iron sulfurs like greigite. The principal magnetic grain size observed in the sediments is pseudo single-domain, determined from King and Day plots. Comparing the results of magnetic mineralogy with different chemistry and oxygen isotopes, we interpreted the paleo climatic-environmental conditions. Zones I (6-4 kyr) is dominated by hight input of sediments, showed in the magnetic susceptibility and Al_2O_3 parameter, interpreted as a wetter conditions. Zone II (4-2.5 kyr) the input of sediments is reduced, there is significan change in grain size of magnetic particles and the presence of hematite, suggesting the change to wetter to dry conditions. Zone III (2.5-1 kyr) we relate the presence of gregite, due the high concentration of organic matter, producing reducing conditions during the low level of the lake, related with dry climates. This episode coincides with the fall of prehispanic city of Cantona around 950 CE. Zone IV (1 kyr - present) is characterized by hight input of sediments related with the increase of anthropogenic activity, first by the spanish conquest and the for the modern agriculture activities.

Confirming the mid-Paleoproterozoic apparent polar wander path for the Rio de la Plata craton: paleogeographic implications

Abstract ID : 810

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Pablo Franceschinis ,pablo.franceschinis2@gmail.com ,(PhD student) ,Argentina ,Buenos Aires ,Presenting[1]

Dr. Augusto Rapalini ,rapalini@gl.fcen.uba.ar ,(Associate Professor) ,Argentina ,Buenos Aires ,Not Presenting[2]

Dr. Leda Sánchez Bettucci ,leda@fcien.edu.uy ,(None) ,Uruguay , ,Not Presenting[3]

1 - CONICET 2 - Universidad de Buenos Aires 3 - Universidad Nacional de la República

Global paleogeographic models for the Paleoproterozoic are largely uncertain despite significant progress in the last two decades. Paleomagnetic data for that era is scarce, uneven and of varied reliability for most cratons. Recently published paleomagnetic results from some post-tectonic plutons in the Piedra Alta terrane (Uruguay) suggested that the Río de la Plata craton experienced a fast apparent polar wander at very high latitudes between ca. 2.1-2.0 Ga. We present new paleomagnetic results from nine small plutonic bodies not previously sampled in the same terrane. After standard paleomagnetic techniques, complemented with rock-magnetic studies, petrographic analysis and magnetic fabric investigations, three new paleomagnetic poles were computed from the Cufré-Cerro Albornoz grantic plutons, the Carreta Quemada gabbro and the Tia Josefa tonalite, respectively. These new poles fall along the recently presented apparent polar wander track for the Rio de la Plata craton confirming high latitude positions for this block and fast polar displacement. A sequence of six poles along the track is determined, from oldest to youngest, by the Mahoma-Marincho, Carreta Quemada, Cufré-Cerro Albornoz, Isla Mala, Tía Josefa and Soca plutonic bodies. A coherence is also observed in the polarity of remanence along the track, showing dual polarity remanence for the older poles (Mahoma-Marincho and Carreta Quemada), normal polarity (assuming southern hemisphere location of the craton) for Cufré-Cerro Albornoz and reverse polarity for the Isla Mala, Tía Josefa and Soca intrusives. These new data also confirm that the hypothetical Paleoproterozoic Atlantica continent, encompassing several South American and African cratons, either never existed or had a radically different paleogeographic configuration.

Detection of the pedogenic magnetic fraction in soils developed on basalts

Abstract ID : 302

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Hana Grison ,grison@ig.cas.cz ,(researcher) ,Czech Republic ,Prague ,Presenting[1]

Dr. Aleš Kapi?ka ,kapicka@ig.cas.cz ,(None) ,Czech Republic , ,Not Presenting[2]

Dr. Eduard Petrovsky ,edp@ig.cas.cz ,(senior researcher) ,Czech Republic ,Prague 4 ,Not Presenting[3]

1 - Institute of Geophysics Czech Academy of Sciences 2 - Institute of Geophysics CAS CR 3 - Institute of Geophysics

Ultrafine superparamagnetic/stable single-domain (SP/SSD) ferrimagnetic grains are commonly thought to represent the so-called 'pedogenic magnetic fraction'. This fraction is produced by weathering (physical and chemical decomposition) and by biological fermentation processes. It is generally accepted that frequency-dependent magnetic susceptibility percentage (χ_{FD}%) reflects the relative significance of the SP/SSD fraction in the total (bulk) magnetic signal, i.e., in low-field mass-specific magnetic susceptibility (χ_{LF}). In strongly magnetic soils, the SP/SSD magnetic signal (mostly biopedogenic) may be masked by the lithological one; making pedogenesis hard to evaluate. In our contribution, we address this problem using a new approach to the discriminating between the lithogenic and biopedogenic magnetic contributions within the SP/SSD fraction by comparing the magnetic data determined in the fine earth (< 2 mm) and the coarse fraction (4-10 mm) samples down the soil profile. In addition to this, we will present a new concept of the identification of biopedogenic SP/SSD fraction, based on field (amplitude)-dependent magnetic susceptibility (χ_{AD}) variations This work was performed on 12 soil profiles (120 samples) collected in areas with highly magnetic parent material (basalts) from the Massif Central, France and from the Bohemian Massif, Czech Republic. Magnetic data of the χ_{FD}%, χ_{LF} and χ_{AD} were obtained by the AGICO MFK1-FA Kappabridge. Our results suggest that in case χ_{FD}% of the fine earth is smaller than χ_{FD}% of the coarse fraction, the lithogenic contribution is dominant. Soil samples with an increased content of biopedogenic SP/SSD fraction show distinct features of χ_{AD} in field between 5 and 100 A/m.

Detection of metallic iron in urban dust with the use of combined high temperature magnetic measurements and microscopic observations.

Abstract ID : 427

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Tomasz Werner ,twerner@igf.edu.pl ,(Head of Paleomagnetic group) ,Poland ,Warsaw ,Presenting[1]

Dr. Beata Górka-Kostrubiec ,kostrub@igf.edu.pl ,(None) ,Poland , ,Not Presenting[1]

Prof. Maria Jele?ska ,bogna@igf.edu.pl ,(None) ,Poland , ,Not Presenting[1]

Ms. Iga Szczepaniak-Wnuk ,igasz@igf.edu.pl ,(None) ,Poland , ,Not Presenting[1]

Miss. Sylwia Dyt?ow ,skdytlow@igf.edu.pl ,(None) ,Poland , ,Not Presenting[1]

1 - Institute of Geophysics, Polish Academy of Sciences 2 - Institute of Geophysics, Polish Academy of Sciences 3 - Institute of Geophysics, Polish Academy of Sciences 4 - Institute of Geophysics, Polish Academy of Sciences 5 - Institute of Geophysics, Polish Academy of Sciences

The work presents the thermomagnetic study of samples collected in different environments such as indoor dust, outdoor dust, street dust and dust from cabin air filters of cars. The temperature changes of magnetic susceptibility k(T) and induced magnetization M(T) were measured with two different devices. The curves of k(T) were measured with the Multi-Function-Kappabridge (MFK1, Agico) in the temperature range of 20-700^{o}C. The curves of M(T) were obtained with Advanced Variable Field Transition Balance (Petersen Instruments) with applied magnetic field of 500mT in the temperature range of 35-800^{o}C. For all the studied samples, the curve of k(T) revealed the Curie temperature of magnetite which confirms the presence of magnetite as the primary magnetic phase. On the heating curves of k(T) the tail (a substantial but decreasing value of k) was visible between 600^{o}C and 700^{o}C which was the attribute of the second high-temperature magnetic phase. The curve of M(T) revealed also the Curie temperature of magnetite and the second magnetic transformation detected at 755^{o}C characteristic for presence of metallic iron and/or iron-based alloys. The presence of metallic iron fraction in the studied material was confirmed by the microscopic (SEM) observation and energy-dispersive X-ray spectroscopy (EDS). The magnetic extract of dust from different environments revealed the elongated shaving-like particles comprise of metallic iron. Additional measurements of hysteresis properties for a few samples at high temperatures and after step-wise annealing indicate the process of oxidation of iron to magnetite. The presence of such tail appearing on the heating curve of k(T) between 600^{o}C and 700^{o}C are often interpreted as the presence of hematite. Our study of M(T) curves in the temperature range of 35-800^{o}C supported by hysteresis properties and by the microscopic observation revealed the second high-temperature magnetic phase should be interpreted

as the iron. Probably in other studies that phase is not recognized as iron due to 700^{o}C limit of heating. Our study shows that it is not possible to distinguish between hematite and metallic iron without heating up to higher temperatures up to 800^{o}C. The study was partly financed by the Polish National Science Centre project No 2013/09/B/ST10/02780.

Magnetic properties of glacial-marine sediments in the area of Werenskiold Glacier (SW Spitsbergen, Arctic Norway)

Abstract ID : 610

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Magdalena Gwizdala ,mgwizdala@igf.edu.pl ,(PhD Candidate) ,Poland ,Warsaw ,Presenting[1]

Prof. Maria Jele?ska ,bogna@igf.edu.pl ,(None) ,Poland , ,Not Presenting[1]

Prof. Leszek ??czy?ski ,ocell@univ.gda.pl ,(None) ,Poland , ,Not Presenting[3]

1 - Institute of Geophysics, Polish Academy of Sciences 2 - Institute of Geophysics, Polish Academy of Sciences 3 - Institute of Oceanography, University of Gda?sk

Studies of the magnetic properties of glacial-marine sediments were carried out in the area of Werenskiold Glacier in Spitsbergen, Svalbard, Arctic Norway. The research was divided into two stages. In the first part, sediments from Nottingham Bay and from two main proglacial streams (north and south) of the Werenskiold Glacier, were investigated. We distinguished the source of this material. During the second stage, surface sediments from the Kvisla and Brattega rivers were subjected to studies. Kvisla river was the part of north stream and transported the material from Werenskiold Glacier in the past. Today, it is a main drainage of Skilrygg Glacier, which is above the Werenskiold Glacier. In contrast, Brattega river is at south from the glacier and flow to the Nottingham Bay. Magnetic properties of the specimens were studied using rock-magnetic methods, including: low-field bulk magnetic susceptibility (χ_{LF}), volume magnetic susceptibility dependence on temperature experiment κ(T), hysteresis parameters. The values of χ_{LF} obtained for Kvisla sediments ($12 < \chi_{LF} < 43 \times 10^{-8} m^3/kg$) fall within the results from the first stage of study. On the other hand, χ_{LF} values of Brattega river are the most diverse from all investigated samples ($22 < \chi_{LF} < 436 \times 10^{-8} m^3/kg$). The κ(T) analysis present two different ways of chemical changes of non-magnetic compounds which produce new magnetic minerals (magnetite and/or maghemite) during heating. These curves of κ(T) are dissimilar to those from Werenskiold streams and Nottingham Bay. The results of hysteresis show significant differences between Kvisla and Brattega sediments. Samples from Kvisla river indicate similar values of hysteresis parameters as north stream. The Brattega sediments have the values of hysteresis parameters close to the values for south stream and Nottingham Bay. Part of the Brattega samples show higher values of coercivity ratio and lower magnetization ratio, than other investigated specimens.These preliminary results present a contrast properties and different source rocks of analysing material.

Rock magnetic characterization of atmospheric deposition in northeastern Spain: Preliminary results from the DONAIRE Project

Abstract ID : 1030

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Juan Larrasoaña ,jc.larra@igme.es ,(Staff Scientist) ,Spain ,Zaragoza ,Not Presenting[1]

Dr. Tania Mochales ,taniamochales@gmail.com ,(None) ,Spain , ,Not Presenting[1]

Dr. Jorge Pey ,j.pey@igme.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Noemí Pérez ,noemi.perez@idaea.csic.es ,(None) ,Spain , ,Not Presenting[4]

Mr. José Cerro ,jccerro@energia.caib.es ,(None) ,Spain , ,Not Presenting[5]

Miss. Marisa Tobar ,mltobar@energia.caib.es ,(None) ,Spain , ,Not Presenting[5]

Miss. Inés de la Parra ,inesdelaparra.m@gmail.com ,(None) ,Spain , ,Not Presenting[7]

Mr. Jesús Reyes ,j.reyes@igme.es ,(None) ,Spain , ,Not Presenting[1]

Dr. Pilar Mata ,p.mata@igme.es ,(None) ,Spain , ,Not Presenting[1]

1 - IGME 2 - IGME 3 - IGME 4 - CSIC 5 - CAIB 6 - CAIB 7 - University of Zaragoza 8 - IGME 9 - IGME

DONAIRE is a research project aimed at characterizing the geochemical, mineralogical and magnetic properties of atmospheric deposition collected at urban, industrial, agricultural and pristine natural environments from north-eastern Spain. The main goal of the project is to apply a number of analytical techniques to quantify and characterize the total atmospheric deposition accumulated throughout a whole year and to discriminate its partitioning among natural (e.g., atmospheric dust, marine aerosols) and anthropogenic (e.g., traffic, industrial activity, shipping emissions) loads at the different settings. We present preliminary bulk rock magnetic data from filters collected on a biweekly basis, which combine magnetic susceptibility measured at two frequencies with artificial remanences, e.g., ARM and two IRM at low and high fields. Preliminary data indicate measurable amounts of magnetic minerals in samples with significant amounts of particles, which correspond to samples in urban settings or affected by strong Saharan dust fallouts. Overall, samples at urban locations appear to be more magnetic than at natural contexts, existing in any case a broad relationship between the total mass of particles and the magnetic moments of the samples. Additional measurements of selected samples (e.g., IRM acquisition curves, hysteresis, FORCs), combined with SEM and TEM observations, will be conducted in order to better characterize the magnetic mineralogy and grain size

of magnetic minerals and to better interpret bulk magnetic properties in terms of natural and anthropogenic loads.

The Curie temperature of magnetite nanoparticles

Abstract ID : 451

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Charles Penny ,charles.penny11@imperial.ac.uk ,(Phd Student) ,United Kingdom ,London ,Not Presenting[1]

Dr. Adrian Muxworthy ,adrian.muxworthy@imperial.ac.uk ,(Convenor) ,United Kingdom ,London ,Presenting[2]

Dr. Karl Fabian ,karl.fabian@ngu.no ,(None) ,Norway , ,Not Presenting[3]

1 - Imperial College London 2 - Imperial College 3 - NGU

Measuring the Curie temperature is a standard technique in determining the mineralogical content of a magnetic sample. The Curie temperatures of magnetic nanoparticles have been observed to both decrease and increase with reducing particle size in agreement with finite scaling theory. However, due to the complex interplay between finite-size and surface effects, predictions as to the exact behaviour of any given material are difficult. A more quantitative understanding of the change in magnetic ordering temperature for minerals of interest is important for interpreting the data acquired from rock magnetic studies. The ordering temperature for magnetite nanoparticles was investigated using an atomistic mean field model applied to a realistic crystal structure, with experimentally determined values for the exchange energies. The arising system of coupled non-linear equations was numerically solved using the SNES library of the Portable, Extensible Toolkit for Scientific Computation (PETSc). Some preliminary calculations have shown a reduction in both Curie temperature and surface magnetisation for magnetic nanoparticles, in qualitative agreement with both experimental and computational results.

Update on the data quality and instrument status of the Thermal Ion Imagers and Langmuir Probes of Swarm

Abstract ID : 266

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Raffaella D'Amicis ,raffaella.damicis@esa.int ,(member) ,Italy ,Rome ,Not Presenting[1]

Dr. Rune Floberghagen ,rune.floberghagen@esa.int ,(None) ,Italy , ,Not Presenting[1]

Dr. Mariano Kornberg ,mariano.kornberg@esa.int ,(None) ,Netherlands , ,Not Presenting[3]

Dr. Igino Coco ,igino.coco@ingv.it ,(None) ,Italy , ,Not Presenting[4]

Dr. Stephan Buchert ,scb@irfu.se ,(None) ,Sweden , ,Not Presenting[5]

Dr. Giuseppe Ottavianelli ,giuseppe.ottavianelli@esa.int ,(None) ,Italy , ,Not Presenting[6]

Dr. David Knudsen ,knudsen@ucalgary.ca ,(Professor) ,Canada ,Calgary ,Not Presenting[7]

Dr. Pierre Vogel ,pierre.vogel@esa.int ,(None) ,Netherlands , ,Not Presenting[3]

Dr. Giuseppe Albini ,giuseppe.albini@esa.int ,(None) ,Germany , ,Not Presenting[9]

Dr. Claudia Stolle ,cstolle@gfz-postdam.de ,(None) ,Germany , ,Not Presenting[10]

Dr. Thomas Nilsson ,thomas.nilsson@irfu.se ,(None) ,Sweden , ,Not Presenting[5]

Dr. Matthias Foester ,mfo@gfz-postdam.de ,(None) ,Germany , ,Not Presenting[10]

Dr. David Patterson ,david.patterson@esa.int ,(None) ,Germany , ,Not Presenting[9]

Dr. Jonhnathan Burchill ,j.burchill@ucalgary.ca ,(None) ,Canada , ,Not Presenting[7]

1 - ESA - ESRIN 2 - ESA - ESRIN 3 - ESA - ESTEC 4 - INGV 5 - IRF 6 - ESA ESRIN 7 - University of Calgary 8 - ESA - ESTEC 9 - ESA - ESOC 10 - GFZ 11 - IRF 12 - GFZ 13 - ESA - ESOC 14 - University of Calgary

This poster will give an overview of the Electric Field Instrument (EFI) on board Swarm after three and a half years operations focusing in particular on the most significant activities performed to support payload investigations to improve science quality.
Each EFI on each of the three-spacecraft consists of two instruments: two Langmuir Probes (LP) and two Thermal Ion Imagers (TII).

The LPs are devoted to the measurement of the electron density and temperature in the ionosphere and the measurement of the spacecraft potential which is auxiliary to the data processing of the TII instrument. The instrument provides high quality observations especially for electron density, which turns to be the most reliable and stable Swarm plasma parameter product. Data validation activities and results are presented along with future validation/calibration plans.

The TII is devoted to measure the velocity and temperature of the bulk O+ distribution in the ionosphere, and to infer the ionospheric Electric field. Despite the overall good health of the instruments and their associated equipment, in-orbit operations showed an unforeseen behaviour in all TII, related to a non-permanent degradation of raw images. The observed image degradation is most likely due to water contamination in the sensor head. Several tests run in-orbit and the implementation of an operational scenario are presented.

Local averages of the core-mantle boundary magnetic field from Swarm and CHAMP satellite observations

Abstract ID : 467

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Magnus Hammer ,magdh@space.dtu.dk ,(None) ,Denmark ,Holte ,Not Presenting[1]

Dr. Chris Finlay ,cfinlay@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[1]

1 - DTU Space, Technical University of Denmark 2 - DTU Space, Technical University of Denmark

We introduce an approach to estimate local spatial averages of the core-mantle boundary (CMB) radial magnetic field, based on magnetic field observations from the CHAMP satellite and the Swarm satellite constellation. Appraisal of the resolving power of these data is of fundamental importance for investigation of the core dynamo. We use the Green's functions for the Neumann boundary value problem to link satellite data to the radial magnetic field on the CMB, and adopt a modified Backus-Gilbert inversion approach. Our approach builds on the Subtractive Optimally Localized Averages (SOLA) method developed in helioseismology, seeking averaging kernels as close as possible to a target function that we choose to define via a Fisher distribution. We present results of our method as applied to first differences and sums of vector magnetic field data taken along track (and across track for Swarm), from geomagnetically quiet and dark times. Examples are given of using our method to estimate local averages of the core-mantle boundary radial magnetic field, its secular variation (SV) and secular acceleration (SA). We also present time-series of the secular variation at locations of interest on the CMB; these are free from the degree-dependent temporal regularization that plagues conventional field models built using spherical harmonic based techniques.

Update on the status of the Swarm Start Tracker package, Vector Field Magnetometer and Absolute Scalar Magnetometer instruments and their data quality

Abstract ID : 475

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Enkelejda Qamili ,enkelejda.qamili@esa.int ,(Swarm Product Quality Expert) ,Italy ,Frascati (Rome) ,Not Presenting[1]

Dr. Rune Floberghagen ,rune.floberghagen@esa.int ,(None) ,Italy , ,Not Presenting[2]

Dr. Pierre Vogel ,pierre.vogel@esa.int ,(None) ,Netherlands , ,Not Presenting[3]

Dr. Igino Coco ,igino.coco@ingv.it ,(None) ,Italy , ,Not Presenting[4]

Dr. Riccardo Mecozzi ,Riccardo.Mecozzi@esa.int ,(None) ,Netherlands , ,Not Presenting[5]

Dr. Lars Tøffner-Clausen ,lastec@space.dtu.dk ,(None) ,Denmark , ,Not Presenting[6]

Dr. Giuseppe Ottavianelli ,giuseppe.ottavianelli@esa.int ,(None) ,Italy , ,Not Presenting[7]

Dr. Jan Miedzik ,jmiedzik@gmv.com ,(None) ,Poland , ,Not Presenting[8]

1 - European Space Agency 2 - ESA - ESRIN 3 - ESA - ESTEC 4 - INGV 5 - ESA ESTEC 6 - DTU Space 7 - ESA ESRIN 8 - GMV

Since its Exploitation Phase since November 2013, the Swarm Vector Field Magnetometer (VFM) and Absolute Scalar Magnetometer (ASM) instruments on-board of the three satellites are providing high precision and high resolution data that have allowed a better understanding of the Earth's magnetic field nature. This poster provides an extensive overview of the VFM (also the Star tracker) and ASM instrument status, data availability and their quality.

Magnetic Schumann Resonances in Swarm ASM Burst Mode, VFM HF and e-POP Data?

Abstract ID : 485

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Ciaran Beggan ,ciar@bgs.ac.uk ,(None) ,United Kingdom ,Edinburgh ,Presenting[1]

Ms. Gosia Musur ,musur@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Dr. Pierdavide Coïsson ,coisson@ipgp.fr ,(Associate Physicist) ,France ,Chambon la forêt ,Not Presenting[3]

Dr. Gauthier Hulot ,gh@ipgp.fr ,(Deputy Director in charge of research and space activities) ,France ,Paris ,Not Presenting[3]

Mr. Pierre Deram ,deram@ipgp.fr ,(None) ,France , ,Not Presenting[3]

Ms. Gosia Musur ,musur@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

1 - British Geological Survey 2 - British Geological Survey 3 - Institut de Physique du Globe de Paris 4 - Institut de Physique du Globe de Paris 5 - Institut de Physique du Globe de Paris 6 - British Geological Survey

The Schumann Resonances (SR) consist of a series of peaks in spectral power in the magnetic and electric field at frequencies of around 8, 14, 22 and 27 Hz etc. They arise from the continuous occurrence of equatorial lightning strikes. The broadband electromagnetic emission from each lightning strike is contained within a waveguide, bounded by the Earth's surface and the ionosphere at around 80 km in altitude. Although, the electric field SR have been detected in space using the C/NOFS satellite in 2010/11 at altitudes of 600 km, there have been no confirmed measurements using magnetic field instruments. There are theoretical arguments that the ionosphere acts to fully shield the magnetic signal from penetrating out of the atmosphere to Swarm altitudes, though other models suggest some secondary signals occur.
We examine data from the Swarm Absolute Scalar Magnetometer Burst Mode (250 Hz), the Swarm Vector Field Magnetometer High Resolution (50Hz) and enhanced Polar Outflow Probe (e-POP) Magnetic Field (160 Hz) instruments collected on the 19-Jan-2014 during the commissioning phase of the mission to look for SR signals. We compare the results to the data from ground-based search coils at Eskdalemuir Observatory in the United Kingdom.

VO-ESD approach: Temporal variations of the geomagnetic field at virtual observatories derived from Swarm measurements

Abstract ID : 866

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Diana Saturnino ,saturnino@space.dtu.dk ,(Postdoc) ,Denmark ,Lyngby ,Presenting[1]

Mr. Benoit Langlais ,benoit.langlais@univ-nantes.fr ,(None) ,France , ,Not Presenting[2]

Mr. Hagay Amit ,hagay.amit@univ-nantes.fr ,(None) ,France , ,Not Presenting[2]

Prof. Mioara MANDEA ,mioara.mandea@cnes.fr ,(Innovation, Application and Science Directorate) ,France ,Paris ,Not Presenting[4]

1 - DTU Space 2 - LPG Nantes 3 - LPG Nantes 4 - CNES - Centre National d'Etudes Spatiales

We present an approach to directly extract time series of the main geomagnetic field and its temporal variation from satellite measurements as it is done at ground observatories. We follow a Virtual Observatory (VO) approach and define a globally homogeneous mesh of VOs at satellite altitude. Because satellite measurements are acquired at different altitudes, an altitude correction is needed. We thus use an Equivalent Source Dipole (ESD) technique for each VO and for each interval of 30 days to reduce all measurements to a constant altitude. This leads to time series similar to those available at ground magnetic observatories. Our VO-ESD scheme is applied to the Swarm mission latest measurements, since its launch until mid 2017. A 2.5 degree resolution global mesh of ~ 3-year-long time series of the magnetic field and of its SV is built and presented. These series are locally compared with ground observations as well as with satellite-based model predictions. Our VO-ESD approach delivers a detailed description of the field's short-term temporal variations at small spatial scales, which are not reproduced by global field models. Our high resolution global mesh may be used to study the SV's spatial variability and its features such as geomagnetic jerks, on a global scale, along with global field models. Finally SH models are derived from the VO-ESD time series. We will discuss their pros and cons.

Derived Poynting flux directions associated with post-sunset equatorial plasma irregularities from Swarm observations

Abstract ID : 1040

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Claudia Stolle ,cstolle@gfz-potsdam.de ,(Professor) ,Germany ,Potsdam ,Not Presenting[1]

Mr. Juan Rodríguez-Zuluaga ,juanrz@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

Mr. Jaeheung Park ,pj@kasi.re.kr ,(None) ,South Korea , ,Not Presenting[3]

1 - GFZ Potsdam 2 - GFZ Potsdam 3 - Korea Astronomy and Space Science Institute, Daejeon

The electromagnetic nature of equatorial plasma irregularities has been predicted since many years from physics-based modelling. Observational evidences have been provided by single event studies from satellites or rocket data. Swarm is the first satellite mission that provides a continuous data set of absolute magnetic field and plasma drift observations. This enables the first survey of field-aligned Poynting flux related to the irregularities. This paper reports on the direction of the Poynting flux associated with equatorial plasma irregularities derived from a selected set of data of both Swarm A and B. The observations suggest mainly a summer-to-winter interhemispheric Poynting flux, but also a longitudinal dependence is noted. The flux is mainly directed into the southern hemisphere about between 60°W and 30°E , and into the northern hemisphere between 110°W and 60°W, with the significant change at 60°W. We suggest the asymmetry between the hemispheres on the ionospheric conductivity is likely due to the influence of thermospheric winds and the presence of the South Atlantic Anomaly.

Interpreting low and mid-latitude ionospheric current signatures in Swarm vector magnetic measurements

Abstract ID : 1066

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Patrick Alken ,alken@colorado.edu ,(Research Scientist) ,United States ,Boulder ,Not Presenting[1]

Dr. Astrid Maute ,maute@ucar.edu ,(None) ,United States ,None ,Not Presenting[2]

Dr. Arthur Richmond ,richmond@ucar.edu ,(None) ,United States , ,Not Presenting[3]

Dr. Gary Egbert ,egbert@coas.oregonstate.edu ,(None) ,United States ,Corvallis ,Not Presenting[4]

Dr. Arnaud Chulliat ,arnaud.chulliat@noaa.gov ,(None) ,United States ,Boulder ,Not Presenting[5]

Dr. Gauthier Hulot ,gh@ipgp.fr ,(Deputy Director in charge of research and space activities) ,France ,Paris ,Not Presenting[6]

1 - University of Colorado at Boulder 2 - National Center for Atmospheric Research 3 - High Altitude Observatory 4 - Oregon State University 5 - University of Colorado Boulder 6 - Institut de Physique du Globe de Paris

The Swarm Level-2 equatorial electric field (EEF) and equatorial electrojet (EEJ) product is based on a single satellite approach and uses only scalar field data. While this product currently produces estimates of the low-latitude eastward EEJ current strength, it may be possible to estimate other components of the current by using the full vector measurements of the multi-satellite Swarm constellation configuration in addition to physics-based modeling. In this study we use the TIEGCM physics-based ionosphere model to derive empirical orthogonal functions (EOFs) which contain statistically significant information about the 3D spatial geometries of the various ionospheric current systems. These EOFs are then fit to the Swarm constellation data to interpret observed measurements of both in-situ F-region currents as well as toroidal E-region currents. Fields due to induction effects at low and mid-latitudes will be accounted for by subtracting the Swarm Level-2 ionospheric Sq field model, DIFI. The remaining signal in the Swarm observations will be due primarily to ionospheric sources, whose spatial geometries will be estimated from TIEGCM runs in order to minimize the dimensionality of the inverse problem.

Correlation based modelling of ionospheric magnetic fields

Abstract ID : 1132

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Matthias Holschneider ,matthias.holschneider@gmail.com ,(None) ,Germany , ,Not Presenting[1]

Miss. Khadidja Ferrat ,ferrat@uni-potsdam.de ,(PhD Researcher) ,Germany ,Potsdam ,Not Presenting[2]

Prof. Vincent Lesur ,vincentlesur65@gmail.com ,(None) ,France , ,Not Presenting[3]

Mr. Julien Baerenzung ,baerenzung@gmx.de ,(Postdoc) ,Germany ,Berlin ,Not Presenting[2]

Dr. Hannes Matuschek ,hmatuschek@googlemail.com ,(None) ,Germany , ,Not Presenting[5]

Mr. Stefan Mauerberger ,mauerber@uni-potsdam.de ,(None) ,Germany , ,Not Presenting[5]

Dr. Claudia Stolle ,cstolle@gfz-potsdam.de ,(Professor) ,Germany ,Potsdam ,Not Presenting[7]

1 - Uni Potsdam 2 - None 3 - IPGP 4 - None 5 - University of Potsdam 6 - University of Potsdam 7 - GFZ Potsdam

Geomagnetic fields resulting from ionospheric currents are modeled in terms of random structures taking into account a mean behavior as well as random fluctuations which are described through two point correlation kernles. These kernels are estimated from long time series of numerical simulations from various models. These correlations are best represented in the Solar-Magnetic (SM) coordinate system of coordinates. For the moment we limit ourselves to spatial correlations only in this coordinate system.
We study the influence of various indices as possible predictor parameters for these correlations as well as seasonal effects. The various time series of ionospheric fields are stored in a HDF5 database which is accessible via a web interface. Other groups are invited to participate in contributing ionospheric models. The so obtained correlation structures serve as prior information to separate external and internal field components from observatory based measurements Th first preliminary results of this inversion are presented.

A core magnetic field model for 2000 – 2016 epochs

Abstract ID : 1389

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Vincent Lesur ,lesur@ipgp.fr ,(Head of magnetic observatories) ,France ,Paris ,Presenting[1]

Mr. Khadidja Ferrat ,khadidja-ferrat@hotmail.fr ,(None) ,Germany , ,Not Presenting[2]

Prof. Matthias Holschneider ,matthias.holschneider@gmail.com ,(None) ,Germany , ,Not Presenting[3]

1 - Institut de Physique du Globe de Paris 2 - Uni. Potsdam 3 - Uni Potsdam

We derived a core magnetic field model from satellite and observatory data for the 2000-2016 epochs. The model is estimated together with other contributions such as the magnetospheric, lithospheric and induced field contributions. The data selection has been set up to have a homogenous data density at satellite altitudes for each year where satellite data are available. Along track differences are also used to limit the effect of the noise associated a poor representation of the external fields. We used a system of representation where the core field contribution is parameterised by its radial component on a Gauss-Legendre grid at the Earth surface, allowing new approaches for regularising the field behaviour at small scales. Preliminary results show acceptable core field Gauss coefficients for the core field, its secular variation and acceleration for the period range 2010-2016.

Nitric Oxide in the lower thermosphere: physical drivers in observations and model

Abstract ID : 1358

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Koen Hendrickx ,koen.hendrickx@misu.su.se ,(None) ,Sweden , ,Not Presenting[1]

Dr. Linda Megner ,linda@misu.su.se ,(None) ,Sweden , ,Not Presenting[2]

Prof. Jörg Gumbel ,gumbel@misu.su.se ,(None) ,Sweden , ,Not Presenting[3]

Mr. Dan Marsh ,marsh@ucar.edu ,(None) ,United States , ,Not Presenting[4]

1 - Department of Meteorology, Stockholm University 2 - 1Department of Meteorology, Stockholm University, Stockholm, Sweden 3 - Stockholm University 4 - NCAR

Throughout the lower thermosphere we assess the physical drivers of Nitric Oxide (NO), which can be represented by geomagnetic activity and solar radiation, and the importance of each driver to the total NO budget.
NO observations from the Solar Occultation For Ice Experiment (SOFIE) instrument onboard the Aeronomy of Ice in the Mesosphere (AIM) satellite and from the Student Nitric Oxide Explorer (SNOE) are used and compared to NO concentrations simulated by the SD-WACCM (Whole Atmosphere Community Climate Model with Specified Dynamics) model.
Similarities and differences between observations and simulations will be discussed using a combination of superposed epoch analyses and multiple linear regressions.

Influence of interplanetary shocks on the VLF wave intensity observed by the DEMETER

Abstract ID : 487

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Barbora Bezdekova ,baja@etranslator.biz ,(student) ,Czech Republic ,Prague ,Not Presenting[1]

Dr. Michel Parrot ,mparrot@lpc2e-cnrs.fr ,(None) ,France , ,Not Presenting[2]

Dr. Vratislav Krupar ,vk@ufa.cas.cz ,(None) ,Czech Republic , ,Not Presenting[3]

Dr. Oksana Kruparova ,ok@ufa.cas.cz ,(None) ,Czech Republic , ,Not Presenting[3]

Dr. Frantisek Nemec ,frantisek.nemec@gmail.com ,(None) ,Czech Republic , ,Not Presenting[5]

Prof. Ondrej Santolik ,os@ufa.cas.cz ,(None) ,Czech Republic , ,Not Presenting[3]

1 - None 2 - LPC2E/CNRS 3 - Czech Academy of Sciences 4 - Czech Academy of Sciences 5 - Charles University 6 - Czech Academy of Sciences

We use a list of a few hundreds of interplanetary shocks identified in the solar wind, along with their estimated times of arrival to the Earth's bow shock, to investigate their influence on the intensity of very low frequency (VLF) electromagnetic waves measured in the Earth's inner magnetosphere. More than 6 years of the low-altitude DEMETER spacecraft (altitude of about 700 km, quasi sun-synchronous orbit at about 10:30 LT and 22:30 LT) data are used for this purpose. One component of power spectral density of electric field fluctuations is analyzed in the frequency range up to 20 kHz. Superposed epoch analysis is employed to identify systematic variations of the wave intensity related to the interplanetary shock arrival and related time delays. We note that the DEMETER spacecraft is particularly useful for this type of studies, as due to its Sun-synchronous orbit and 14 orbits per day it allows for a fast sampling of a given portion of the magnetosphere.

HSS and CME events related to change in the outer radiation belt electron flux during the Van Allen Probes mission era

Abstract ID : 750

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Jose Paulo Marchezi ,jose.marchezi@inpe.br ,(Phd. Candidate in Space Geophysics) ,Brazil ,Sao Jose dos Campos ,Not Presenting[1]

Dr. Livia Ribeiro Alves ,livia.alves@inpe.br ,(None) ,Brazil , ,Not Presenting[1]

Dr. Ligia Alves da Silva ,ligia.alves01@gmail.com ,(None) ,Brazil , ,Not Presenting[1]

1 - National Institute for Space Research - INPE 2 - National Institute for Space Research - INPE 3 - National Institute for Space Research - INPE

Changes in the solar magnetic field configuration influence the solar wind and, consequently, all the planets and spacecrafts inside the heliosphere can be affected by a disturbed solar wind condition. Coronal Mass Ejections (CME) and Solar wind High Speed Streams (HSS) cause disturbances in the Earth's magnetosphere including the Van Allen Radiation Belts. The CME events are more frequently observed during the increasing phase of the solar cycle, while HSS are more important during the decline phase. The characteristics of the disturbances observed at the Van Allen outer radiation belt electron flux due to those events are also different. Since October, 2012, NASA has launched the Van Allen Probes Mission that monitor the magnetic field and particles variation on the radiation belts. This work aims to survey, during the Van Allen Probes era, the change on the electron's outer radiation belt during CME and HSS. All the events were compiled and performed an statistical analysis of the occurrence of reduction, enhancements or small variations in the flux related to those events reported through October, 2012 to December, 2016.

The Identification of Waves at Discrete Frequencies in the Magnetosphere: the Role of the Spectral Analysis Techniques and the Relations with Solar Wind Fluctuations

Abstract ID : 225

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Simone Di Matteo ,simone.dimatteo@aquila.infn.it ,(PhD Student) ,Italy ,L'Aquila ,Presenting[1]

Prof. Umberto Villante ,umberto.villante@aquila.infn.it ,(None) ,Italy , ,Not Presenting[1]

1 - University of L'Aquila 2 - University of L'Aquila

Mr. Simone Di Matteo, University of L'Aquila, Italy
Prof. Umberto Villante, University of L'Aquila, Italy
The identification of ULF waves at discrete frequencies (~1-5 mHz) in the magnetosphere has been extensively discussed in previous works, with some controversial results regarding the existence of sets of favoured frequencies. Following a recent analysis devoted to the critical aspects of the identification of waves in the solar wind streams following interplanetary shocks (i.e. the performance of different methods for the spectral analysis in presence of multi-component signals and/or non-persistent waves; *Di Matteo and Villante,* 2017), we compare and combine the results of two methods: the Welch Method and the Multi-Taper Method. We focus attention on the manifestation of waves in the magnetic field measurements following Sudden Impulses at geostationary orbit and on their relations with the fluctuations in the solar wind dynamic pressure. We investigate the possible occurrence of favoured frequencies and their manifestation in different LT sectors. Some case events are discussed in detail to elucidate the problems related to the analytical methods and signal characteristics.

EMIC wave propagation in the magnetosphere

Abstract ID : 1054

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Eun-Hwa Kim ,ehkim@pppl.gov ,(None) ,United States , ,Not Presenting[1]

Dr. Jay Johnson ,jrj@andrews.edu ,(None) ,United States ,Michigan ,Presenting[2]

Dr. Ernest Valeo ,valeo@pppl.gov ,(None) ,United States , ,Not Presenting[1]

1 - Princeton Plasma Physics Laboratory 2 - Andrews University 3 - Princeton Plasma Physics Laboratory

We explore the dependence of EMIC waves on plasma conditions using a recently developed 2D full-wave code. The plasma in our code is specified based on empirical models, such as the global core plasma model (GCPM, http://plasmasphere.nasa.gov/models/). In particular, we focus on role of heavy ions on EMIC wave propagation. Recent 2D full-wave calculations showed that left-hand polarized EMIC waves cannot propagate to the ionospheric altitude in 5% He plasmas, but unguided right-hand polarized waves propagate to the inner magnetosphere. By adopting the empirical density structures for various Kp index and magnetic local time, we discuss how EMIC wave propagation varies along plasma density spatial structures, wave frequency, and L-shell, as well as heavy ion density ratio.

SMILE: Sun-Earth connection imaging mission

Abstract ID : 1374

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. C. Philippe Escoubet ,philippe.escoubet@esa.int ,(Project Scientist) ,Netherlands ,Noordwijk ,Presenting[1]

Dr. Chi Wang ,cw@spaceweather.ac.cn ,(None) ,China , ,Not Presenting[2]

Dr. Graziella Branduardi-Raymont ,g.branduardi-raymont@ucl.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. Steve Sembay ,sfs5@leicester.ac.uk ,(None) ,United Kingdom , ,Not Presenting[4]

Dr. Li Dai ,ldai@spaceweather.ac.cn ,(None) ,China , ,Presenting[5]

Dr. Lei Li ,lil@nssc.ac.cn ,(None) ,China , ,Not Presenting[5]

Mr Eric Donovan ,edonovan@ucalgary.ca ,(None) ,Canada , ,Not Presenting[7]

Dr. Emma Spanswick ,elspansw@ucalgary.ca ,(None) ,Canada , ,Not Presenting[8]

Dr. David Sibeck ,david.g.sibeck@nasa.gov, ,(None) ,United States , ,Not Presenting[9]

Dr. Andy Read ,amr30@leicester.ac.uk, ,(None) ,United Kingdom , ,Not Presenting[10]

Mr. David Agnolon ,David.Agnolon@esa.int ,(None) ,Netherlands , ,Not Presenting[11]

Mr. Walfried Raab ,Walfried.Raab@esa.int ,(None) ,Netherlands , ,Not Presenting[11]

Mr. Chris Runciman ,Chris.Runciman@esa.int ,(None) ,Netherlands , ,Not Presenting[11]

Mr. Arno Wielders ,arno.wielders@esa.int ,(None) ,Netherlands , ,Not Presenting[11]

Dr. Andrew Dimmock ,andrew.dimmock@aalto.fi ,(None) ,Finland , ,Not Presenting[11]

Mr. Jing Li ,lijing@nssc.ac.cn ,(None) ,China , ,Not Presenting[5]

Dr. Jianhua Zheng ,zhengjianhua@nssc.ac.cn ,(None) ,China , ,Not Presenting[5]

Dr. Jens Romstedt ,jens.romstedt@esa.int ,(None) ,Netherlands , ,Not Presenting[11]

Dr. David Lumb ,David.Lumb@esa.int ,(None) ,Netherlands , ,Not Presenting[11]

1 - ESA 2 - National Space Science Center, Chinese Academy of Sciences 3 - MSSL 4 - Liecester U. 5 - NSSC/CAS 6 - NSSC/CAS 7 - The University of Calgary 8 - Calgary U. 9 - NASA/GSFC 10 - Leicester U. 11 - ESA/ESTEC 12 - ESA/ESTEC 13 - ESA/ESTEC 14 - ESA/ESTEC 15 - ESA/ESTEC 16 - NSSC/CAS 17 - NSSC/CAS 18 - ESA/ESTEC 19 - ESA/ESTEC

The interaction between the solar wind and the Earth's magnetosphere, and the geospace dynamics that result, is a fundamental process in plasma physics. Understanding how this vast system works requires knowledge of energy and mass transport, and coupling between regions and between plasma and neutral populations. In situ instruments on a fleet of solar and solar wind observatories now provide unprecedented observations of the external Sun-Earth connection drivers. However, we are still unable to quantify the global effects of those drivers, including the conditions that prevail throughout geospace. This information is the key missing link for developing a complete understanding of how the Sun gives rise to and controls Earth's plasma environment and space weather.

Solar wind Magnetosphere Ionosphere Link Explorer (SMILE) is a novel self-standing mission dedicated to observing the solar wind-magnetosphere coupling via simultaneous in situ solar wind/magnetosheath plasma and magnetic field measurements, X-Ray images of the magnetosheath and polar cusps, and UV images of global auroral distributions. Remote sensing of the cusps with X-ray imaging is now possible thanks to the relatively recent discovery of solar wind charge exchange (SWCX) X-ray emission, first observed at comets, and subsequently found to occur in the vicinity of the Earth's magnetosphere. SMILE is a collaborative mission between ESA and the Chinese Academy of Sciences (CAS) that was selected in November 2015 and is due for launch at the end of 2021. The SMILE science as well as the results of the on-going study undertaken jointly by ESA and CAS will be presented.

Polar caps of Ganymede and Callisto

Abstract ID : 1372

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Katrin Stephan ,Katrin.Stephan@dlr.de ,(None) ,Germany ,Berlin ,Not Presenting[1]

Mr. Harald Hoffmann ,Harald.Hoffmann@dlr.de ,(None) ,Germany , ,Not Presenting[2]

Mr Ralf Jaumann ,ralf.jaumann@dlr.de ,(None) ,South Africa ,None ,Not Presenting[1]

1 - Institute of Planetary Research, DLR, Berlin, Germany 2 - DLR 3 - Institute of Planetary Research, DLR, Berlin, Germany

Ratios of band depths of different H2O ice absorptions as measured by the Near Infrared Spectrometer NIMS onboard the Galileo spacecraft have been found to be semi-quantitative indicator of changes in the particle size of ice across the surfaces of the Jovian satellite Ganymede. This method has been now applied to Ganymede's neighboring satellite Callisto. On Ganymede, sizes reach from 1 µm near the poles to 1 mm near the equator. Smallest particles occur at latitudes higher than ±30? where the closed magnetic field lines of Ganymede's magnetic field change into open ones and Ganymede's polar caps become apparent. Thus, the formation of these polar caps has often been attributed to brightening effects due to bombardment of plasma originating from Jupiter's magnetosphere. Intriguingly, Callisto, which does not exhibit an intrinsic magnetic field, however, also shows the same trend as observed on Ganymede with slightly larger particle sizes on Callisto than on Ganymede at low and mid latitude but similar particle sizes in the polar regions. Similar trends in the particle size variations on Callisto and on Ganymede imply that these variations are caused by similar surface processes. Our measurements rather point to a continuous decreasing of ice particle sizes toward the poles on both satellites related to changes of the surface temperatures. Maximum temperatures during the day reach 150 K and 165 K near the equator of Ganymede and Callisto, respectively and sublimation of ice particles and crystal growth is expected to be the dominant surface process in these regions. In contrast, polar temperatures do not exceed 80 ± 5 K. Larger particles in the equatorial region of Callisto than on Ganymede could be explained due to the slight higher maximum temperature but also a longer Callistoan day (Callisto: ~ 17 Earth days; Ganymede: ~ 7 Earth days).

A Case Study: Magnetotail Response to the Directional Changes in Solar Wind Flows

Abstract ID : 658

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Dana Saxonbergova ,jdanka25@yahoo.com ,(Researcher) ,Czech Republic ,Praha 4 ,Presenting[1]

Mr. Zoltan Voros ,zoltan.voeroes@oeaw.ac.at ,(None) ,Austria , ,Not Presenting[2]

1 - IAP Academy of Science CR 2 - Space Research Institute, Austrian Academy of Science

For understanding the magnetospheric substorm onset it is necessary to find out whether substorm onset is always externally triggered or sometimes is a result of internal processes, which can be observed for example during northward oriented interplanetary magnetic field i.e. in the time when there is no significant flux transfer. Large directional changes in the solar wind flow, especially observed during the northward oriented interplanetary magnetic field, can result in large-scale windsock motion of magnetotail. It can lead to current sheet thinning and force magnetic reconnection in magnetospheric tail, which consequently can lead to substorm onset.
We analysed case studies of concurrent observations of the solar wind OMNI and Geotail data of distant tail's response. We present here a statistical study of the temporal resposes of magnetotail to the vertical directional changes in the solar wind flow.

Characterizing the geomagnetic field variability for the study of magnetic storm and substorm impact on electric power lines

Abstract ID : 396

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Vyacheslav Pilipenko ,space.soliton@gmail.com ,(head of laboratory) ,Russia ,Moscow ,Not Presenting[1]

1 - Geophysical Center

Geomagnetically induced current (GIC) is determined by variations of the geomagnetic field. Predominantly geomagnetic field disturbances are oriented in the N-S direction, and produced by variations of the E-W ionospheric electrojet intensity. Thus, such disturbances seemingly do not induce any significant GIC in a N-S oriented system. However, the GIC-recording system deployed by Polar Geophysical Institute in Kola Peninsula in the electric power lines elongated in the N-S direction recorded quite significant GIC during magnetic storms and substorms. A relative contribution of geomagnetic disturbances into GIC enhancements is examined using simultaneous data from the PGI GIC-recording stations and near-by IMAGE magnetometers for several geomagnetic storms and substorms. We apply various techniques to characterize the geomagnetic field variability: the vector mapping of time series, and a measure of time variations of vector angle cosines. These techniques have shown that the equivalent ionospheric currents and GICs fluctuate not just in E-W direction, but chaotically in both E-W and N-S directions. These fluctuations cannot be described by variations of the auroral electrojet intensity only, but an adequate GIC model must take into account fast changing small-scale current systems embedded into large-scale ionospheric electrojet.

Current density and electric field variation within a layered Earth model during different phases of a geomagnetic storm for Grassridge substation in South Africa.

Abstract ID : 423

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Electdom Matandirotya ,electdom@gmail.com ,(Student) ,South Africa ,Hermanus ,Presenting[1]

Prof. Pierre Cilliers ,pjcilliers@sansa.org.za ,(Senior Researcher) ,South Africa ,Hermanus ,Not Presenting[2]

1 - UZ and SANSA Space Science 2 - SANSA

Understanding the current density distribution and the electric field variation within the different layers of the Earth can contribute to the understanding of which layers should be considered for adequate GIC modelling. In this study we present results of the current density and electrical field distribution based on a Finite Element modelling of three conductivity profile configurations derived from a 7 layer Earth model of the Grassridge substation in South Africa. Using a planar layer Earth model with a one-dimensional variation of conductivity with depth and a measured geomagnetic field, it was found that the current density is not continuous at adjacent layer interfaces, while the electric field is. From the finite element method analysis, it is observed that 95 % of the total current flows above the 200 km depth. However, it is noted that as depth of the poorly conducting top layer increases, so does the enhancement of the electric field. The introduction of a highly conducting infinite layer underlying the top layers did not have a significant effect on the electric field. These results corroborate the theoretical results obtained for a two-layer Earth by Pirjola (2010). If the bottom layers are highly conductive compared to the top layer, the top layer will not have much influence on the electric field on the surface. The high frequencies of the magnetic field during the phases of the storm characterized by rapid field changes result in a lower skin depth. Thus, the incident wave will be more attenuated closer to the surface, compared to the phases of the storm when the lower frequencies dominate the spectrum of the magnetic field.

Dealing with Uncertainty in GIC Modelling: An Empirical Approach

Abstract ID : 449

Conflict Declaration : None

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Additional Information : None

Mr. Michael Heyns ,mheyns@sansa.org.za ,(Student) ,South Africa ,Hermanus ,Presenting[1]

Prof. Charles Gaunt ,ct.gaunt@uct.ac.za ,(Em. Prof,, Senior Scholar) ,South Africa ,Cape Town ,Not Presenting[2]

Dr. Stefan Lotz ,slotz@sansa.org.za ,(None) ,South Africa ,Hermanus ,Not Presenting[3]

Prof. Pierre Cilliers ,pjcilliers@sansa.org.za ,(Senior Researcher) ,South Africa ,Hermanus ,Not Presenting[3]

1 - SANSA/UCT 2 - UCT 3 - SANSA 4 - SANSA

Modelling geomagnetically induced currents (GICs) is generally split up into two distinct steps, namely the geophysical and engineering steps. This stems from the assumption that GICs at any specific node in a power network are linearly related to the horizontal vector components of an induced plane-wave geoelectric field (geophysical step) by a pair of network parameters, *a* and *b* (engineering step). Given a power network, these parameters are not easily derived explicitly but may be estimated empirically from measured GIC and geoelectric field data. A new method of ensemble estimation is used to derive estimates for *a* and *b* by solving the linear relation for more than two time instances. A geomagnetic storm time-series (of length n) of simultaneous GIC and geoelectric field data is used to solve for *a* and *b* for all possible pairs of equations, yielding approximately $n^2/2$ estimates for *a* and *b*. The most probable estimates of the parameter ensembles are used to estimate GICs for an out-of-sample dataset and are found to out-perform previous estimation methods for the Halloween Storm of 2003 in the South African power network. For the first time, it is shown that errors in GIC and geoelectric field measurements are absorbed into the network parameter estimates. Using a range of ensemble estimates, a band of possible GIC values may be calculated - this corresponds to an uncertainty estimate. It is further shown that estimated network parameters vary with GIC magnitude during an event. To limit the uncertainty brought about in the geophysical step of deriving the geoelectric field, a quasi-impedance tensor that relates the geomagnetic field directly to the measured GIC is derived using a similar approach to the ensemble estimation of network parameters.

Estimation of GIC amplitude in the Brazilian equatorial region during a moderate geomagnetic storm

Abstract ID : 1126

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Erica Monteiro Diogo ,erica.monteiro.diogo@gmail.com ,(PhD Student) ,Brazil ,São José dos Campos ,Not Presenting[1]

Dr. Antonio Lopes Padilha ,antonio.padilha@inpe.br ,(None) ,Brazil , ,Not Presenting[2]

Dr. Livia Ribeiro Alves ,livia.alves@inpe.br ,(None) ,Brazil , ,Not Presenting[3]

1 - National Institute for Space Research (INPE) 2 - National Institute for Space Research 3 - National Institute for Space Research - INPE

Geomagnetically induced currents (GIC) flowing in technological systems installed on the Earth's surface can represent a significant hazard for these systems during severe geomagnetic storms. Although GIC effects are well studied in auroral and mid latitude regions, there are few studies in low latitudes and especially in the equatorial region. The latter is characterized by the diurnal ionospheric currents of the equatorial electrojet (EEJ) that cause large magnetic disturbances in the ground within a few degrees of the magnetic equator. In this study we use data from a magnetometer array operated in N-NE Brazil between November 1990 and March 1991, previously used to evaluate the characteristics of the EEJ and to derive the Earth's conductivity structure in this area. The array extends for 3 degrees of latitude on either side of the dip equator and covers 4 degrees of longitude. Geologically, a large part of the array is located over the Parnaíba Basin, covered by a small thickness of Mesozoic and Paleozoic sediments (maximum thickness just exceeding 3000 m). Electromagnetic induction surveys show that the basement of the basin is characterized by a highly resistive central cratonic core and by adjacent less resistive mobile belts. The magnetometer data are here used to evaluate the GIC amplitude during the moderate magnetic storm of February 1-2, 1991 (Dst-index of -79 nT). The geomagnetic field was interpolated using the SECS (Spherical Elementary Current Systems) method and the amplitude of the induced currents was obtained from the available conductivity models. GIC in a transmission line was then estimated using the Lehtinen-Pirjola method. The maximum intensity calculated for the GIC was 11.4 A, obtained during the SSC (Sudden Storm Commencement) and for the region where the resistive cratonic basement of the Parnaiba Basin is located. This result derived for a moderate magnetic storm indicates that the Brazilian electric network in the equatorial region can be subject to the effect of intense GIC during more severe magnetic storms.

Heliospheric Magnetic Field And Solar Wind Behaviour During Solar Cycle 23-24

Abstract ID : 52

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Pieter B. Kotze ,pkotze@sansa.org.za ,(SA IAGA delegate) ,South Africa ,Hermanus ,Not Presenting[1]

1 - South African National Space Agency (SANSA)

Magnetic field and solar wind particle data from the ACE satellite will be used to perform a spectral analysis of the solar wind charge state ratios, e.g. O7+/O6+ and C6+/C5+ as well as the alpha to proton abundance ratios during solar cycle 23 and 24. These oxygen and carbon charge state ratios are a proxy for the electron temperature in the solar corona while the solar wind elemental composition abundances are related to processes in the source region of the solar wind. As the solar corona expands and collision rates drop, these properties are then embedded into the solar wind plasma and contrary to the solar wind velocity, do not evolve as the solar wind travels to 1 AU. Solar wind composition observations and measurements by ACE at 1 AU therefore encapsulate imprints of the conditions under which the solar wind formed. Lomb-Scargle and Morlet wavelet spectral analysis techniques will be used to investigate the evolution of several periodicities of solar wind parameters during cycle 23-24, particularly the unusual minimum between these cycles. Pearson correlation analysis between ACE magnetic field observations and solar spherical harmonic coefficients as a function of the 27-day Carrington rotation also reveals that the sectorial solar magnetic is dominating during the minimum 23-24, indicating an unusual configuration of the solar dynamo.

Solar wind properties deduced from the measurements of proton and alpha components

Abstract ID : 301

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Miss. Tereza Durovcova ,durovcova.t@gmail.com ,(student Department of Surface and Plasma Science Faculty of Mathematics and Physics Charles University) ,Czech Republic ,Prague ,Not Presenting[1]

Prof. Jana Safrankova ,jana.safrankova@mfff.cuni.cz ,(None) ,Czech Republic , ,Not Presenting[2]

Prof. Zdenek Nemecek ,zdenek.nemecek@mff.cuni.cz ,(professor) ,Czech Republic ,Prague ,Not Presenting[2]

1 - 2 - Charles University 3 - Charles University

According to different properties and origin in the corona, the solar wind is usually divided into three major types: a fast solar wind ($v \geq 500$ km/s), a slow solar wind, and a transient wind which is associated with interplanetary coronal mass ejections (ICMEs). The relative abundance of alphas to protons in the solar wind is believed to provide important information about source regions in the solar corona. The high-speed solar wind originates in coronal holes and it is related to high and nearly constant helium content (~4%), whereas highly averaged (250 days) relative alpha abundance in the slow solar wind is correlated with the sunspot numbers and ranges between 1% and 4%. ICMEs are associated with the considerably enhanced helium content (8-35%). However, compressive processes such as turbulence, co-rotating interaction regions and fast interplanetary shocks could change the parameters of alpha and proton components. We employed Wind measurements of the solar wind plasma and magnetic field for the long-term statistical study encompassing past two solar cycles. We used 2D histograms of the ratio of proton and alpha velocities and the cone angle of the interplanetary magnetic field (IMF) to distinguish changes given by a source of a particular solar wind and the changes that occurred along the path to the L1 point. We identify various combinations of solar wind types differing by the parameters of proton and alpha components and study variations of their properties. Last but not least, we discuss the differences between the cases when IMF is either nearly aligned with the solar wind velocity or nearly perpendicular to the solar wind velocity.

Solar rotation from sunspot and flocculi data in Ebro catalogs.

Abstract ID : 434

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Juan José Curto ,jjcurto@obsebre.es ,(GPS: 40.8210, 0.4955) ,Spain ,Roquetes ,Presenting[1]

Mr. Aleix Seguí ,aleixsegui12@gmail.com ,(None) ,Spain , ,Not Presenting[1]

Mr. Víctor de Paula ,vdepaula@obsebre.es ,(None) ,Spain , ,Not Presenting[1]

1 - Observatori de l'Ebre 2 - Observatori de l'Ebre 3 - Observatori de l'Ebre

The tables of sunspot and flocculi heliographic positions included in the catalogues published by the Ebro Observatory in the 1930s have recently been recovered and converted into digital format by using optical character recognition (OCR) technology. Firstly, we have analyzed these data by computing the angular velocity of several sunspot and flocculi groups. Then, the results are fitted with a differential-rotation law to compare the data obtained with the results published by other authors. We also have studied the possible relationship between the sunspot/flocculi group areas and their corresponding angular velocity. Finally, we have investigated the relative occurrence, in percentage, and the daily frequencies of every group class of sunspots (according to the Cortie classification) and flocculi as well as the North-South asymmetry of the sunspots and flocculi groups according to their velocity, frequency and areas.

Non Linear Force Free Field Modeling for a Pseudostreamer

Abstract ID : 1422

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Nishu Karna ,nishu.karna@cfa.harvard.edu ,(None) ,United States , ,Presenting[1]

Dr. Antonia Savcheva ,asavcheva@cfa.harvard.edu ,(Astrophysicist) ,United States ,Cambridge ,Presenting[1]

Dr. Sarah Gibson ,sgibson@ucar.edu ,(Senior Scientist/Section Head) ,United States ,Boulder ,Not Presenting[3]

1 - Center for Astrophysics/Harvard University 2 - Center for Astrophysics/Harvard University 3 - NCAR/HAO

In this study we present a magnetic configuration of a pseudostreamer observed on April 18, 2015 on southern east limb embedding a filament
cavity. We constructed Non Linear Force Free Field (NLFFF) model using the flux rope insertion method. The NLFFF model produces the
three-dimensional coronal magnetic field constrained by observed coronal structures and photospheric magnetogram. SDO/HMI magnetogram
was used as an input for the model. The high spatial and temporal resolution of the SDO/AIA allows us to select best-fit models that
match the observations. The MLSO/CoMP observations provide full-Sun observations of the magnetic field in the corona. The primary
observables of CoMP are the four Stokes parameters (I, Q, U, V). In addition, we perform a topology analysis of the models in order to
determine the location of quasi-separatrix layers (QSLs). QSLs are used as a proxy to determine where the strong electric current sheets
can develop in the corona and also provide important information about the connectivity in complicated magnetic field configuration. We
present the major properties of the 3D QSL and FLEDGE maps and the evolution of 3D coronal structures during the magnetofrictional
process. We produce FORWARD-modeled observables from our NLFFF models and compare to a toy MHD FORWARD model and the observations.

Comparison of helioseismic cut-off frequency formulations by the means of MHD simulation results

Abstract ID : 1486

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Philippe-A. Bourdin ,Philippe.Bourdin@oeaw.ac.at ,(Post-Doc) ,Austria ,Graz ,Not Presenting[1]

1 -

The discussion of helioseismic wave phenomena requires a self-consistent description of the plasma pressure. Magnetically active regions on the Sun are observed to have distinct wave phenomena as compared to quiet regions. With better helioseismologic diagnostics near active regions one may also better understand not only the chromospheric energy budget, but also halo formation and running penumbral waves. The line formation height (with respect to the beta=1 level) and the magnetic field inclination near the solar surface are in the same time difficult to measure and important to correctly interpret observations. With the help of a large-scale 3D magneto-hydrodynamic (MHD) model, that features an active region as bottom boundary and has shown good agreement to various observations, we may compute values for theoretically derived formulations of cut-off frequencies from the model plasma parameters. Our results show the influence of a highly dynamic solar atmosphere above and around active regions on the expected helioseismic cut-off frequencies.

Preparing the Livingston Island Geomagnetic Observatory (Antarctica) for accommodating an automatic DI-flux

Abstract ID : 374

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Santiago Marsal ,smarsal@obsebre.es ,(Researcher) ,Spain ,Roquetes ,Presenting[1]

Mr. Miquel Ibañez ,mibanez@obsebre.es ,(None) ,Spain , ,Not Presenting[1]

Mr. Oscar Cid ,ocid@obsebre.es ,(None) ,Spain , ,Not Presenting[1]

Mr. Jean Rasson ,jr@oma.be ,(Head) ,Belgium ,Viroinval ,Not Presenting[4]

Mr. Alexandre Gonsette ,agonsett@meteo.be ,(Your Magesty) ,Belgium ,Dourbes ,Not Presenting[5]

Prof. J. Miquel Torta ,jmtorta@obsebre.es ,(Head of research group) ,Spain ,Roquetes ,Not Presenting[1]

Mr. Vicent Favà ,vff@tinet.org ,(None) ,Spain , ,Not Presenting[1]

Dr. Juan José Curto ,jjcurto@obsebre.es ,(GPS: 40.8210, 0.4955) ,Spain ,Roquetes ,Not Presenting[1]

1 - Observatori de l'Ebre 2 - Observatori de l'Ebre 3 - Observatori de l'Ebre 4 - RMI 5 - IRM 6 - Observatori de l'Ebre 7 - Observatori de l'Ebre 8 - Observatori de l'Ebre

During the last austral summer survey, the Livingston Island Geomagnetic Observatory, sited in the Spanish Antarctic station, has undergone works to accommodate an automatic DI-flux. These consist in assembling a dome shelter containing a thermally regulated box especially designed to keep the new instrument at a constant temperature, and a thorough system of power management and control. The automatic DI-flux, developed by the Royal Meteorological Institute of Belgium (RMI), consists of a theodolite with two sensitive elements: the usual fluxgate magnetometer and a rate gyroscope for the True North referencing. It is projected to be installed during the next Antarctic survey, and it is intended to carry out continuous absolute measurements of the geomagnetic field, including the nine months of the winter season that the Spanish Antarctic station is unmanned. We show all the designs and preparations that have been undertaken.

Timestamping corrections of geomagnetic measurements with an open source magnetic pulser

Abstract ID : 636

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Mojca Miklavec ,mojca.miklavec@viviss.si ,(Head of Laboratory for Geomagnetism and Aeronomy) ,Slovenia ,Sezana ,Presenting[1]

Mr. Matjaz Vencelj ,matjaz.vencelj@ijs.si ,(None) ,Slovenia , ,Not Presenting[2]

Mr. Achim Morschhauser ,mors@gfz-potsdam.de ,(Staff Scientist) ,Germany ,Niemegk ,Not Presenting[3]

1 - Higher Education Centre Sezana 2 - Jozef Stefan Institute 3 - GFZ Potsdam

INTERMAGNET recommends keeping the timestamping accuracy of 1-second data below 10 ms. Due to longer delays introduced by analogue or digital filters and various steps in the data acquisition chain it is important to be able to measure the time delay with the help of a precise magnetic pulser. We developed an open-source low-cost generator of magnetic pulses based on Arduino with a GPS module that can be used to characterise the time delays in data acquisition chain. We discovered that while binary pulses are much easier to implement, being able to set a gradual slope and change the time delay from the PPS pulse offers a number of benefits, including much more reliable measurement of timing.
We will present the results of time delay measurements from both overhauser magnetometer and different variometers and dataloggers from three observatories. We will explain why sometimes misleading results may arise in some instrument setups and propose some improvements of the measuring procedures compared to procedures described in the INTERMAGNET TechnicalNote TN 4.

Merging Fluxgate and Induction Coil Data to produce low Noise geomagnetic Observatory Data meeting the INTERMAGNET Definitive One-second Data Standard

Abstract ID : 1082

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Heinz-Peter Brunke ,brunke@gfz-potsdam.de ,(None) ,Germany , ,Not Presenting[1]

Dr. Rudolf Widmer-Schnidrig ,widmer@geophys.uni-stuttgart.de ,(None) ,Germany , ,Not Presenting[2]

Dr. Monika Korte ,monika@gfz-potsdam.de ,(Researcher) ,Germany ,Potsdam ,Presenting[1]

1 - GFZ German Research Center for Geosciences 2 - University Stuttgart 3 - GFZ German Research Center for Geosciences

The instrument self-noise of typical fluxgate magnetometers used at geomagnetic observatories often mask ambient magnetic field variations on magnetically quiet days for frequencies above 30 mHz, especially for stations located at mid- and low-latitudes. Natural field variations referred to as pulsations (Pc-1, Pc-2, Pi-1) fall in this band. Usually their intensity is so small that they rarely surpass the instrumental noise of fluxgate magnetometers. Moreover, high quality magnetic field observations in the band 30 mHz - 0.5 Hz contain interesting information, e.g. for the study of ionospheric electron interactions with electromagnetic ion cyclotron (EMIC) plasma waves. We propose a method to improve 1Hz observatory data by merging data from proven and tested fluxgate magnetometers with induction coil magnetometers into a single data stream. We show how measurements of both instruments can be merged without information loss or phase distortion. The resulting time series of the magnetic field vector components combines the benefits of both instruments: long term stability (fluxgate) and low noise at high frequencies (induction coil). These data clearly surpass the minimum quality requirements set in the INTERMAGNET Definitive One-second Data Standard. We present the applied algorithm and validate the results by comparing power spectra of the fluxgate magnetometer output with the merged signal. Daily spectrograms from the Niemegk observatory (NGK) show that the resulting data series reveal information at frequencies above 0.05 Hz that cannot be seen in raw fluxgate data.

The Italian magnetic repeat station network: the 2015 cartography

Abstract ID : 1262

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. DOMENICO DI MAURO ,domenico.dimauro@ingv.it ,(None) , , ,Not Presenting[1]

Mr. Guido Dominici ,guido.dominici@ingv.it ,(None) ,Italy , ,Not Presenting[1]

Mr. Antonio Meloni ,antonio.meloni@ingv.it ,(None) ,Italy , ,Not Presenting[1]

Mr. Massimo Miconi ,massimo.miconi@ingv.it ,(None) ,Italy , ,Not Presenting[1]

Mr. Fulvio Biasini ,fulvio.biasini@ingv.it ,(None) ,Italy , ,Not Presenting[1]

Mrs. Lili Cafarella ,lili.cafarella@ingv.it ,(None) ,Italy , ,Not Presenting[1]

1 - INGV 2 - INGV 3 - INGV 4 - INGV 5 - INGV 6 - INGV

In Italy INGV (Istituto Nazionale di Geofisica e Vulcanologia) has systematically undertaken the task of periodically making measurements of the Earth's magnetic field on a network of more than 110 points, called the first order repeat stations, with an average spacing around 55-60 km. Measurements are repeated regularly every 5 years and, in this poster, we will present the last published cartography referred to 2015.0. The cartography was based on a survey of 122 repeat stations (including 11 stations in Albania, 3 stations in Corsica and 1 in Malta) carried out between the end of 2014 and the first months of 2015, with the purpose of updating the national magnetic cartography.
We describe the characteristics of magnetic first and second order networks, the magnetic measurements and the data reduction procedure. In agreement with the recommendations of MagNetE Committee, we report new repeat station data measured and reduced at 2015.0. An analytical expression, a second order polynomial, in latitude and longitude for the field elements was used, and coefficients for 2015.0 and average secular variation over the period 2010-2015 were determinated The new maps for Italy of the elements D, F, H and Z, at the epoch 2015.0, are shown. A selection of stations from the Italian Magnetic Network, based on their low values of anomaly with respect to a 'normal' field is also proposed for future surveys.

Geomagnetic Field Observatories run by Italian INGV

Abstract ID : 1376

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mrs. Lili Cafarella ,lili.cafarella@ingv.it ,(None) ,Italy , ,Not Presenting[1]

Mr. DOMENICO DI MAURO ,domenico.dimauro@ingv.it ,(None) , , ,Presenting[1]

Mr. Achille Zirizzotti ,achille.zirizzotti@ingv.it ,(None) ,Italy , ,Not Presenting[1]

1 - INGV 2 - INGV 3 - INGV

Istituto Nazionale di Geofisica e Vulcanologia (INGV) is responsible for systematic magnetic observations in Italy made by means of observatories and repeat stations. At present three geomagnetic observatories provide a full coverage of the whole Italian latitudinal extension. L'Aquila (AQU, central Italy) was the main Italian observatory since 1958; in 2003 AQU joined the INTERMAGNET consortium but in 2009 the city of L'Aquila was struck by a M=6.3 earthquake and also the observatory was affected. It was replaced in 2010 by a new observatory, in Duronia (DUR, 120 km apart in SE direction).
In northern Italy the INGV operates since 1964 the Castello Tesino (CTS) observatory; absolute measurements were made twice a month till the end of 2014. Starting from the end of 2014 absolute measurements are made three times a month in order to improve and reach the quality required by INTERMAGNET consortium. Recently a new observatory was installed in the southern part of Italy, in the middle of the Mediterranean (near Sicily) at Lampedusa Island; the IAGA code of the new observatory is LMP. We are working to reach also at Lampedusa the INTERMAGNET standard, since LPM data are particularly valuable as the southernmost observatory in Europe.
In addition, INGV has been involved since the eighties in geomagnetic field observations in Antarctica. In particular, during the 1986-87 austral summer a geomagnetic observatory was installed at the Italian Antarctic Base Mario Zucchelli Station (TNB) and since 1991 the recording was implemented with an automatic acquisition systems operating through the year. Lastly, in 2003 a geomagnetic observatory was installed on the Antarctic plateau, at Dome C (DMC), very close to the geomagnetic pole; it is jointly operated by INGV (Italy) and EOST (France).
New standard acquisition systems with low power industrial computers, optical fiber between instruments and dataloggers and new method of transmission allow a stable and reliable data management. A comparison among the observatories on the level of noise, spectral content and other local parameters are presented and discussed.
Acknowledgements The work on Antarctic observatories was supported by Italian PNRA (Programma Nazionale Ricerche in Antartide).
*The Italian Geomagnetic Team:*Paolo Bagiacchi, Giovanni Benedetti, Fulvio Biasini, Lili Cafarella, Domenico Di Mauro, Manuele Di Persio, Angelo Di Ponzio, Michele Di Savino, Guido Dominici,

Lucrezia Fattore, Cesidio Gizzi, Stefania Lepidi, Luciana Macera, Massimo Miconi,Emanuele Petracca, Andrea Policardi, Lucia Santarelli, Achille Zirizzotti,

Lithospheric structure of the Alboran Sea and the relationship with the seismic activity

Abstract ID : 424

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Manuel Catalán ,mcatalan@roa.es ,(Head of Geomagnetism Department) ,Spain ,San Fernando ,Not Presenting[1]

Dr. Yasmina M. Martos ,yasmar@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Jesús Galindo ,jgalindo@ugr.es ,(None) ,Spain , ,Not Presenting[3]

Dr. Gemma Ercilla ,gemma@icm.csic.es ,(None) ,Spain , ,Not Presenting[4]

1 - Real Observatorio de la Armada 2 - British Antarctic Survey 3 - Instituto Andaluz de Geofísica 4 - Instituto de Ciencias del Mar

The Alboran Sea basin is part of the Alboran Domain, and locates in the south-westernmost part of the Mediterranean, where the Eurasian and African plates interact. The geological evolution of this basin is consequence of the westward motion of the Alboran Domain since the Oligocene. It provides a good example of an extensional basin formed in a convergence regime, where the Eurasian and African plates experienced about 200 km of roughly N-S convergence between the mid-Oligocene and the late Miocene, followed by further 50 km of NW-SE oblique convergence in the late Miocene to recent times. Although seismic activity is widely distributed along the basin, its south central area (Al Hoceima area) constitutes the most active zone. In this study we use the most advance compilation of potential field marine data to get the most updated and complete picture of the Alboran Sea. Additionally we applied different image processing tools to identify the fault systems in the area, and analyzed their relationships with the most recent seismic activity. The results suggest a crustal thinning related to the southward end of the today active Al Idrissi and a new fault zone discovered in the Al-Hoceima area. Magnetic data also gives new insights in the geometry of the intermediate and basic rock bodies emplaced during the recent geodynamic evolution of the Alboran basin.

Inverting satellite magnetic field data for the Earth's magnetization

Abstract ID : 472

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Foteini Vervelidou ,foteini@gfz-potsdam.de ,(Postdoctoral researcher) ,Germany ,Potsdam ,Presenting[1]

Dr. Vincent Lesur ,lesur@ipgp.fr ,(Head of magnetic observatories) ,France ,Paris ,Not Presenting[2]

1 - GeoForschungsZentrum Potsdam 2 - Institut de Physique du Globe de Paris

Satellite magnetic field data are traditionally used as input into various inversion schemes in order to obtain models of the lithospheric magnetic field. The use of vector Spherical Harmonics allows us, however, to relate the Gauss coefficients of the lithospheric magnetic field to the Gauss coefficients of the part of the magnetization that contributes to this magnetic field. We make use of this formalism and invert magnetic field data directly for this visible part of the magnetization. Such an inversion offers the flexibility of applying appropriate constraints that depend on the characteristics of the magnetization distribution and not on the characteristics of the magnetic field. Here we present some preliminary results of the inversion of Swarm and CHAMP magnetic field data for a global magnetization model which accounts for the difference in thickness between the oceanic and the continental crust.

Aeromagnetic Constraints on the Basement Structure along the Izu Collision Zone in Central Japan

Abstract ID : 1321

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Shigeo Okuma ,s.okuma@aist.go.jp ,(Chief Senior Researcher) ,Japan ,Tsukuba ,Presenting[1]

Dr. Tadashi Nakatsuka ,tad.nktk@nifty.com ,(None) ,Japan , ,Presenting[1]

1 - Geological Survey of Japan, AIST 2 - Geological Survey of Japan, AIST

The Geological Survey of Japan, AIST has been conducting geophysical surveys such as seismic reflection, ocean floor gravity and aeromagnetic surveys in the transition zones of the Japanese Islands to better understand the subsurface structures with a special reference to active faults and geologic basement structures.

A high-resolution aeromagnetic survey has been conducted in the northern Sagami Bay, central Japan using a stinger-mounted helicopter-borne magnetic survey system. The survey was flown along E-W traverse lines and N-S tie lines spaced 250 m and 1,000 m, respectively. The flight altitudes were 150 m above sea level over offshore areas and 300 m above terrain over onshore areas, respectively. Total magnetic intensities were observed by a Cesium magnetometer at 10 Hz and flight paths were recovered by DGPS. The observed magnetic data were processed and reduced onto a smoothed observed surface by assuming of equivalent anomalies below the observation surface.

According to the compiled aeromagnetic anomaly map, a NNW-SSE trending magnetic high belt lies in the western part of the Oiso Hills and is edged by the Kozu-Matsuda fault system to the west. Local magnetic highs are also present in the east of the hills. According to a geologic map, these highs are related to the surface and subsurface distribution of late Miocene - late Pliocene volcaniclastic rocks which constitute parts of accretionary prisms formed along the Izu Collision Zone. Pairs of magnetic highs and lows are distributed over the eastern foot of Hakone Volcano and associated with distributions of volcanic products from the volcano. Since one of magnetic highs extends to the central part of the Ashigara Plain near the Sakawa River, the plain is implied to be underlain by volcanic products from the volcano.

Magnetic survey plays an important role in better understanding the basement structure of the study area for earthquake and volcanic hazards mitigations.

Aeromagnetic and airborne gravity views unveil a Pan-African transpressional orogen superimposed on a Grenvillian accretionary belt in interior East Antarctica

Abstract ID : 1455

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Fausto Ferraccioli ,ffe@bas.ac.uk ,(Science Leader Geology and Geophysics) ,United Kingdom ,Cambridge ,Not Presenting[1]

Mr. Samuel Seddon ,samon@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[1]

Mr. Wu Guochao ,wuguochao36@163.com ,(None) ,China , ,Not Presenting[3]

Dr. Carol Finn ,cfinn@usgs.gov ,(None) ,United States , ,Not Presenting[4]

Dr. Tom A Jordan ,tomj@bas.ac.uk ,(None) ,United Kingdom , ,Not Presenting[5]

Prof. Robin Bell ,robinb@ldeo.columbia.edu ,(None) ,United States , ,Not Presenting[6]

1 - NERC/British Antarctic Survey 2 - NERC/British Antarctic Survey 3 - Zhejiang University 4 - USGS 5 - British Antarctic Survey 6 - LDEO

The Gamburtsev Subglacial Mountains in interior East Antarctica are underlain by 50-60 km thick crust imaged by seismic and gravity models. In contrast, the Archean to Mesoproterozoic Mawson craton that occupies the Wilkes and Terre Adelie sector of East Antarctica features only 40-45 km thick crust. Over 200 km thick and seismically fast lithosphere underlies the Gamburtsev Province, as typically observed over Precambrian lithosphere that has not been substantially reworked during Phanerozoic subduction or collision.
Here we interpret a set of enhanced aeromagnetic and airborne gravity images, depth to magnetic and gravity anomaly sources and 2D and 3D forward and inverse models to characterise the crustal architecture of the Gamburtsev Province.
Enhanced aeromagnetic images reveal a system of subglacial faults that segment the Gamburtsev Province into three distinct geophysical domains. Offsets in high-frequency magnetic anomalies are interpreted as revealing a right-lateral predominantly transpressional intraplate fault system parallel to the previously proposed Gamburtsev Suture. Magnetic modelling provides support for the existence of positive flower structures and inferred basement push ups. Large-scale Pan-African age transpression may have occurred in interior East Antarctica in response to collision of Greater India and a mosaic of distinct Proterozoic-Archean lithospheric provinces in East Antarctica. Pan-African transpression likely reactivated pre-existing fault systems that may have been active during Grenvillian-age accretion of island arc terranes, as recently hypothesised in the interior of Eastern

Dronning Maud Land. By compiling aeromagnetic, airborne gravity, and satellite magnetic and satellite gravity data over the Gamburtserv Province and Eastern Dronning Maud Land we conclude that these two areas may potentially be linked together during the inferred Grenvillian accretionary tectonic phase. However, they appear to be separated and offset (likely in Pan-African times) along the newly identified Trans East Antarctic Shear Zone that is hypothesised here to extend from the Yamato Belgica Complex region to South Pole.

Local time dependence of SC amplitude for long data series from low-latitude magnetic observatories

Abstract ID : 432

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Juan José Curto ,jjcurto@obsebre.es ,(GPS: 40.8210, 0.4955) ,Spain ,Roquetes ,Presenting[1]

Prof. Tohru Araki ,tohru.araki.24m@st.kyoto-u.ac.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Antoni Segarra ,asegarra@obsebre.es ,(None) ,Spain , ,Not Presenting[1]

1 - Observatori de l'Ebre 2 - Department of Geophysics, Graduate School of Science, Kyoto University 3 - Observatori de l'Ebre

On the basis of long series of sudden commencements, we studied the local time dependence of Sudden Commencement (SC) amplitude. We analysed three long series with around 100 years of data from Colaba-Alibag (India), Kakioka (Japan) and Ebro (Spain) magnetic observatories, and we also worked with long series from other six low-latitude observatories: Honolulu (USA), M'Bour (Senegal), Kanoya (Japan), San Juan (USA), Fuquene (Colombia) and Port Moresby (Papua New Guinea), with SC data from 1968 to present. In all these low-latitude observatories being well distributed in longitude we obtained a regular pattern, with a minimum around 6 h LT, and a maximum around mid-night. Taking into consideration this local time dependence of SC amplitude we re-calculated the parameters in the Siscoe's linear relationship which connects the SC amplitude with the corresponding dynamic pressure variation of the solar wind. In addition to a statistical analysis at each station, we compared SC's simultaneously observed at stations with different LT. We checked how different is the longitudinal distribution of amplitude for large SC's and for small SC's.

Nowcast of the BeNeLux regional magnetic activity for use in space weather applications

Abstract ID : 582

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Stanimir Stankov ,S.Stankov@meteo.be ,(Research Scientist) ,Belgium ,Brussels ,Presenting[1]

Dr. Tobias Verhulst ,Tobias.Verhulst@meteo.be ,(None) ,Belgium , ,Not Presenting[1]

1 - Royal Meteorological Institute (RMI) 2 - Royal Meteorological Institute (RMI)

The planetary Kp index is an established choice among ionosphere/space weather researchers when an estimate of the geomagnetic activity is needed, being for research of the geomagnetic storm impact, developing of services, or as an input parameter for various models. However, the Kp index is deduced from a several magnetic observatories that are irregularly distributed around the globe and thus do not necessarily provide an accurate estimate of the local/regional magnetic activity. Moreover, the standard 3-hour time scale of producing the index is much larger than the characteristic time of various phenomena associated with active geomagnetic conditions, some types of ionospheric disturbances in particular. Also, modern space weather applications often require real-time estimation (nowcast) of the magnetic activity which necessitates some modifications in the original procedure for calculating the Kp from ground-based observations or, alternatively, the use of space-based observations (e.g. of the solar wind) for deducing a Kp proxy. This presentation is concerned with the development of a new K-type index nowcast suitable for the BeNeLux region - Belgium, The Netherlands, and Luxembourg. The nowcast is based on real-time measurements from four magnetic observatories, inside or in close proximity to that region: Dourbes (DOU; 50.1N, 4.6E), Manhay (MAB; 50.3N, 5.7E), Chambon la Foret (CLF; 48.0N,2.3E), and Wingst (WNG; 53.7N, 9.1E). The new index (K_{BLX}) closely resembles the "classical" Kp index in the sense that it is derived from 3-hour ranges estimated at the four stations using common limits of range classes. However, instead of the fixed 3-hour periods used for the Kp, in the new approach, a K_{BLX} value can be derived at any moment of time using data from the most recent three hours. Implementing this approach, a nowcast system was developed based on an automated computer procedure for real-time digital magnetogram data acquisition, data cleaning, removing the regular variation, calculating the K_{BLX} index, and issuing an alert if storm-level activity is indicated. The nominal cadence of index production is envisaged to be one hour. Preliminary results and evaluations will be presented, and possible space weather applications discussed.

Automatic detection of geomagnetic pulsations using continuous wavelet transform and Fourier surrogates

Abstract ID : 640

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Hugo Larnier ,hlarnier@unistra.fr ,(None) ,France , ,Not Presenting[1]

Dr. Aude Chambodut ,aude@unistra.fr ,(None) ,France ,Strasbourg ,Presenting[2]

Prof. Pascal Sailhac ,pascal.sailhac@u-psud.fr ,(None) ,France , ,Not Presenting[3]

1 - EOST - CNRS/University of Strasbourg 2 - EOST - University of Strasbourg 3 - Géosciences Paris Sud - UMR CNRS-UPS 8148

In the period range from 1 to 600 seconds, geomagnetic pulsations are one major source of induction of electric currents in the earth. Geomagnetic pulsations are, in particular, indicators of physical processes in the magnetosphere or act as induction source for magnetotellurics.
Geomagnetic pulsations are sorted in two main classes.
Continuous pulsations (Pc) are quasi-periodic oscillations with amplitude about the nT. The amplitude has diurnal, seasonal and even longer periods variations. Pc pulsations are separated in five main classes. For example, Pc3 amplitude is maximized during daytime and minimal during night-time.
Irregular pulsations (Pi) are short signals containing few oscillations compared to Pc pulsations. They are also subdivided into two main classes with different behaviours.
We have developed an automatic detection scheme of geomagnetic pulsations in 1Hz-magnetic observatory data, based on continuous wavelet transform (CWT) and Fourier surrogates. CWT is used to detect, on a time-frequency plane, where geomagnetic pulsations are characterized by wavelet coefficients with significant amplitude. Two criteria are set: (i) a minimum amplitude of the cross-wavelet spectrogram, and (ii) a minimum area size of thresholded coefficients. Threshold in amplitude is obtained using Fourier surrogates (obtained through the computation of synthetic magnetic time series based on the computation of an average hourly power spectrum over the analysed day). The population of surrogates is then compared to the actual analysed time series to obtain significant wavelet coefficients. The area criterion is computed from the size of the wavelet kernel above a predefined value. From the final set of wavelet coefficients, we are also able to compute horizontal polarisations attributes.
We show that this approach allows to automatically detect and characterize geomagnetic pulsations activity on geomagnetic observatory time series. The methodology has been implemented on a computing cluster to allow for fast detection and characterization of geomagnetic pulsations. Results of this algorithm have been compared to the literature about geomagnetic pulsations to assess for efficiency. We aim at implementing this procedure to make available geomagnetic pulsations characteristics in an automatic way and on a planetary scale.

Observatory data products for space weather applications

Abstract ID : 1020

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Ellen Clarke ,ecla@bgs.ac.uk ,(Geomagnetism Scientist) ,United Kingdom ,Edinburgh ,Presenting[1]

Ms. Sarah Reay ,sjr@bgs.ac.uk ,(None) ,United Kingdom ,None ,Not Presenting[2]

Dr. Gemma Richardson ,gemk@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[3]

Dr. Laurence Billingham ,laurence@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Mrs. Orsi Baillie ,orba@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Mr. Tom Humphries ,thom2@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Mr. John Williamson ,johwil@bgs.ac.uk ,(None) ,United Kingdom , ,Not Presenting[2]

Dr. Alan Thomson ,awpt@bgs.ac.uk ,(Head of Geomagnetism) ,United Kingdom ,Edinburgh ,Not Presenting[2]

1 - British Geological Survey, Edinburgh, United Kingdom 2 - British Geological Survey 3 - British Geological Survey, Edinburgh 4 - British Geological Survey 5 - British Geological Survey 6 - British Geological Survey 7 - British Geological Survey 8 - British Geological Survey

With the inclusion of space weather on the UK government's national risk register, continuous monitoring of geomagnetic activity levels and real-time dissemination of the information is essential. BGS, as a long-term operator of magnetic observatories carries out this role and provides advice on geomagnetic hazard on a daily basis. This includes human-derived predictions of geomagnetic activity levels for up to three days ahead made on a daily basis, as well as more continuous computer-based predictions of 3-hourly and daily activity indices. These local and global activity forecasts and the associated nowcasts, whether they are of well-established, IAGA endorsed, indices or other purpose-built parameters, all rely on good quality, accurate and reliable real-time observatory data as the primary essential ingredient for derivation. Near real-time processing of data from the BGS observatories can be supplemented by data from other INTERMAGNET standard observatories for the derivation of global parameters.
This poster includes a summary of this work and highlights scientific developments behind some of these space weather products, such as forecast evaluation and the value of machine learning prediction algorithms. Difficulties in finding the most suitable parameter and cadence of that parameter for given specific applications are discussed. For example this might be for the monitoring

of geomagnetically induced currents for the power industry or for the establishment of a meaningful and useful local alert system for aurorae enthusiasts.

From 1D to 3D: MT/MV inversion results of new synchronous profile data across Lake Ladoga conductivity anomaly

Abstract ID : 186

Conflict Declaration : no conflict of interests

Content Motivation : Our research was initiated in response to actual demand of the Precambrian studies in solid geophysical constraints for understanding the deep architecture and evolution of the Baltic Shield

Additional Information : Ladoga Workgroup community of researchers involved in Ladoga project are our co-authors too

Mrs. Yana Taran ,yanataran@hotmail.com ,(post graduate student Moscow State University) ,Russia ,Moscow ,Not Presenting[1]

Mr. Sergey Zverev ,zay.ser.vl@gmail.com ,(None) ,Russia , ,Not Presenting[1]

Mr. Pavel Pushkarev ,pavel_pushkarev@list.ru ,(None) ,Russia , ,Not Presenting[1]

Mrs. Elena Sokolova ,sokol_l@mail.ru ,(None) ,Russia , ,Not Presenting[4]

1 - MSU 2 - MSU 3 - MSU 4 - IPE RAS

Lake Ladoga anomaly was originally discovered by MV soundings in 1980s on the SE of the Baltic (Fennoscandian) Shield at the boundary between Archaean Karelian craton and Paleoproterosoic Svecofennian accretionary orogen. Modern stage of LLA investigations has been initiated in 2013 responding to actual demand of the Precambrian studies in solid geophysical constraints for understanding the deep architecture and evolution of the Shield in this key region, which were still absent. New MT/MV sounding experiment has overcome serious restrictions of previous phases of the studies: it is characterized by synchronous scheme of broad-band and basic long-period recording and application of advanced data processing and inversion techniques for adequate analyses of the observations. About 50 Phoenix and 20 LEMI soundings have been accomplished by "Nord-West" Ltd, MSU and KRS RAS along 200 km long Vyborg-Suoyarvi profile and supported by Finnish geomagnetic observatories, providing new reliable MT/MV data ensemble. The paper is focused on the methodology and results of Vyborg-Suoyarvi MT/MV data set interpretation, extending limits of earlier 1D approaches and proceeding to 2D and 3D analyses. New ideas on LLA deep conductivity structure have appeared already at the stage of invariant analyses of new MT/MV response function estimates, including synchronous two-sites ones. Then, in the result of application of effective 2D inversion tools and different regularization and weighting strategy testing, a geoelectrical model of the LLA cross-section has been constructed and gone through a resolution analyses with a help of synthetic inversions. At the latest stage of our interpretation, with kind support of Finnish colleagues, we have extended our collection of MT/MV data by their earlier MV responses on the territory adjacent to Lake Ladoga and then have performed full multi-component 3D inversion. The inversion results have generally approved former approach model, meanwhile showing obvious

advances of extension of the area data coverage and more adequate model approximation. Finally, the verification of latest geoelectrical models by the interpretation of regional potential fields is presented and new insights into nature of LLA and regional deep tectonic structure are discussed in comparison with old conceptions taken shape by pioneer investigators.

3-D MT modelling and HMT analysis to image the condactivity structures of Poland

Abstract ID : 310

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. Waldemar Jozwiak ,jozwiak@igf.edu.pl ,(None) ,Poland , ,Not Presenting[1]

Ms. Katarzyna Slezak ,katia@igf.edu.pl ,(Assistant) ,Poland ,Warsaw ,Presenting[2]

Dr. Krzysztof Nowo?y?ski ,kn@igf.edu.pl ,(None) ,Poland , ,Not Presenting[2]

1 - Institute of Geophysics, Polish Academy of Sciences 2 - Institute of Geophysics, Polish Academy of Sciences 3 - Institute of Geophysics, Polish Academy of Sciences

We present the results of the comparison of a 3-D inversion model based on tippers with the interpretation of Horizontal Magnetic Tensor (HMT) invariants. For the 3-D inversion, we used an electromagnetic inverse modeling program written in FORTRAN 95, called ModEM. The program is based on a standard minimum-structure, non-linear conjugate gradients algorithm (NLCG). Our work was focused on results of calculations and their comparison obtained by this program. We used a parallel implementation on a Linux cluster with the standard Message Passing Interface (MPI).
As a result, the resistivity tomography model of the lithospheric structure of the contact area between Precambrian and Phanerozoic Europe in Poland was obtained.
We used nearly 600 magnetovariational points with the period range of 10s to 10,000s. The mesh was located in Poland and it spreads over a surface area of approximately 855 km x 855 km (central part) and the depth was 800 km. The total grid size was 73 x 73 x 43, in x, y, and z directions, where the central part of the model held 57 x 57 cells (on the Earth's surface).
Based on the collected experimental material, magnetic transfer functions were determined for a wide range of periods with the aid of advanced algorithms using reference stations. As a result, we obtained a clear, three-dimensional model of conductivity distribution, where the highly conductive rock complexes appear. These complexes we tentatively connected to the past tectonic events that took place in the study area.
All tests were carried out in order to obtain the most realistic model geometries i.e. model which corresponds well to geological knowledge.

Synthetic modeling of the global induction by the GAIA Sq source model

Abstract ID : 469

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Takao Koyama ,tkoyama@eri.u-tokyo.ac.jp ,(Assistant Professor) ,Japan ,Tokyo ,Presenting[1]

Ms. Yuka Murata ,st3ymurata@mc-jma.go.jp ,(None) ,Japan , ,Not Presenting[2]

Prof. Shigeru Fujita ,sfujita@mc-jma.go.jp ,(None) ,Japan , ,Not Presenting[2]

Dr. Ikuko Fujii ,ifujii@mc-jma.go.jp ,(Associate Professor) ,Japan ,Kashiwa ,Not Presenting[4]

Dr. Kiyoshi Baba ,kbaba@eri.u-tokyo.ac.jp ,(Research Associate) ,Japan ,Tokyo ,Not Presenting[1]

Dr. Yasunobu Miyoshi ,miyoshi@geo.kyushu-u.ac.jp ,(None) ,Japan , ,Not Presenting[6]

Prof. Hitoshi Fujiwara ,h_fujiwara@st.seikei.ac.jp ,(None) ,Japan , ,Not Presenting[7]

Dr. Hidekatsu Jin ,jin@nict.go.jp ,(None) ,Japan , ,Not Presenting[8]

Dr. Hiroyuki Shinagawa ,sinagawa@nict.go.jp ,(None) ,Japan , ,Not Presenting[8]

1 - Earthquake Research Institute, The University of Tokyo 2 - Meteorological collage, Japan Meteorological Agency 3 - Meteorological collage, Japan Meteorological Agency 4 - Meteorological College, Japan Meteorological Agency 5 - Earthquake Research Institute, The University of Tokyo 6 - Department of Earth and Planetary Sciences, Kyushu University 7 - Faculty of Science and Technology, Seikei University 8 - National Institute of Information and Communications Technology 9 - National Institute of Information and Communications Technology

The electromagnetic sounding has been widely used to reveal the electrical conductivity structure in the Earth. For shorter periods than 10000 sec, a plain wave approximation of the EM field is generally used in magnetotelluric studies to elucidate structures of the subsurface, crust and uppermost mantle. For longer periods than several days, a simple dipole field distribution approximates well the EM variations in a global scale and can reveal the structure in a lower part of the mantle transition zone and lower mantle. In order to unveil the whole mantle structure, the use of intermediate period bands is inevitable. Geomagnetic fields in this band such as the Sq field, however, are known to have complicated spatial distributions and careful consideration of the distribution of the EM field must be required. On the other hand, geomagnetic observatories are sparsely and non-uniformly distributed on the ground, and thus it is difficult to detect a realistic Sq field distribution from only the geomagnetic observatory data.
In our paper, instead of conventional ways, we use the GAIA (Ground-to-topside model of Atmosphere and Ionosphere for Aeronomy) model to represent the realistic Sq field. The GAIA model

is a whole atmosphere model from the surface to the exobase including the ion and electron dynamics and the dynamo process in the ionosphere. It is noted that the GAIA model assimilates the meteorological reanalysis data (JRA-55) to the whole atmosphere-ionosphere coupled model. Therefore, it provides us 3-D grid point values of the realistic electrical current in the ionosphere.
By using the Sq model derived from the GAIA and a supposed conductivity model in the Earth, the effect of the global induction is evaluated by a comparison between computed and observed geomagnetic field data on the ground. We choose some quiet days from time series of the GAIA model and conducted numerical induction modeling in a frequency domain. Also, some synthetic inversion tests of global induction are performed.
In our presentation, we show the result of synthetic tests and its performance to elucidate the electrical conductivity structure in the mantle, especially, mantle transition zone and around.

Probing upper mantle electrical conductivity with Sq variations: An approach and Results.

Abstract ID : 759

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Ms. Martina Guzavina ,martina.guzavina@erdw.ethz.ch ,(Doctoral Student) ,Switzerland ,Zürich ,Presenting[1]

Dr. Alexander Grayver ,agrayver@erdw.ethz.ch ,(Lecturer) ,Switzerland ,Zurich ,Not Presenting[1]

Prof. Alexey Kuvshinov ,kuvshinov@erdw.ethz.ch ,(None) ,Switzerland , ,Not Presenting[1]

1 - ETH Zürich 2 - ETH Zürich 3 - ETH Zürich

Electrical conductivity of the upper mantle and transition zone can be studied using solar quiet (Sq) magnetic field variations. We parameterize Sq source in terms of spherical harmonic coefficients. These coefficients vary on a daily basis, hence we work with daily magnetic field measurements from observatories for which we determine global source coefficients using robust least-squares method. We choose geomagnetically truly quiet days around equinoxes such that Sq current system has the simplest, most symmetric shape. We determine source coefficients in a prior 3-D Earth's model using horizontal magnetic fields. The prior model consists of a 1-D background supplemented by a thin 2-D conductance layer in the uppermost part, which accounts for the ocean effect.
In daily recordings the effects from Sq and tidal magnetic signals become indistinguishable due to similar periods. Multiple coastal observatories are affected by the tidal magnetic signals. We correct for it through rigorous three-dimensional (3-D) numerical modeling of motionally-induced tidal magnetic fields. From the corrected data, we estimate transfer functions which relate global source coefficients and locally measured Z magnetic fields. The acquired estimates are thus global-to-local responses. We invert them for conductivity profile underneath observatories taking into account effect of the heterogeneous oceans. To this end, we used stochastic optimization method called Covariance Matrix Adaptation Evolution Strategy (CMAES), which explores the parameter space globally and provides uncertainties of the recovered model parameters. Finally, we compare the results of inversions in order to detect lateral variability in the recovered conductivity profiles.

Analysis of magnetotelluric data along two profiles crossing the Gour Oumelalen area (Egere-Aleksod terrane, Central Hoggar, South of Algeria)

Abstract ID : 878

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Mr. zakaria boukhalfa ,boukhalfa.zakaria1@gmail.com ,(research assistant) ,Algeria ,boumerdes ,Presenting[1]

Dr. Abderrezak Bouzid ,bouzid_a@yahoo.fr ,(None) ,Algeria , ,Not Presenting[2]

Prof. Khadidja Ouzegane ,k.ouzegane@gmail.com ,(None) ,Algeria , ,Not Presenting[3]

Prof. Abderrahmane Bendaoud ,abendaoud@gmail.com ,(None) ,Algeria , ,Not Presenting[3]

Prof. Mohamed Hamoudi ,hamoudi@usthb.dz ,(None) ,Algeria , ,Not Presenting[3]

Mr. Aboubakr Deramchi ,aboubakarderamchi@gmail.com ,(None) ,Algeria , ,Not Presenting[2]

Mr. Sofiane Saïd Bougchiche ,s.bougchiche@craag.dz ,(None) ,Algeria , ,Not Presenting[2]

Prof. Abdeslam Abtout ,abtout@hotmail.com ,(None) ,Algeria , ,Not Presenting[2]

Mr. Walid Boukhlouf ,w.boukhlouf@craag.dz ,(None) ,Algeria , ,Not Presenting[9]

Mr. Abdelhamid Bendekken ,a.bendekken@craag.dz ,(None) ,Algeria , ,Not Presenting[9]

1 - centre de recherche en astronomie, astrophysique et géophysique (CRAAG) 2 - centre de recherche en astronomie, astrophysique et géophysique 3 - Faculté des Sciences de la Terre, de la Géographie et de l'Aménagement du Territoire, U.S.T.H.B 4 - Faculté des Sciences de la Terre, de la Géographie et de l'Aménagement du Territoire, U.S.T.H.B 5 - Faculté des Sciences de la Terre, de la Géographie et de l'Aménagement du Territoire, U.S.T.H.B 6 - centre de recherche en astronomie, astrophysique et géophysique 7 - centre de recherche en astronomie, astrophysique et géophysique 8 - centre de recherche en astronomie, astrophysique et géophysique 9 - Unité de recherche de Tamanrasset, CRAAG, P.B. 32, Tamanrasset, Algérie 10 - Unité de recherche de Tamanrasset, CRAAG, P.B. 32, Tamanrasset, Algérie

The Gour Oumelalen (GO) region is located in the northeastern part of the Egere-Aleksod terrane part of the Central Hoggar (Touareg shield, South of Algeria). This key area presents a very important diversity from lithological point of view and also deformation (thrusting, shear zone). Archean and Paleoproterozoic terrains in this region have been described as the best preserved in Central Hoggar. It is subdivided into three main units, the red series with an Archean age (2.7GA), the Paleoproterozoic Gour Oumelalen series (2.1-1.9 Ga) and Neoproterozoic series (the Toukmatine

series). Here, we report the results of a magnetotelluric survey along E-W profiles crossing the GO, from Ounane granodiorite to the East until the Amadror Wadi to the West, passing through Adrar Ounane. Magnetotelluric (MT) data were collected at 34 sites, forming two parallel E-W profiles of a hundred km long, the first profile located to the north is composed of 18 braodband measurement sites obtained from merging magnetotelluric with audio-magnetotelluric (AMT) data. The second one located 10 km south of the first, is composed of 15 MT sites. For this study we discuss the result of data analysis of the north profile. After analyzing the data following several methods, we conclude that the underlying structure beneath this profile can be described by 3D/2D model, which means a two-dimensional regional structure with superimposed small superficial three-dimensional inhomogeneities. Two strike directions were calculated for the north profile, a strike of 35° for the upper part which corresponding to the period 0.001s-30s and an 80° strike angle for the lower part beyond 30s. The magnetic transfer function data by the Real Induction Vector (Parkinson, 1962) support these directions. A first conductivity modelling of the underlying structure of the GO region along the north profile will be presented and discussed in this work.

A new declination chart for 1600-1640 based on Athanasius Kircher compilation

Abstract ID : 1063

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Prof. Maria Luisa Osete ,mlosete@fis.ucm.es ,(None) ,Spain ,Madrid ,Not Presenting[1]

Mr. F. Javier Pavón-Carrasco ,fjpavon@ucm.es ,(Marie Sk?odowska-Curie Postdoctoral Fellow) ,Spain ,Madrid ,Not Presenting[1]

Prof. Agustin Udias ,audiasva@fis.ucm.es ,(None) ,Spain , ,Not Presenting[3]

1 - Complutense University of Madrid 2 - Complutense University of Madrid 3 - Compltense University of Madrid

We present a new magnetic declination map for 1600-1640 AD based on the compilation carried out by Athanasius Kircher (1602-1680), in his book *Magnes sive de arte magnetica* (The magnet or the magnetic art) published in 1641 and reedited in 1643 and 1654. Kircher in his book presents a list of 524 observations of magnetic declination made in different parts of the world, some of them were made by himself or by his supervision and other were compiled from navigators, other geomagnetic researchers or solicited by Kircher. He suggested in 1641 the possibility of drawing a magnetic map (*Mapam magneticam*) that would present the values of declination on a world map, but he did not do so himself, this would have been the first magnetic map. We show here the magnetic map that he would have been obtained. Only in one of the 5 tables shown in his book, Kircher provided information on the longitude of the measuring point, the list of measurements given by Ioanne Teliero on his trip to the East Indian. In the rest of the data only latitude and geographical information, often very uncertain, is provided on the location of the observation point. In this work we have relocalized the observation points and correct few mistakes. A total amount of 375 observations can be considered as reliable and were used to draw a coherent magnetic declination map. The new map is compared with the expected values given by the GUFM1 model (Jackson et al. in Philos Trans R Soc Lond A 358:957-990, 2000) for 1950-1640.

Evidence of quasi-90 day oscillations in the thermosphere as revealed by GOCE measurements and MERRA/TIME-GCM

Abstract ID : 1523

Conflict Declaration : None

Content Motivation : None

Additional Information : None

Dr. Federico Gasperini ,gasperini@usu.edu ,(Postdoctoral Research Fellow) ,United States ,Logan ,Presenting[1]

Prof. Maura E Hagan ,maura.hagan@usu.edu ,(None) ,United States , ,Not Presenting[1]

Prof. Jeffrey M Forbes ,forbes@colorado.edu ,(Professor) ,United States ,Boulder ,Not Presenting[3]

1 - Utah State University 2 - Utah State University 3 - University of Colorado

In the last decade evidence has demonstrated that terrestrial weather significantly impacts the ionosphere-thermosphere (IT). Periodic absorption of solar radiation in local time and longitude by tropospheric water vapor and stratospheric ozone as well as latent heat release in clouds generate a spatially- and temporally-evolving spectrum of global-scale atmospheric waves. A subset of these waves propagates vertically, evolving with height due to wave-mean flow, wave-wave, and wave-plasma interactions, and driving electric fields of tidal origin in the dynamo region. One of the largest waves that is known to greatly affect the IT is the diurnal eastward propagating wave with zonal wavenumber 3 (DE3). In this work, using neutral density and cross-wind measurements from the Gravity field and steady-state Ocean Circulation Explorer (GOCE) satellite, we present evidence of a new and persistent global-scale quasi-90 day oscillation in the thermosphere possibly connected to DE3 originating in the tropical troposphere. We investigate the origin and nature of this oscillation taking advantage of a high-resolution numerical simulation from the National Center for Atmospheric Research (NCAR) Thermosphere Ionosphere Mesosphere Electrodynamics General Circulation Model (TIME-GCM) with the lower boundary based on Modern Era Retrospective-Analysis for Research and Applications (MERRA) re-analysis data.