PREFACE-PIRATA-CLIVAR Tropical Atlantic Variability Conference

August 25th – 27th 2015, Breakwater Lodge, Cape Town, South Africa

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ORAL PRESENTATIONS (excluding welcome and introductory session)

(By order of presentation)

Session 1 - Key oceanic processes in the eastern Tropical Atlantic, observations and modelling

Title: 1) Impact of Resolving Along-Shore Wind Structure on the SST Bias and Coastal circulation along Angola-Benguela Coast AND **2) The Benguela Coastal Low-Level Jet: An Atmospheric Source of Oceanic Bias in the Angola-Benguela Frontal Zone** (*2 orals combined into 1*)

Authors and affiliations: Jaison Kurian[1], Christina M. Patricola[1], Ping Chang[1], Ramalingam Saravanan[1]

[1] Texas A&M University, College Station, TX, USA

Abstract 1: The southeast tropical Atlantic is one of the regions where global climate models consistently exhibit warm sea surface temperature (SST) bias, which can exceed 5°C off the coast of Africa. Previous studies suggest this SST bias originates from both atmospheric model errors in the wind and heat flux and the ocean model errors in simulating the coastal circulation and the sharp thermocline along Angola coast.

Using Regional Ocean Modelling System (ROMS) ocean simulations at 27 and 9 km resolutions, forced with winds, heat and freshwater flux from CORE II (Coordinated Ocean-Ice Reference Experiments, Version II) and outputs from a hierarchy of WRF (Weather Research and Forecasting model) simulations at 81, 27 and 9 km resolutions, we investigate the sensitivity of this SST bias to the wind forcing. In particular, we explore the impact of wind spatial pattern, coastal wind drop-off and the double core structure of the Benguela coastal low-level jet (BCLLJ, presented in detail in a companion talk) on SST simulation in this region. The 27 and 9 km winds from WRF have a more realistic BCLLJ structure compared to CORE II winds, which in turn significantly reduce the simulated SST bias in the ocean model compared to that from the coarse resolution (1.875°) CORE II dataset. In addition, high-resolution WRF winds lead to more realistic coastal circulation and upwelling in the ROMS simulations.

Abstract 2: Coupled atmosphere-ocean general circulation models (AOGCMs) have long been plagued by persistent warm sea surface temperature (SST) biases in the eastern equatorial and southeastern tropical Atlantic, where biases can reach 6-10°C off the coast of Namibia and Angola near the Angola-Benguela Front (ABF). SST biases near the ABF are sensitive to the surface wind-stress curl associated with the Benguela coastal low-level jet (BCLLJ), a southerly jet oriented parallel to the Angola coast, however, little has been documented about this atmospheric source of oceanic bias.

We investigated the characteristics and dynamics of the BCLLJ using observations, reanalyses, and a suite of atmospheric model simulations at 9, 27, 81, and 243 km horizontal resolution. Coarse resolution (2.5°) reanalyses, such as CORE-II and NCEP-II, have severe biases in the BCLLJ and show a single broad jet core at the surface, while the BCLLJ represented in the Cross-Calibrated Multi-Platform (CCMP) Ocean Surface Wind Vector Analyses shows two near-shore preferred jet core

regions, one near the ABF at 17.5°S, and the other near 25-27.5°S. Momentum budget analysis suggests that the preferred location of the BCLLJ core near the ABF relies on the conditions of coastal topography, the convex coastal geometry, and surface friction, which permit a maximum in the meridional pressure gradient. The BCLLJ structure is represented well in 9, 27, and 81 km resolution atmospheric model simulations, while the 243 km simulation fails to represent the core near the ABF, suggesting insufficient resolution contributes to the BCLLJ biases in CORE-II and NCEP-II. This also highlights the need for a sufficiently resolved BCLLJ in coupled AOGCMs in order to reduce ocean model bias. A companion presentation will demonstrate that fine resolution BCLLJ forcing considerably improves SST bias in the ABF region in ocean model simulations.

Title: Annual and semi-annual variations of equatorial Atlantic circulation associated with basin mode resonance

Authors and affiliations: PETER BRANDT[1], MARTIN CLAUS[1], RICHARD J. GREATBATCH[1], ROBERT KOPTE[1], JOHN M. TOOLE[2], WILLIAM E. JOHNS[3]

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Abstract: The seasonal circulation variability in the tropical Atlantic is dominated by the annual cycle. Despite a weak forcing at semi-annual period, the semi-annual cycle is relatively enhanced. Here we use multi-year full-depth velocity measurements from the central equatorial Atlantic, 23°W, to analyse the vertical structure of annual and semi-annual variations. The annual cycle is dominated by the 4th baroclinic mode, the semi-annual cycle by the 2nd baroclinic mode. Similar local behaviour is found in a high-resolution general circulation model (GCM). The GCM simulation reveals that the annual, 4th baroclinic mode variability and the semi-annual, 2nd baroclinic mode variability are associated with characteristic basin-wide structures. The observed circulation variability and the simulated basin-wide structures are well replicated by resonant equatorial basin modes as simulated with an idealized linear reduced-gravity model. Different model simulations with the reduced-gravity model varying the basin form, i.e. square box versus realistic coast lines, and forcing, i.e. spatially constant versus spatially varying wind forcing, show a structural robustness of the simulated basin mode. A main focus of this study is the understanding of the seasonal variability of the Equatorial Undercurrent (EUC) as identified in recent observational studies. Main characteristics of the EUC including seasonal variability of transport, core depth, and maximum core velocity can be explained by the linear superposition of the two dominant equatorial basin modes as obtained from the reduced-gravity model and the mean velocity of the EUC.

Title: Mixing in the Tropical Atlantic: the contribution of tides, intra-seasonal winds and equatorial dynamics.

Authors and affiliations: Julien Jouanno (LEGOS, IRD) and Xavier Capet (LOCEAN, CNRS)

Abstract: The aim of this study is to clarify the distribution of mixing in the Tropical Atlantic in a very high resolution regional model configuration (1/36º, 300 vertical levels) based on the NEMO model. Sensitivity experiments allowed to evaluate the influence of tides, intra-seasonal winds, equatorial dynamics, rough bathymetry, and mid-Atlantic ridge to mixing distribution and intensity. Comparison with a state of the art lower resolution model (1/4º) point out challenging issues on how models are able to represent interior mixing.

Title: Forcing of the Atlantic Equatorial Deep Jets derived from observations

Authors and affiliations: MARTIN CLAUS[1], RICHARD J. GREATBATCH[1], PETER BRANDT[1], JOHN M. TOOLE[2]

[1] GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Kiel, Germany, [2] Woods Hole Oceanographic Institution, Woods Hole, MA, USA

Abstract: The Equatorial Deep Jets (EDJs) are an ubiquitous feature of all equatorial oceans and, in the Atlantic Ocean, they are the dominant mode of inter-annual variability of the zonal flow at intermediate depth. On the basis of more than 10 years of moored observations of zonal velocity at 23°W, the vertically propagating EDJs are best described as superimposed oscillations of the 10th to the 25th baroclinic mode, whereby the dominant oscillation period for all modes is 1660 days. For each mode, this period is close to the resonance period of the respective gravest equatorial basin mode. Since the equatorial basin mode is composed of linear equatorial waves, i.e. equatorial Kelvin and Rossby waves, we employ a linear reduced gravity model for each baroclinic mode, driven by spatially homogeneous zonal stress oscillating with the EDJ period. The fit of the model solutions to observations at 23°W yields a basin wide reconstruction of the EDJs and the associated vertical structure of their forcing. The robustness of these model results is tested by using different domains, i.e. rectangular basin versus basin with realistic coast line, and by changing the amount of lateral eddy viscosity. From the resulting vertical profile of mean power input on the equator it follows that the EDJs are maintained over a considerable depth range, from 400m – 2000m, with the maximum power input at 1300m. The shape of this profile together with the presence of dissipation can explain both the observed upward propagation of energy above 2000m and apparent absence of downward propagation below.

Title: Why is there a Front North of the Atlantic Cold Tongue ?

Authors and affiliations: Hervé Giordani, Guy Caniaux and A. Voldoire

CNRM/GAME (Météo-France, CNRS), 42, Av. G. Coriolis 31057 Toulouse

Abstract: The Equatorial Atlantic front is located along 1°N in the eastern equatorial Atlantic basin, at the northern boundary of the cold tongue. It separates the cold waters of the southern cold tongue from the warmest, tropical waters circulating in the Gulf of Guinea. This seasonal front appears every year from May to August, and is characterized by meridional SST gradients up to 2 to 3°C/20 km. It is thought to play an important role for the circulation in the marine atmospheric boundary layer and influence the coastal precipitation and the western African monsoon onset.

In this presentation, the processes at the origin of the equatorial front are investigated. For that, diagnosis of the frontogenesis forcings were applied on a realistic high-resolution simulation of the equatorial Atlantic in 2006. It is found that the turbulent forcing term associated with the mixed layer turbulent heat fluxes is frontolytic (meaning a destruction of the front). However, a splitting of the turbulent forcing into its low and high-frequency (wavy) components, indicates that the low-frequency forcing may initiate the equatorial front, a forcing that is finally amplified and fully maintained by dynamical effects. Finally, the dynamic forcing has a leading frontogenetic role (meaning a reinforcement of the front) and is fully driven by the meridional convergence between the Guinea Current and the South Equatorial Current.

Title: Oceanic processes associated to the interannual variability of the Atlantic Cold Tongue

Authors and affiliations: Planton, Yann; Voldoire, Aurore; Giordani, Hervé; Caniaux, Guy

CNRM-GAME, Météo-France/CNRS

Abstract: The processes governing the Atlantic Cold Tongue (ACT) development are now better understood, but the mechanisms of its interannual variability are still unclear. The aim of the present study is to explore the mechanisms leading to the cold tongue formation during cold and warm ACT events. Cold and warm ACT events are classified statistically from several datasets following a criteria derived from Richter et al. (2013) and slightly adapted. This classification allows to analyze composites of extreme events. In particular, composites of the mixed layer heat budget have been calculated, computed online in a forced global ocean model. This mixed layer heat budget is a good tool to identify the oceanic processes which control the formation of the ACT and its variability.

Consistently with earlier studies, the results show that the turbulent mixing at the base of the mixed layer plays a dominant role in controlling the ACT formation. The turbulent mixing is also the main driver of the interannual variability of the cold tongue, Cold (warm) events being associated with a strong increase (decrease) of the turbulent mixing from March to July. Not surprisingly, the vertical mixing is shown to be strongly controlled by the wind stress forcing through wind energy flux.

Horizontal advection also plays an important role in July and August: during cold events, positive advection anomalies tend to damp the ACT, while during warm events, there is a negative advection anomaly that contributes to cool the region. Consequently, the warm events are characterized by a later than usual cooling.

Title: New insight on the upper layer circulation in the Gulf of Guinea

Authors and affiliations: Herbert, Gaëlle; Bourlès, Bernard; Grelet, Jacques; Cambon, Gildas; Penven, Pierrick

IRD

Abstract: Despite of the presence of coastal upwelling and its impact on regional climate, the circulation in the Gulf of Guinea is poorly documented. Close to the coast, precise description of the Guinea Current is still needed to better understand the regional ocean and coastal upwelling dynamics. Uncertainties also remain about the fate of the eastward North Equatorial UnderCurrent (NEUC) in the eastern Tropical Atlantic. Is the eastward flow found under the Guinea Current (named the Guinea UnderCurrent : GUC) an extension of the NEUC ? In this study, we propose to analyse the upper layer circulation thanks to the analysis of in situ data obtained in the framework of various programs from several years (e.g. PIRATA and EGEE cruises). A high resolution (1/15°) numerical model based on the Regional Ocean Modelling System (ROMS) has also been implemented in order to better analyse the seasonal to interannual variability of the observed currents and associated hydrological properties. The results reveal several new insights which help us to clarify still open questions on the regional circulation and dynamics in the Gulf of Guinea. Some description of the interannual and seasonal variability is also presented and discussed.

Title: Interannual Variability of the Boreal Summer Upwelling along the Northern Coast of Gulf of Guinea

Authors and affiliations: Elisée Toualy1, Frédéric Marin2, Angora Aman1, Bernard Bourlès3

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Abstract: This study analyses a 13-year (1999-2011) time series of remotely sensed data to describe the spatial and temporal structures of sea surface temperature (SST) in the North of the Gulf of Guinea (GG). The time variability of SST in this region was dominated by the seasonal cycle, the strongest manifestation of which was the presence of cold waters in the boreal summer over a broad region extending from 7°W to 5°E, and from 2°N to the African coast. The potential role of westward-propagating waves along the African coast in the onset of this upwelling was demonstrated.

A strong interannual variability of the boreal summer coastal upwelling is also observed, with colder years in 1999-2005, in 2009 and in 2011 and warmer years in 2006-2010 (at the exception of 2009), suggesting a possible transition from stronger to weaker upwelling conditions in 2006. The year-to-year variability was strongest at the beginning and at the end of the upwelling season, thus modulating interannually the date of onset, the date of disappearance and the duration of the upwelling season. The interannual variability of the cooling suggests that the spring conditions modulate some years the magnitude of the cooling. The seasonal coastal upwelling was found to be essentially confined to the coast, but may sometimes result from the combination of both coastal processes and from changes in the global SST conditions over the northern Gulf of Guinea. The local wind forcing on this upwelling is weak corroborating previous results in this area. Some years, the annual variability of some parameters characterising the coastal upwelling are correlated to those of the Atlantic Cold Tongue.

Title: The relation of SST-bias and water mass distribution seen in a regional numerical ocean model of the Benguela system

Authors and affiliations: Martin Schmidt1, Tim Junker1, Volker Mohrholz1, Lydia Siegfried1, Anja Van der Plas2

1) Leibniz-Institute for Baltic Sea Research Warnemünde, Germany, 2) National Marine Information and Research Centre, Swakopmund, Namibia

Abstract: Numerical models of the Benguela upwelling system tend to over-estimate the SST notoriously. Hence, important processes governing the heat budget of the Benguela are not well represented either in the ocean model or in the forcing data sets. We evaluate several contributions to the model of heat budget in the Benguela system: 1) solar and long-wave downwelling radiation bias 2) coastal and curl driven upwelling in response to spatial structures in the driving wind fields 3) the mixed layer depth and its seasonal cycle 4) poleward water transport in the Eastern Boundary current system.

We present results from numerical simulations carried out with a regional ocean-only model of the Benguela system but driven with different atmospheric forcing data sets. We discuss the model performance by comparison with ship borne CTD data and with data from several moorings. The resulting water mass distribution off Namibia and its variability reveals as sensitive to the quality of the wind stress data. Driving the model with scatterometer based winds, the model water mass distribution compares well with field data. However, the same ocean model may fail completely if driven with other wind data. The key process is the different pole-ward transport of heat and salt in the eastern boundary currents. We demonstrate that a SST-bias may be the surface expression of an unrealistic water mass distribution in the Benguela system.

Besides wind driven upwelling, the pole-ward undercurrent with its nutrient and oxygen transport is a major driver of ecosystem variability in the Benguela system. Our results for the oxygen distribution off Namibia demonstrate that realistic wind fields are a basic prerequisite for a successful application of ecosystem models to the Benguela system.

Title: Sensitivity of sea surface temperature to wind stress in the Benguela upwelling system

Authors and affiliations: M. Krebs, A. Biastoch; J.; M. Latif; C. Böning

GEOMAR Helmholtz Centre for Ocean Research Kiel

Abstract: Most ocean and climate models exhibit a warm sea surface temperature (SST) bias in the upwelling areas. In order to understand the reasons for this warm bias, a global 1/2° ocean-only model with a 1/10° nest around Africa is used, which is forced by different satellite wind products with high temporal and spatial resolution, mostly based on QuikSCAT. As the theory predicts, the upwelling is directly proportional to the wind stress and therefore the wind forcing is crucial for modeling the upwelling. Other parameters turn out to be almost irrelevant. Increasing the model resolution by inserting a second nest with 1/30° horizontal resolution in the Benguela upwelling system did not show any significant effect on the amount of upwelling and the warm bias. Moreover, also the resolution of the wind forcing, which was tested by downscaling the wind data, and the temporal resolution of the wind are less important for the upwelling. Consequently, mainly the alongshore wind and its gradient are relevant for modeling the temperature in an eastern boundary upwelling system, but the usage of realistic satellite winds only improve the SST close to the coast. The offshore SST warm bias still remains, probably due to other reasons than the wind.

Title: Thermal Impact of oceanic coastal Kelvin waves along West African coasts

Authors and affiliations: Malick WADE[1], Alban Lazar[2]

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Abstract: We investigate the role of the intra-seasonal oceanic Kevin waves and their impacts on Sea Surface Temperature (SST) along the West African coast upwelling regions. Equatorially and coastally trapped intra-seasonal Kelvin waves are depicted and characterized through altimetry datasets at fine temporal and spatial scales. It is first shown that fine scales of intraseasonal coastal propagations are captured at first order by radar altimetry, despite the reputed poor quality of sea surface height anomaly reconstruction within the first fifty kilometers offshore. Hence the TOPEX-Poseidon dataset was first able to reveal, when properly filtered, an impressive continuous activity of long range SSHA propagations from the equator up to the two Atlantic extremities of Africa. Interannual run and idealized experiments supported the altimetry results, and particularly the observed amplitude and velocity changes. Details analysis of the mechanism at play during the growing and decaying phase of the Kelvin wave will be presented in the Senegal-Mauritania and the Angola-Benguela upwelling regions.

Title: Inter-annual coastal-trapped wave in the South-Atlantic ocean : Remote versus local forcing

Authors and affiliations: Marie-Lou Bachelery, Serena Illig, Isabelle Dadou

LEGOS (CNES-CNRS-IRD-UPS), Toulouse, France

Abstract: The variability of the northern part of the Benguela Upwelling System (BUS) is under the influence of both, the equatorial remote forcing and the local forcing (Ekman dynamic associated to wind and heat flux forcing). The remote forcing is mainly associated with the propagation of Equatorial Kelvin Waves (EKW) as well as the intrusion of warm, salty, high nutrient and low oxygen water. The relative influence of the remote versus the local forcing in the BUS have not been quantified yet.

We investigated the respective role of remote (EKW) and local (wind, heat fluxes) forcing on the BUS variability using a set of 4 numerical experiments based on an oceanic regional model (ROMS) at 1/12° resolution over the 2000-2008 period. The experiments only differ by their boundary conditions (surface and lateral), which are either climatological or real-time. Results show that at subseasonal timescales, the oceanic variability (Currents, thermocline and sea level anomalies) is mainly driven by the local forcing, while at interannual timescales, it is largely forced by the remote forcing. At interannual timescales, remotely forced Coastal-Trapped Waves (CTW) propagate poleward in subsurface along the African west coast to the Northern part of the BUS (up to 25°S), with phase speeds ranging from 0.9 to 1.3 m/s. The interannual variability of the local forcing modulates the magnitude of the coastal interannual event. In particular, when the local wind stress forcing is (out) in phase, the magnitude of the inter-annual event increases (decreases). Then, the dynamic processes associated with the CTW propagations are further investigated using the online budget of the temperature tracer, for two intense interannual events that occurred in 2001 and 2004. We also discuss the maximum latitude at which the signature of CTW can be observed.

Title: Contribution of upwelling filament to cross shelf transport of matter in the Northern Benguela Upwelling system

Authors and affiliations: Mohrholz, Volker[1], Flohr, Anita[2], Muller, Annethea A.[1], Rixen, Tim[2], Schmidt, Martin[1], Wasmund, Norbert[1]

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Abstract: Offshore spreading filaments of cool water are common for all major upwelling systems in eastern boundary currents. They are well known from remote sensing data of SST or water colour, but synoptic field studies are rare because of the transient character of the filaments. Here we present results of a multi-disciplinary field study carried out within an upwelling filament in the northern Benguela system during the main upwelling season. Data of the internal filament structure were gained with a towed undulating CTD, a towed current meter, and a microstructure probe. Chemical underway measurements and plankton sampling supplied additional information. The observed filament covers the upper 100 m and was found stable for a period of nearly one month. The water within the filament has enhanced density compared with the ambient ocean water. Because of the long lifetime of the filament geostrophic adjustment is observed. The resulting off-shore and on-shore transports overlay the wind driven Ekman transport. Within the filament oxygen concentration is decreased, whereas methan and CO2 concentrations are enhanced. At its special location within the northern Benguela system, the filament separates two different central water masses and serves as a mesoscale pattern extending the interface between the water bodies. High phytoplankton biomass and high measured primary productivity in the front between filament and ocean waters show its impact on the ecosystem. A regional ecosystem model of the Southeast Atlantic is able to reproduce similar mesoscale patterns.

Title: Boundary circulation and water mass variability off Angola

Authors and affiliations: Pedro Tchipalanga (1), Marissa Macuéria (1), Bomba Bazik-Sangolay, Marcus Dengler (2), Marek Ostrowski (3), Peter Brandt (2)

(1) Instituto National de Investigacao Pesqueira (INIP), Luanda, Angola, (2) GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany, (3) Institute of Marine Research (IMR), Bergen, Norway

Abstract: Repeated velocity sections from ship-board ADCP measurements collected during Austral summer and winter period between 2005 and 2013 are analyzed to describe the variability of the boundary circulation off Angola. In addition, hydrographic data from the bi-annual FA Nansen cruises between 1998 and 2014 are used to investigate the variability of water masses at the Angolan continental margin. Subsurface temperature anomalies are linked to the Angola-Benguela area index and the occurrences of Benguela Niños.

Title: Warm and cold events in the SouthEast Atlantic Ocean

Authors and affiliations: Rodrigue Anicet IMBOL KOUNGUE[1], Mathieu ROUAULT[1], Julien JOUANNO[2]

[1]Nansen-Tutu Center for Marine Environment, Department of Oceanography, University of Cape Town, [2]LEGOS - IRD

Abstract: Extreme warm (cold) events are observed in the Benguela Upwelling System (BUS). These events observed are called Benguela niños (niñas) which have considerable impacts in this area. To investigate these events, different products are used: remote sensing data for Sea Surface Temperature provided by TRMM-TMI, OI-SST; Wind speed from FLK Atlas and ERA INTERIM; altimetry with sea level height derived from AVISO. The state of the art model outputs (DRAKKAR ORCA12) is also used, and an Atlantic Tropical simulation to infer quantities such as volume transport and heat budget. The novel of this study is the usage of the Pilot and Research Moored Array in the Tropical Atlantic (PIRATA) data from 5 buoys sampling the water column along the equator.

It is shown that warm (cold) events off Angolan and Namibian coasts are generated by relaxation (strong) easterlies in the western part of the equator. That was the case for the Benguela niño 1995 (March/April) and the Benguela niña 1997 (March/April). The evolution of the warm (cold) events is clearly seen through the positive (negative) sea level anomalies. These events seem to be associated with the activities of the wind forced downwelling (upwelling) Equatorial Kelvin waves that cross the equatorial basin, and propagated poleward after reaching the African coast. Then their signatures are also observed by the development and the propagation of the positive (negative) equatorial subsurface anomalies and the thermocline anomalies (depth of isotherm 20°C) which are recorded by the local measurements from the buoys of PIRATA along the equator as a good indicator. The heat content at the Angola Benguela front seems to be dominated by the advection term in the heat budget which is a key element during the development of the warm and cold events.

Title: First results of a ocean-atmosphere mooring in the Senegalese upwelling

Authors and affiliations: Alban Lazar[1], Saliou Faye[2], Moussa Diakhaté[3], Eric Machu[4], D. Dausse[1], A.T. Gaye[3], Dominique Dagorne[4]

[1]LOCEAN-UPMC Sorbonne Universités, [2]CRODT-ISRA,, [3]LPAOSF-UCAD, [4]LPO-UBO

Abstract: In the framework of the PREFACE European project, the Joint International Laboratory ECLAIRS set up an oceanographic and meteorological buoy, dedicated to monitoring and analysis of the short and long-term changes in climate, atmosphere and marine environment within the Senegal upwelling. The buoy “MELAX » was deployed early 2015 in the heart of the Senegalese upwelling by 30m-depth at (14°20'N, 17°14'W). Data collected are, for the atmosphere, surface wind, solar radiation, humidity and rain, and for the ocean, temperatures, salinity, and currents (from the surface to the bottom) and oxygen.

We present the first months of measurements by MELAX, in particular the relationship between wind, sea surface temperatures, hydrology and current. Satellite and model data are used to provide a larger-scale context to the punctual observations.

Title: Inertial terms effects on the ocean dynamics in the Tropical Atlantic

Authors and affiliations: Sandrine DJAKOURE1, Pierrick PENVEN2, Bernard BOURLES3, Jennifer JACKSON-VEITCH4, Vamara KONE5

1) International Chair of Mathematical Physics and Applications, (ICMPA-UNESCO Chair CIPMA), University of Abomey-Calavi, Cotonou, BENIN, 2) Institut de Recherche pour le Développement (IRD), LPO, Brest, FRANCE, 3) Institut de Recherche pour le Développement (IRD), LEGOS, Brest, FRANCE, 4) Oceanography department, University of Cape Town (UCT), Cape Town, SOUTH AFRICA, 5)Centre de Recherche Océanologique (CRO), Abidjan, CÔTE D'IVOIRE.

Abstract: In the eastern Tropical Atlantic, the sea surface temperature (SST) and its variability have been found to modulate the amplitude of the African monsoon. These climate variations have economic and social consequences. Local changes in SST are principally associated with the Atlantic Cold Tongue (ACT) and the coastal upwelling in the northern Gulf of Guinea. Whereas the controls of the ACT are known, those of the coastal upwelling are not clearly identified.

The Regional Oceanic Modeling System (ROMS_AGRIF) is used to address the processes controlling the coastal upwelling in the northern Gulf of Guinea. The ocean model configurations are based on two-way nesting over the Tropical Atlantic at 1/5 resolution with a higher resolution (1/15) zoom in the Gulf of Guinea. Compared against observations from satellite and in-situ data, the model is able to reproduce the main oceanic patterns and their variability.

An idealized experiment in which the advection of momentum have been cancelled shows the importance of inertia for the North Equatorial Counter Current (NECC) and the Guinea Current (GC). In absence of inertia the NECC takes the form of zonal jets and the GC is no more detached from the coast. In the realistic experiment the GC is a board current which adjust on a length scale defined by inertia. The idealized experiment also reveals that Cape Palmas upwelling is caused by the GC detachment while the upwelling east of Cape Three Points is wind driven.

Title: An updated mixed-layer climatology of the eastern tropical Atlantic

Authors and affiliations: Willi Rath, Marcus Dengler, Peter Brandt, Sunke Schmidtko, Michael Schlundt, Robert Kopte (GEOMAR), Marek Ostrowski (IMR), Anja van der Plas (MFMR), Tim Junker (IOW), Volker Mohrholz (IOW), Abdoulaye Sarré (CRODT-ISRA), Pedro Tchipalanga, Bomba Sangolay (INIP)

Abstract: A new seasonal climatology for different components of the heat and freshwater budget in the mixed layer will be presented, that was compiled for the equatorial and eastern boundary upwelling regions in the Atlantic. This climatology constitutes the PREFACE Deliverable D3.1: "Seasonal heat and fresh water ML-balance: Dataset of the seasonal heat and fresh water mixed-layer fluxes (monthly-means) contributing to the mixed layer balances in the eastern boundary upwelling regions off northwestern and southwestern Africa and in the Gulf of Guinea."

The compilation used all publically available hydrographic data sets from global data repositories including most recent ARGO floats and glider measurements as well as previously unpublished hydrographic data from the EAF Nansen program and other programs of the PREFACE partners. The seasonal climatology of mixed-layer depth, temperature and salinity was computed on a 0.25° x 0.25° grid. The chosen interpolation scheme included an isobath-following component and a front-sharpening components originally used in the MIMOC climatology (Schmidtko et al., 2013). The data set covers the whole eastern Tropical Atlantic between 30°S and 30°N and east of 30°W.

Furthermore, an updated heat budget in the north-eastern tropical Atlantic will be presented that is calculated using the new climatology, surface-flux estimates from TROPFLUX, and ARGO- and drifter-based estimates of horizontal advection of heat.

Session 2 - Climate variability, modelling and prediction
(not yet by order of presentation)

Title: Conceptual model for meridional mode and its connection with equatorial mode in tropical Atlantic

Authors and affiliations: Mesmin Awo1, Benoit Koubodana1, Gaël Alory1,2, Ezinvi Baloitcha1

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Abstract: The equatorial mode and the meridional mode are the two main modes of interannual variability in the tropical Atlantic. A new conceptual model based on thermodynamical feedbacks is developed and calibrated for the meridional mode, based on air-sea coupling observed in a climate reanalysis. This model takes into account anomalies in the position of the intertropical convergence zone, latent heat flux, sea surface temperature and their interaction. It can explain a large part of interannual oscillations of the meridional mode, and highlights the importance of the latent heat flux on the dynamics of intertropical convergence zone. Recent studies showed that this mode can contribute to some warm events in the Atlantic cold tongue region via wave propagation or meridional advection processes. To support these findings, an ocean general circulation model is used to extract the main patterns of the meridional and equatorial modes and also investigate the impact of the meridional on the equatorial mode. In particular, the model helps to classify years when the wave propagation mechanism and/or meridional advection mechanism is active. We plan to test the connection between the meridional mode and the equatorial mode in a conceptual model framework, to see how it can improve our understanding of the cold tongue interannual variability and its potential predictability.

Title: Impact of enhanced low-level stratus on simulated SSTs, precipitation and the circulation in the tropical Atlantic sector

Authors and affiliations: Juergen Bader, Astrid Eichhorn

Max Planck Institute for Meteorology, Meteorologisches Institut der Universität Hamburg

Abstract: Most coupled atmosphere-ocean general circulation models (AOGCMs) show a substantial warm bias in sea-surface temperatures (SSTs) in the eastern tropical Atlantic. The impact of enhanced low-level clouds on SST, precipitation and the circulation in the tropical Atlantic sector is tested. Therefore, we have conducted sensitivity experiments with the atmospheric model ECHAM6 and the coupled version of it (MPI-ESM1) in which we enhance the formation of low-level stratus at the inversion layer in the low troposphere.

The impact of the enhanced low-level clouds is compared to the standard version of the models. There is a direct cloud impact by reducing the incoming solar radiation at the surface. The reduced incoming solar radiation leads to a reduction of SSTs in the eastern tropical Atlantic in the coupled atmosphere-ocean model. This in turn causes not only locally rainfall reductions in oceanic precipitation but also causes a remote precipitation enhancement over north east Brazil. These precipitation changes are associated with changes in the equatorial wind-tress forcing. The impact of the wind stress changes on the equatorial zonal SST-gradient and the seasonal cycle is also analysed.

Title: Using the Transpose-AMIP framework to disentangle atmospheric biases in the equatorial Atlantic

Authors and affiliations: Claudia Frauen, Romain Roehrig, and Aurore Voldoire

CNRM-GAME (Météo-France/CNRS), Toulouse, France

Abstract: Most state-of-the-art coupled general circulation models (GCMs), including those that contributed to the CMIP5 experiments, have serious biases in the tropical Atlantic. In particular, some recent studies showed that the warm sea surface temperature (SST) bias in this oceanic basin is partly related to a westerly bias in the equatorial surface winds during spring. In most CMIP5 models, and in particular in the CNRM-CM5 model, this wind bias already exists in atmosphere-only simulations forced with observed SSTs (AMIP).

In the present study, we compare two configurations of the CNRM-CM5 model to gain insight in the origin of this bias: a 30-year AMIP simulation and an ensemble of short-term initialized experiments following the so-called Transpose-AMIP framework. This allows us to track the development of the model bias away from a realistic initial state. Analysis of the zonal momentum budget highlights the important role of biases in the east-west pressure gradient for the set-up of the zonal wind bias, in agreement with previous studies. This appears to be linked to biases in tropical convection over the tropical Atlantic and adjacent continents. Further sensitivity experiments are carried out, in which the diabatic heating profiles over different regions are academically modified in order to distinguish if improved convective properties have an effect on the representation of the east-west pressure gradient and thus reduce the zonal wind bias. The results provide some guidance on the way forward to improve coupled GCMs over the region.

Title: On the origin and control by air-sea processes of the SST warm biases

Authors and affiliations: Hourdin, F., Gainusa-Bogdan, A., Braconnot, P., Dufresne, J.-L, Rio, C., Grandpeix, J.-Y. and Traore, A. K.

LMD/IPSL/UPMC/CNRS
LSCE/IPSL

Abstract: All but one of the CMIP5 coupled models show warm biases of sea surface temperature (SST) on the east side of the tropical oceans, over oceanic upwelling regions, that also correspond to the occurrence of strato-cumulus. Based on a cross analysis of coupled and atmosphere-alone simulations, we demonstrate that a large part of the SST biases have their origin in biases of the atmospheric model that are already present in prescribed SST experiments.
We propose new metrics that allow to anticipate those SST biases from atmosphere-alone simulations.

We also propose a decomposition of surface turbulent fluxes that allow to better interpret the readjustments that are at work in the coupling process, and that determine the relationship between the atmospheric surface flux biases and SSTs biases.

Title: Impact of sea surface temperature bias on equatorial Atlantic interannual variability in partially coupled model experiments

Authors and affiliations: M. Latif, H. Ding, R. J. Greatbatch, and W. Park
GEOMAR Helmholtz Centre for Ocean Research Kiel

Abstract: Climate models have difficulty to simulate interannual variability in the Tropical Atlantic. The strong influence of mean-state errors on the quality in simulating interannual variability is shown by Partial Coupled Model (PCM) integrations with and without surface heat flux correction. In the experiments, surface wind stress anomalies are specified from observations while the thermodynamic coupling between the atmospheric and oceanic components is still active as in the fully coupled model. The results show that the PCM can capture around 50% of the observed variability associated with the Atlantic Niño from 1958 to 2013, but only when the bias is substantially reduced using heat flux correction, with no skill otherwise. We further show that ocean dynamics explain a large part of the SST variability in the eastern equatorial Atlantic in both observations (50-60%) and the PCM experiments (50-70%) with heat flux correction, implying that the seasonal predictability potential may be higher than currently thought.

Title: Atlantic opportunities for ENSO prediction*

Authors and affiliations: Marta Martín-Rey (1-2), Belén Rodríguez-Fonseca (1-2) and Irene Polo (2,3)

(1) Instituto de Geociencias, IGEO, centro mixto UCM-CSIC, (2) Departamento de Física de la Tierra, Astronomía y Astrofísica I (Geofísica y Meteorología), Facultad de C.C. Físicas. UCM, Av/ Complutense 28040, Madrid, Spain, (3) Department of Meteorology, University of Reading, UK, PO Box 243, Earley Gate, Reading RG6 6BB, U.K.

Abstract: El Niño-Southern Oscillation (ENSO) is the dominant mode of inter-annual climate variability with worldwide impacts. The knowledge of ENSO drivers and the underlying mechanisms is crucial to improve ENSO prediction, which still remains a challenge. The recently discovered connection between an Atlantic Niño (Niña) and a Pacific Niña (Niño), through an air-sea coupled mechanism during the first and last decades of the 20th century, highlights an opportunity for ENSO prediction. Here, a statistical cross-validated hindcast of ENSO along the 20th century is presented, considering the Atlantic Sea Surface Temperatures as the unique predictor field, and a set of atmospheric and oceanic variables related to the Atlantic-Pacific connection as the predictand field. The observed ENSO phase is well reproduced and the skill is enhanced at the beginning and the end of the 20th century. This multidecadal modulation of ENSO predictability could be crucial to improve its seasonal-to-decadal forecast and associated impacts.

*This paper has been submitted to Geophysical Research Letters and it is under review

Title: High resolution atmospheric topography key to reduce south Atlantic coastal SST bias

Authors and affiliations: Sebastian Milinski, Johann H. Jungclaus, Jürgen Bader, Helmuth Haak

Max Planck Institute for Meteorology (Hamburg, Germany)

Abstract: A common feature among most of the current earth system models is a strong warm bias in sea-surface temperatures (SST) of the eastern Tropical Atlantic which is strongest south of the equator, close to the African coast. This SST bias is studied in different versions of the MPI-Earth system model. The horizontal model resolutions range from the standard configuration used for the Fifth Phase of the Coupled Model Intercomparison Project (CMIP5) at T63 (~200 km) in the atmosphere and 0.4° in the ocean to a very high-resolution set-up with T255 (~52 km) in the atmosphere and 0.1° in the ocean.

Reductions in the SST bias close to the African coast of up to 50% in the high-resolution runs are related to an improved representation of the surface-wind stress. Model integrations with different combinations of high and low resolution in the ocean and in the atmosphere have shown that the atmospheric resolution is the most crucial part. Sensitivity experiments with a modified, low-resolution orography in a high resolution atmospheric model reveal that the wind stress bias at the African coast is caused by the overshooting of the topography near the coast in lower resolution configurations of the spectral atmospheric model component.

The large scale warm bias as well as the reversed equatorial SST gradient cannot be reduced by using higher resolution in the ocean and atmosphere. Thus, the Atlantic SST biases have different causes in the model and increasing the resolution only helps to improve some of these mostly independent biases.

Title: Decadal prediction of Sahel rainfall using dynamics-based indices

Authors and affiliations: Elsa Mohino (1), Noelia Otero (2), Marco Gaetani (3)

(1) Dpto. Física de la Tierra, Astronomía y Astrofísica I, Universidad Complutense de Madrid, Madrid, Spain, (2) Institute for Advanced Sustainability Studies eV (IASS), Postdam, Germany, (3) LATMOS-IPSL, CNRS, Sorbonne Universites, UPMC and UVSQ, Paris, France.

Abstract: At decadal time scales, the capability of state-of-the-art atmosphere-ocean coupled climate models in predicting the precipitation in Sahel is assessed. A set of 13 models participating in the Coupled Model Intercomparison Project Phase 5 (CMIP5) is selected and two experiments are analysed, namely initialized decadal hindcasts and forced historical simulations. Considering the strong linkage of the atmospheric circulation signatures over West Africa with the rainfall variability, this study aims to investigate the potential of using wind fields for decadal predictions. Namely, a West African monsoon index (WAMI) is defined, based on the coherence of low (925 hPa) and high (200 hPa) troposphere wind fields, which accounts for the intensity of the monsoonal circulation. A combined empirical orthogonal functions (CEOF) analysis is applied to explore the wind fields' covariance modes, and a set of indices is defined on the basis of the identified patterns. The WAMI predictive skill is assessed by comparing WAMI from coupled models with WAMI from reanalysis products and with a standardized precipitation index (SPI) from observations. Results suggest that the predictive skill is highly model dependent and it is strongly related to the region chosen for the WAMI definition. In addition, hindcasts are more skilful than historical simulations, which suggests an added value of initialization for decadal predictability. In some models, the WAMI yields improved skill with respect to the direct rainfall outputs. Therefore, we conclude that dynamics-based indices are potentially more effective for decadal prediction of precipitation in Sahel than precipitation-based indices for those models in which Sahel rainfall variability is not well simulated. We thus recommend a two-fold approach when testing the performance of models in predicting Sahel rainfall, based not only on rainfall but also on the dynamics of the West African monsoon.

Title: Future Sahelian rainfall projections and selection of a sub-ensemble of CMIP5 models for impact studies

Authors and affiliations: Paul-Arthur Monerie; Emilia Sanchez-Gomez; Julien Boé
SUC URA 1875 CERFACS/CNRS, Toulouse, France

Abstract: The climate change effect on the West African Monsoon is evaluated with CMIP5 OGCMs under the rcp8.5 emission scenario. The projections range from an increase to a decrease of rainfall amounts, exhibiting a large spread. These differences are due to radiative forcing ranging from 4 to up to 6°C in the Saharan desert and to feeding (export) of moisture at low-level (mid-level). A majority of models exhibits a decrease (increase) of rainfall over the western (central) Sahel along with more subsidence (air ascent) and a southward location of the AEJ (more moisture flux convergence). We argue that there is no relationship between the mean biases and the projections of the climate models and defined several methodologies in order to allow a selection of models for the impact studies. Based on a classification of the model projections their aim is to take into account both the pattern of the rainfall change and the range of the CMIP5 data-set projections. A “best” ensemble of four models is also defined (composed by the cmcc_cm, gfdl_cm3, mpi_esm_lr and the mri_cgcm3 climate models). This study draw up a catalogue of the model projections.

Title: Extratropical forcing of equatorial Atlantic variability

Authors and affiliations: Hyacinth C. Nnamchi1, Jianping Li,2,3, Fred Kucharski4, In-Sik Kang5 , Noel S. Keenlyside6, Ping Chang7,8 and Riccardo Farneti4

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Abstract: The current understanding of the equatorial Atlantic Niño is largely based on the Bjerknes theory, similar to the Pacific El Niño. But it remains unclear why the dynamical predictability of equatorial Atlantic climate variability is comparatively low. We use observations and multi-model experiments to show that Atlantic Niño variability is not significantly different from a first-order autoregressive process. Largely driven by perturbations of the St. Helena subtropical anticyclone, variability of the Atlantic Niño simulated in state-of-the-art coupled models is linearly dependent on the thermodynamic component of these models (R2=0.92). The presentation will highlight the implications of these findings for improved predictability of equatorial Atlantic climate variability.

Title: Summary of IC3 (Barcelona, Spain) contribution to the PREFACE project

Authors and affiliations: Chloé Prodhomme, Eleftheria Exarchou, Danila Volpi, Virginie Guemas (IC3) Francisco Doblas-Reyes (BSC, IC3, ICREA)

Abstract: During the last two years IC3 has been involved in several aspects of the PREFACE project. This presentation will summarize the status of our contribution to the project. We have studied the coupled model bias development, also known as forecast drift, with the help of seasonal hindcasts. We assessed the role that both the resolution and ocean initialization can have on the drift using in the EC-Earth coupled model. In particular, focusing in the Angola-Benguela region, we find that there is no significant impact on the model drift of increasing horizontal resolution. We also find that initializing with different ocean reanalysis has only a weak impact on the bias development. Trying to understand the bias development, we have performed, in collaboration with Univ. Wageningen, a set of sensitivity experiments, where the model wind-stress is replaced by ERA-interim in different areas, as part of the coordinated set of experiments in WP6. We will also present results from the analysis of the interannual variability in the EC-Earth forecast system, as well as the relation between bias in the CMIP5 database and representation of seasonal to decadal variability in the tropical Atlantic. The assessment of skill in the tropical Atlantic in different coupled models will also be shown.

Title: The impact of ENSO on the South Atlantic Subtropical Dipole Mode

Authors and affiliations: Regina R. Rodrigues1, Edmo J. D. Campos2, Reindert Haarsma3

1)Department of Geosciences, Federal University of Santa Catarina, Florianópolis, Brazil, 2) Oceanographic Institute, University of São Paulo, São Paulo, Brazil, 3) Royal Netherlands Meteorological Institute, De Bilt, Netherlands

Abstract: The impact of the El Niño - Southern Oscillation (ENSO) on the South Atlantic subtropical dipole mode (SASD) is investigated using both observations and model simulations. The SASD is the dominant mode of coupled ocean-atmosphere variability in the South Atlantic. This study focuses on austral summer, when both ENSO and SASD peak. We show that negative SASD events are associated with central Pacific El Niño events by triggering the Pacific-South America wave train (PSA). The latter resembles the 3rd leading mode of atmospheric variability in the Southern Hemisphere (PSA2) and causes a weakening and meridional shift of the South Atlantic subtropical high, which then generates the negative SASD events. On the other hand, a strengthening of the South Atlantic subtropical high related to central La Niña teleconnections causes positive SASD events. Our results show that the PSA2, triggered by central Pacific ENSO events, connects the tropical Pacific to the Atlantic. This connection is absent from eastern Pacific ENSO events, which appear to initiate the 2nd leading mode of atmospheric variability in the Southern Hemisphere (PSA1). It is for this reason that previous studies have found weak correlations between ENSO and SASD. These findings can improve the climate prediction of southeast South America and southern Africa since these regions are affected by sea surface temperature anomalies of both Pacific and Atlantic oceans. Implication for the TAV will also be discussed.

Title: The Atlantic Meridional Mode and the WES feedback in CMIP5 models

Authors and affiliations: Emilia Sanchez-Gomez, Katerina Goubanova, Laurent Terray and Christophe Cassou
CNRS-CERFACS, Toulouse, France

Abstract: In this work we investigate the representation of the Atlantic Meridional Mode (AMM), and the associated mechanism (Wind-Evaporation-SST (WES) feedback) by the CMIP5 multi-model database. We compare the historical simulations from CMIP5 with observations and reanalysis using as reference period 1950-2004.

The AMM representation is obtained by using the Maximum Covariance Analysis (MCA) statistical technique focusing on winter and spring seasons, where the AMM peaks. Results show that the SST dipole of AMM is not well reproduced by most of models, zonal wind anomalies are slightly overestimated (underestimated) north (south) of equator and cross-equatorial anomalous meridional winds are in general underestimated. The links between the errors in the model mean state and the misrepresentation of AMM seem not to be evident, since the multi-model ensemble shows very similar biases in SSTs.

The physical mechanism associated to the AMM, the WES feedback, is evaluated by using the wind speed, the latent heat flux and the SSTs. Results show that a large model spread on the feedback strength exists. Further analysis is under progress to elucidate whether there is a link between the feedback strength and the representation of the AMM. In general, the first two parts of the WES the feedback, involving the interaction SST→surface wind speed → latent heat, are well simulated by the models. However models do not correctly simulated the third part, concerning latent heat → SST relation. To understand this, a study of the respective roles of the heat fluxes (radiative and turbulent) on the SSTs in the Tropical Atlantic has been analysed by using a straightforward multiple regression statistical model. Results reveal that the latent heat contribution is underestimated by models, whereas the radiative fluxes (short and long wave) contribution on SSTs is overestimated.

Title: Deterministic and stochastic aspects of El Niño's impact on Atlantic tropical cyclones

Authors and affiliations: Christina M. Patricola, Ping Chang, and R. Saravanan

Texas A&M University, College Station, Texas (USA)

Abstract: Due to a short data record that is complicated by Atlantic sea surface temperature (SST) variability, observationally based studies produce conflicting claims regarding how the location of tropical Pacific sea SST warming during El Niño, which varies from the East Pacific (EP) to Central Pacific (CP), impacts Atlantic tropical cyclone (TC) activity. We attempt to resolve this issue using large ensembles of simulations with a tropical-extratropical channel model forced by different boundary conditions to isolate the El Niño influence from the confounding effects of Atlantic SST and stochastic atmospheric variability. We find statistically significant reductions in seasonal Atlantic TC activity in response to both CP and EP El Niño. Despite large differences in the location and magnitude of tropical Pacific warming during the two El Niño types, moderate warming east of the Pacific warm pool is common to both and satisfies the SST threshold for deep convection, leading to tropical Atlantic vertical wind shear enhancements that suppress Atlantic TCs. However CP El Niño, which has occurred more frequently in recent decades, is significantly less effective at suppressing Atlantic TCs compared to EP El Niño. We also note the importance of stochastic atmospheric variability in contributing to variability in TC activity, as there is a considerable range between the maximum and minimum ACE in the ensemble of experiments for each El Niño type, despite having fixed surface and lateral boundary conditions. This large stochastic variability may explain some of the inconsistencies in observational analyses, as it is clear that analysis on an insufficient sample size could easily produce a misleading result that CP Niño drives an increase or no significant change in Atlantic TC activity.

Title: On the role of internal atmospheric processes in equatorial Atlantic variability

Authors and affiliations: Ingo Richter, JAMSTEC, Yokohama, Japan

Abstract: Major modes of tropical variability, such as El Nino-Southern Oscillation (ENSO), the Indian Ocean Dipole (IOD) have been found to arise from coupled air-sea interaction. An often invoked mechanism in this context is the Bjerknes feedback, in which equatorial zonal winds respond to sea-surface temperature (SST) anomalies in such a way as to reinforce the original anomaly. How important a role coupled feedbacks play in the equatorial Atlantic is less clear. Here we examine the issue by focusing on equatorial surface winds, which undoubtedly play an important role in driving oceanic variability in the equatorial region. We compare fully coupled general circulation models (GCMs) from the Coupled Model Intercomparison Project Phase 5 (CMIP5) with an experiment in which the atmospheric component is forced with the climatological seasonal cycle of SST. The analysis reveals that surface wind variability decreases by only about 25% when climatological SSTs are prescribed. Composite analysis of surface wind, precipitation and sea-level pressure further shows that the spatial patterns of variability remain almost unchanged in the runs with climatological SSTs. This suggests that a large portion of equatorial Atlantic surface wind variability is due to internal atmospheric processes, which may limit predictability of the equatorial Atlantic zonal mode.

Title: Oceanic Indices to Forecast the Seasonal Rainfall over the Northern Northeast of Brazil

Authors and affiliations: G. A. Hounsou-Gbo1, J. Servain2,3, M. Araújo1, E.S. Martins3, B. Bourlès2, G. Caniaux4

1) UFPE, 2) IRD, 3) FUNCEME, 4) Météo-France

Abstract: A detailed study of a lagged relationship between oceanic climate conditions in the north-west equatorial Atlantic (NWEA) and the seasonal rainfall over the northern Northeast of Brazil (NNEB) allows to identify a valuable potentiality in forecasting large climate events with a delay of a few months. The analysis, using observed sea surface variables (SST, wind stress, latent heat flux, …) and simulated subsurface temperature and salinity profiles 0-150m during the period 1974-2008, indicates that progressive perturbations in the Wind-Evaporation-SST (WES) mechanism over the NWEA during the last months of the year, and the very first months of the following year, is of prime importance to evaluate the risk of such strong climate events occurring during the subsequent core of the seasonal rainfall over NNEB in March-April. Especially interesting are the status of the barrier layer thickness (BLT) in the NWEA region from August-September, and its slow and steady evolution during the following months. Thru its relationship with the local surface dynamic conditions, such BLT perturbation during the last months of the year can be used as valuable indicator in the forecasting of especially wet or dry events over NNEB during the subsequent rainfall season. The discussion ends by a proposal to implement additional temperature/salinity sensors until 140m depth for three PIRATA moorings located in the NWEA region.

Title: Toward better understanding of the relationships between central Africa climate variability and its surrounding tropical Oceans

Authors and affiliations: Georges-Noel T. Longandjo and Mathieu Rouault
Nansen-Tutu Center for Environmental Marine Research, Cape Town, RSA
Oceanography Department, University of Cape Town

Abstract: The main objectives of this study are to advance our understanding of the relationships between Central Africa rainfall (7-32°E; 10°N-15°S) and surrounding tropical ocean basins and mechanisms linking the two. Using observational and reanalysis datasets, we have characterized various features of the austral spring rainfall anomalies by EOF analysis. The first leading mode (EOF1) is characterized by a homogeneous pattern over central Africa whereas the second mode (EOF2) features an east-west dipole pattern that distinguishes two areas: West central Africa (or Atlantic coasts, 7°-15°E) and Eastern central Africa (15-32°E) over similar latitude (10°N-15°S). We have noticed a positive trend of rainfall over Eastern central Africa since 1979 while over Atlantic Coasts there is no significant trend. The correlation between rainfall anomalies in the three domains and surrounding tropical Oceans shown that: (1) over tropical Atlantic, the SST correlation pattern with Atlantic Coast and Central Africa rainfall anomalies resembles the Atlantic zonal mode; (2) Eastern central Africa rainfall anomaly is positively correlated with the Indian Ocean and the pattern is reminiscent of the IOD. The inter-basin SST gradient index (ΔSST) has been defined as difference of detrended SST anomalies averaged over tropical Atlantic (tropical Atlantic index, 20°W-10°E, 6°N-6°S) and over western tropical Indian (western tropical Indian index, 45°-80°E, 5°N-15°S). ΔSST play a key role in modulating central Africa rainfall and it induces a low-level zonal wind anomalies that link the two surrounding Oceans. In the upper troposphere, ENSO and IOD trigger westerly wind anomalies over central Africa.

Title: Long-term Variability of NorthWest African coastal upwelling and its Predictability

Authors and affiliations: Malick Wade1, Belen Rodriguez-Fonseca2, Alban Lazar3

1) LPAOSF, UCAD, Dakar (Senegal), 2) UCM Madrid (Spain), 3) LOCEAN, Paris (France)

Abstract: The sea surface temperature variability off NorthWest Africa is largely driven by that of the Canary Current upwelling system, which in turn can be due to variations in mostly local air-sea fluxes of momentum and heat or salt, as well as changes in remote winds particularly, that induce atmosphere or ocean propagation towards this region.

This work analyses in detail and over 50 years the various causes of the interannual SST variability and how dominant environmental variables vary at decadal timescales. We use observations and atmosphere reanalyses, and statistical techniques. One of the main results discussed is the non stationarity of El Niño influence in February-March-April.

Title: Spatial-temporal characterization of climate model biases

Authors and affiliations: Davide Zanchettin, Carlo Gaetan, Angelo Rubino

University of Venice, Dept. of Environmental Sciences, Informatics and Statistics, Venice, Italy

Abstract: Climate model biases are systematic errors affecting geophysical quantities simulated by coupled general circulation models and earth system models against an observational target. To this regard, sea-surface temperature (SST) biases are a major concern due to the central role of SST properties for the dynamical coupling between the atmosphere and the ocean, and for the associated variability. Strong SST biases can be detrimental for the overall quality of historical climate simulations, they contribute to uncertainty in simulated future climate scenarios and complicate the initialization and assessment of decadal climate prediction experiments.
Inter-hemispheric and inter-basin connections are apparent between climatological SST biases. They often resemble the imprint on SSTs of dominant large-scale oceanic and atmospheric phenomena. Still, climatological values only provide a static description of a phenomenon, and the hypothesis of teleconnections between regional model biases requires further substantiation. We propose a dynamic linear model developed within a Bayesian hierarchical framework for probabilistic assessment of spatial and temporal characteristics of SST biases in ensemble climate simulations. In our formulation, the statistical model distinguishes between seasonal and longer-term bias components. In the considered Bayesian framework, the conditional estimation of bias components and their evolution accounts for uncertainty in model Gaussian error parameters through sampling of the posterior distribution of associated variances by a Monte Carlo Markov Chain.
In this contribution we illustrate a first application of the model using the MiKlip prototype system for decadal climate predictions. We focus on the tropical Atlantic Ocean – a region where climate models are typically affected by a warm SST bias - to demonstrate how our approach allows for a more reliable estimation of model biases, and for a more efficient identification of associated sources of heterogeneity, non-stationarities and propagation pathways.

Session 3 - Marine ecosystems, fisheries and climate change

Title: Explaining shifts in pelagic fauna: Redundancy analysis as tool for model evaluation

Authors and affiliations: Heino O. Fock, Stephanie Czudaj

Thünen Inst. of Sea Fisheries

Abstract: Seasonal variability in pelagic ichthyofauna as observed during the recent AWA-PREFACE cruises in 2014 and 2015 is applied to develop a methodology for climate model evaluation.

Seasonal differences in faunal composition at five oceanic stations in the subtropical North Atlantic are analysed and linked to their respective temperature and salinity fields, aggregated over 0-100 m and 0-700 m in line with CTD casts and available analysed monthly data from WOA13.

It is intended to apply this approach to project model hindcasts and thus evaluate the degree of fit between faunal and model change between the 1960's and present.

Title: Food-web structure of mesopelagic communities in high and low oxygen environments in the eastern tropical north Atlantic as identified by stable isotope analysis

Authors and affiliations: Czudaj S.1, Hoving H.J.T.2, Piatkowski U.2 & Fock H.1

1 Thuenen Insitute, Hamburg, Germany, 2 GEOMAR, Kiel, Germany

Abstract: Due to its enormous biomass and ubiquitous vertical migration the mesopelagic community forms an important trophic link between the upper and lower parts of the ocean ecosystem, thereby supporting the biological pump. Oxygen minimum zones (OMZs) have been shown to impact the vertical distribution of pelagic communities. OMZ are changing (expanding, intensifying, shoaling) and the effects on pelagic fauna have been hypothesized to include habitat shift, compression and expansion. However, the impact of OMZ change on mesopelagic communities is poorly known.

Our study analyses stable isotopes C13 and N15 of major mesopelagic food-web components (fishes, cephalopods, crustaceans) in the upper 600m, comparing net trawled specimens from the hypoxic OMZ region southeast of Cabo Verde with animals of the oxygen-rich equatorial current system between 4°N – Equator. Trophic community patterns are related to oceanographic conditions. We provide the first insights into trophic ecology of mesopelagic communities in the OMZ region. These data will set a starting point for determining the potential impact of deoxygenation on the food web structure of mesopelagic communities. Investigating such potential is important since changes to the mesopelagic community would have implications for pelagic predators that feed heavily on this group, and the biogeochemistry of the pelagic ecosystem of the eastern tropical north Atlantic.

Title: Sardine pilchardus dynamic in Cape Blanc - Cape Boujdor shelf within its upwelling ecosystem

Authors and affiliations: Najib Charouki1, Naoki Tojo2, Issa Bennazouz1, Omar Ettahiri1, Marek Ostrowski3, Aziza Lakhnigue1

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Abstract: The sardine stock in southern shelf between Cape Blanc and Cape Bojador belongs to one of the larger pelagic stocks in the world with a standing biomass in more than 4 million tons. After a period of intensive fishery in the seventies and eighties, this stock has been moderately exploited and its status is never evaluated to by over exploited. The state of the stock has been monitored through annual surveys with R/Vs “Dr. Fridtjof Nansen” until 2006 and “Al Amir Moulay Abdallah” the years after, showing consistent periods of growth followed by sudden collapse or major decline that cannot be explained as a result of fishing pressure.

This work propose an analysis of the stock indicators, mostly the fish distribution, recruitment, recruitment rate (RPS), eggs and larvae distribution and environmental factors that could be behind these fluctuations, in this case an upwelling index and NAO index.

Title: The evolution of the Angolan sardinella stock in relation to the climatic events in the eastern tropical Atlantic 1985-2014

Authors and affiliations: Barradas A.1, Miguel A. A.1, Djamila, P. M.1, Sangolay, B.B1, Rouault M.2, Ostrowski, M.3

1) Instituto Nacional de Investigacaõ Pesqueira Ilha de Luanda, C.P. 2601, Luanda, Angola, 2) Nansen-Tutu Center for Marine Environment, University of Cape Town, Rondebosch, South Africa, 3) Institute of Marine Research, Nordnesgaten 50, 5817 Bergen, Norway

Abstract: The Angolan stock of sardinella (*Sardinella aurita* and *S. maderensis*) has been exposed to a moderate fishing pressure during the last 30 years. During the same period the coastal ocean off the tropical Angola (5-13°S) experienced a series of climatic interannual perturbations, exhibited a systematic warming trend on the decadal time scale, and was dominated by a strong seasonal variability characterized by contrasting seasons of the equatorial water intrusions (February-March and October-November) and a windless upwelling (June-August). Here we relate trends in the biomass of the two species sardinella derived from acoustic surveys and in its length and composition structure by region derived from concurrent trawl observations during 1985-2014 to the climatic variability off Angola during the same period. As the coastal ocean has become warmer, sardinella biomass has been increasing. While the oceanic *S. aurita* dominated the biomass of the two species during the most of the observational period, the sedentary *S. maderensis* became dominant along the coast during 2002-2005. Whereas the latitudinal and cross-shelf fish distribution patterns were tied strongly to the seasonal cycle of environmental variability, there was little response to the interannual climatic events.

Title: Monitoring Senegalese small pelagic stocks: current state of the resource, variability and levels of exploitation

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Abstract: In Senegal, the coastal pelagic resources occupy a leading place in the landing and are mainly constituted by both sardinella species, horse mackerels, mackerels and ethmalosa. On average, they represent about 70 to 80 % of the global annual catch. The exploitation of these resources is mainly done by the small-scale fisheries. The pelagic resources follow a migratory pattern in the South part of the Canary Current Large Marine Ecosystem area located between the South Senegal and South Morocco. It is thus a shared fish resource and their management is made at a sub-regional level within the framework of the Workgroup Fishery Committee for the Eastern Central Atlantic (CECAF) under the supervision of the FAO. The current state of these resources in the light of our last annual acoustic assessment survey led in January, 2015 on Senegalese continental shelf, on the framework of the Preface project is presented in this work as well as the historic series of the biomasses estimated by the FRV Fridtjof Nansen vessel in Senegal over the last twenty years. All the acoustics surveys carry out was completed with physical measurement with CTD probe (temperature and salinity profile) and sometimes ADCP (current). At the sub-regional level, the last management measures delivered by the Workgroup CECAF are presented and state an overexploitation of the main Senegalese stocks of small pelagics i.e. Sardinella, horse mackerels, mackerel, anchovy and ethmalosa, with the exception of the sardine, the biomasses of which are not significant in Senegal until now. This work led independently by Senegal allow to discuss the effect of the departure of the last industrial foreign fisheries in 2012 which targeted small pelagics and also the potential effect of climate change as the 2015 survey complete the Nansen series, stopped in 2006, to get an 20 years overview.

Title: Toward new scenario on small pelagic fish spatial population dynamics related on both hydrodynamic and biogeochemical simulations

Authors and affiliations: Timothée Brochier,1,8, Pierre-Amaël Auger2, Patrice Brehmer1,8, Xavier Capet3, Christophe Lett4, Eric Machu5, BayeCheikh Mbaye6, Laure Pecquerie7, Modou Thiaw8, Cheikh-Baye Braham9, Omar Ettahiri10, Najib Charouki10, Philippe Verley11

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Abstract: Small pelagic fish species are keystones species in upwelling ecosystems because they are dominant in biomass and they transfer energy from low trophic levels to top predators. Upwelling ecosystems are often referred to as “wasp-waist” because only a few small pelagic species are present and operate this transfer. The atmospheric variability usually causes high fluctuation in the upwelling intensity, duration and extent. The responses of the small pelagic fish species to this variability is complex. This complexity integrates mainly fish migration, larval retention, predation, competition, fishing, food, oxygen and temperature limitations. A growing number of studies have shown that it is now possible to capture a large part of this complexity with spatially explicit biophysical individual-based models forced with accurate hydrodynamic and biogeochemical simulations of their environment. Applying a systematic sensitivity test to such a model can give important insight into the main drivers of the small pelagic fish biomass variability. Here we describe such a generic model that can be adapted for different small pelagic fish species and geographical areas. It is a full life cycle multi-generational model, which allows us to study age truncation effects, homing behaviour and evolutionary effects. As an illustration, we present results obtained for the Sardinella aurita population off North-West Africa, the main small pelagic fish species in the region. The hydrodynamic and biogeochemical environment were simulated by the coupled regional models (ROMS-PISCES) in a configuration covering the area 05°-40°N and 05°-30°W, with a ~8 km resolution over three decade(1980-2009). We argue that this approach is well-suited to data poor ecosystems. Indeed, the needs for a new species/area configuration mainly consist in (1) an accurate, i.e “validated”, inter-annual hydrodynamic and biogeochemical simulations of the environment; (2) specific Dynamic Energy Budget parameters; and (3) simple rules to reproduce fish schools kinematics. The whole provides a new framework to analyse observed fish spatio-temporal distribution and biomass complexity. Such issue can be achieved by confrontation between the different scales and aspect the modelled fish populations and the one found in the observations through the Pattern Oriented Modelling approach.

Title: Spatio-temporal variability and trends in primary productivity in the Canary upwelling system, 1998-2014

Authors and affiliations: Hervé DEMARCQ (1), Eric MACHU (2), Aissa BENAZZOUZ (3)

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Abstract: The observation of spatio-temporal patterns of primary productivity in highly productive regions and especially in upwelling systems is of particular interest in supplying a background for the understanding of climate induced changes in these key regions of the world. It has already been observed from remote sensing data sets (Demarcq, 2009) that coastal tropical areas – and specifically upwelling systems – do not respond in the same way than the open ocean to the recent climatic variability.

Here, we propose a merging of two data sets from SeaWiFS and MODIS sensor, based on empirical but precise corrections to compute spatially independent temporal trends of productivity in the Canary system, from 1998 to 2014. Self-emerging spatial trends show that the Canary system is not evolving in an homogeneous way during the observing period, highlighting distinct regional patterns related to different upwelling-favourable wind forcing.

Comparisons made with observed trends in sea surface temperature also show the growing independence of thermal effects in productivity trends.

These results are compared with outputs of the ROMS-PISCES regional coupled model during the same period for different sub-regions of the Canary system. They show different local spatial patterns but large scale consistent results in term of productivity.

These results highlight the interest of monitoring and predicting the variability in productivity in the major upwelling systems, all submitted to the combined effects of growing anthropic and climatic pressures.

Title: Bigger or smaller: Effects of climate change on intraspecific size spectra

Authors and affiliations: Heino O. Fock1, Stephanie Czudaj1, Kim Wieben2

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Abstract: Climate change induced warming in the North Atlantic affected in particular upper water layers, i.e. the mesopelagic zone. Theory predicts that individual sizes will become smaller, being constrained by metabolism and the ability to uptake oxygen. Length composition of mesopelagic fishes from recent cruises in 2014 and 2015 are compared to historical data from the 1960's and 1970's.

First results indicate that length composition in mesopelagic fishes has only marginally changed. Implications for food web structure are discussed.

Title: An individual-based model study of *Sardinella aurita* early life history in the northern Gulf of Guinea

Authors and affiliations: Koné Vamara1, Lett Christophe2, Penven Pierrick3, Bourlès Bernard4, Djakouré Sandrine3

1) Centre de recherches Océanologiques d'Abidjan, Côte d'Ivoire, 2) Institut de Recherche pour le Developpement (IRD)- UMI 209 UMMISCO, Centre de Recherche Halieutique Méditerranéenne et Tropicale (CRHMT), Sète, France, 3) Laboratoire de Physique des Océans (LPO) Ifremer, UMR 6523, CNRS/IFREMER/IRD/UBO, Plouzané, France, 4) Laboratoire d'Etudes en Géophysique et Océanographie Spatiales, UMR 5566 CNES/CNRS/IRD/UPS, Toulouse, France.

Abstract: *Sardinella aurita* is the most abundant small pelagic fish in the northern Gulf of Guinea. Its reproduction and recruitment crucially depend on the environmental condition. We used an individual-based model (Ichthyop) of *S. aurita* early life history coupled offline with the regional oceanic modelling system (ROMS) to investigate the main factors driving variability in egg and larval survival in the northern Gulf of Guinea. Individuals were randomly released in the different spawning areas defined and followed for a period of 28 days. Those of individuals that remained in the coastal area (recruitment area) with a given age (more than 7 days) were considered as recruited. Ours results show the importance of the spawning area, timing and depth on the recruitment success of *S. aurita* in the northern Gulf of Guinea.

Title: Ocean climate change in the tropical Atlantic and adjacent upwelling

Authors and affiliations: Mathieu Rouault, Nansen Tutu Center, dept. of Oceanography, University of Cape Town

Abstract: Various sea surface temperature dataset were analysed and trends for all month of the year were calculated for the period 1982-2013. Changes in the tropical Atlantic and adjacent upwellings are reflecting a variety of process and have a distinct seasonality. Some regions have warmed up and some regions have cooled down while some other regions have not significantly changed. The tropical Atlantic experienced a slight warming of 0.1 to 0.2 oC per decade at all months of the year while the Angolan and North Namibian coastline displays a warming at all month of the year from 0.2 C to 0.5 oC per decade. The central part of the Benguela upwelling has not changed while the South Benguela has cooled down mainly from April to August by 0.3 to 0.5 oC per decade which out of the upwelling season suggesting stronger unseasonal upwelling favourable winds. Warming from 0.3 to 0.5 oC per decade occurred in Mauritania and North Senegal from May to November while warming in south Senegal and Gambia occurs at a different time from January to April with change from 0.4 C to 0.6 oC per decade. Prior to the satellite era, 1980, it is difficult to ascertain coastal changes using gridded products that are based on a paucity of observations with gaps filled up with statistical technics. For instance Hadley SST version 1 (Rayner et al, 2003) uses satellite remote sensing estimate of SST from 1982 and sparse observation before and cannot be used for trends analysis in upwelling regions.

Title: Northward migration of small pelagic fish off West Africa: The barrier of the Sahara Bank in the context of climate change

Authors and affiliations: Timothée Brochier (1,4), Eric Machu (2), Laure Pecquerie (3), Modou Thiaw (4), Baye Cheikh Mbaye (5), Cheikh-Baye Braham (6), Omar Ettahiri (7), Najib Charouki (7), Pierre-Amaël Auger (8), Patrice Brehmer (1,4).

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Abstract: The Northwestern coast of Africa shelters is a wide part of the Canary Current Large Marine Ecosystem (CCLME). Small pelagic fisheries are of major interest for the economics of the coastal states and food security of Sahel region. Furthermore, small pelagic fish are keystone species for the energy transfer from primary production to large predators in the upwelling ecosystems. Along the CCLME system, different small pelagic fish species dominates the catch. In the Northern part of the CCLME combining seasonal and permanent upwelling, Anchovies (*Engraulis encrasicolus*) and sardines (*Sardina pilchardus*) dominate the catches from Gibraltar to Cape Blanc, while in the Southern part, from Cape Blanc to Cape Roxo, where occur a seasonal upwelling, the main small pelagic species is the round sardinella (*Sardinella aurita*). Understanding the factors responsible of this ecological barrier is essential to address the potential effects of climate change on the spatial patterns of fish distribution.

We address this issue using a new individual based bio-physical model for round sardinella where the environmental forcing is taken from archived hydrodynamical and bio-geochemical simulations of the upwelling system from 10 to 35°N, with a 1/12° spatial resolution. The model reproduces the main patterns of *S. aurita* seasonal migrations and inter-annual fluctuations. The sensitivity tests performed with the model suggest that the northward limit of the *S. aurita* population is strongly related on the strength of the southward current in the Sahara Bank region. More generally, the collective fish swimming capacity may be a determinant factor for small pelagic fish species presence over the Sahara bank. North of 26°N, our bio-energetic model suggest that the combination of food limitation and low temperatures prevent the growth and maturation of *S. aurita* individuals. The observed decreasing trends of the wind intensity and the increasing catches of sardinella reported South of Morocco and in the Canary Islands fit well with such outcome, and should be considered in climate change scenario.

Title: Fishing and climate change in Saloum: Between drought and advancing sea

Authors and affiliations: Adama Mbaye, Aliou Ba, Patrice Brehmer

ISRA/CRODT

Abstract: The long years of drought resulted in a loss of much of the mangrove areas which constituted nurseries and spawning grounds for fish stocks. With the high salinity of the water, salt harvesting has become in recent years the main activity of some villagers. This salt harvesting activity tends to aggravate the situation. Salt fields production residues are continuously discharged into bolong thereby increasing the salinity of the water. The high salt content, in the dry season especially, prevented reassembling species in inland waters and finally eliminated fishing in some villages of Saloum. However, due to the advance of the sea, the large increase in the opening of the mouth has in recent years risen more water from the ocean into the river. This water inlet tends to reduce the salt content of the river allowing a resumption of fishing in some localities. Nevertheless, the strong current induced reassembled waters, while facilitating the use of drifting gear, a constraint for other gear used in fixed mode. This communication shows how advanced the sea has allowed the maintenance of fishing in some medium Saloum.

POSTER PRESENTATIONS

Session 1 - Key oceanic processes in the eastern Tropical Atlantic, observations and modelling

1- Title: Evaluation of forced oceanic models in the Gulf of Guinea

Authors and affiliations: J. Yandjimain (1) G. Alory (1,2) F. Adjibode (1)

(1) CIPMA, Cotonou, Bénin**,** (2) LEGOS, Toulouse, France

Abstract: The Gulf of Guinea in the tropical Atlantic is a region where climate models show a warm bias in Sea Surface Temperature. One of the main goals of PREFACE is to improve these models, reduce this bias for better climate predictions, in particular of the West African monsoon that is largely ocean-driven. While smaller, the bias is also present in forced oceanic models. We will evaluate and compare regional simulations from the 3 oceanic models used in PREFACE for process studies and sensitivity experiments: NEMO, ROMS and MOM. The validation will rely on PIRATA mooring and cruises as well as satellite observations. We will focus on models' skills at reproducing dynamic topography, seasonal to interannual variability of the Atlantic cold tongue and coastal upwelling regions in the northern Gulf of Guinea,characteristics of the Equatorial Under-Current. We will test different statistical methods to identify the main strengths and weaknesses of the models, and their cause when possible.

2- Title: Surface mixed-layer heat budget in a regional Tropical Atlantic ocean model

Authors and affiliations: Gaëlle de Coëtlogon (1), Rémi Meynadier (1), Julien Jouanno (2), Moussa Diakhaté (3), Alban Lazar (4), Sélim Kebir (1)

(1) LATMOS-IPSL, Paris, (2) LEGOS, Toulouse, (3) LPAO-SF, Dakar, (4) LOCEAN-IPSL, Paris.

Abstract: A regional configuration of NEMO3.6 was developed with a horizontal resolution of 0.25° and 70 vertical levels in the Tropical Atlantic (30°S-30°N). Seasonal monthly averages of the sea surface temperature (SST) are compared with Reynolds SST in 2000-2009. Since this model is to be coupled with the regional atmospheric model WRF3.6 (through the OASIS3-MCT coupler), the mixed-layer heat budget is of particular interest, and the different "online" terms involved in the SST tendency equation are examined. A special focus is made on MAMJJA, when the equatorial cold tongue emerges and is maximal. This budget is presented for the SST variability at three different timescales: annual (all-months average), seasonal (monthly averages from March to August), and intraseasonal (by filtering out all periodicities longer than 90 days). Eventually, the heat budget diagnostic using online terms is compared with the similar estimation using offline parameters – i.e. daily averaged parameters in the output files of the model (gridded temperature and velocities).

3- Title: Evaluating the role of the model resolution and coupling frequency in the SST biases development in the South-Eastern Tropical Atlantic based on high- and low resolution versions of CNRM-CM CGCM

Authors and affiliations: Katerina Goubanova (1), Emilia Sanchez-Gomez (1), Claudia Frauen (2), Aurore Voldoire (2), Eric Maisonnave (1), Sophie Valcke (1), Marie-Pierre Moine (1)

1 – CERFACS, Toulouse, France; 2- CNRM, Toulouse, France

Abstract: Too warm SST in the Tropical South-Eastern Atlantic (SETA) is one of the persistent systematic biases in Coupled General-Circulation Models (CGCM) which have not been improved since several models' generations. One of the objectives of the EU-FP7 PREFACE project is to better identify physical mechanisms responsible for the development of this bias in the current CGCMs. In this study we analyse the development of SETA warm SST error in a High Resolution (HR) version of CNRM-CM CGCM based on seasonal and decadal hindcasts simulations. The model is initialized from atmospheric reanalysis ERA-Interim and oceanic reanalysis GLORYS.

First, comparison with Lower Resolution (LR) version of the model show weaker (but still present) bias in the HR version and indicates that resolving high-resolution oceanic and/or atmospheric processes is a first step towards improving simulations of the SETA region. We further document the process leading to the fast growth of the SETA SST errors, from the initial conditions to 6-months lead-time, based on seasonal hindcasts starting at 1st May and 1st November each year over 1993-2008. The results suggest that even the initial (observed during month 1) SETA SST bias in the HR model may be explained my excessive solar radiation, oceanic processes (in particular deficient cold advection) plays an important role in further bias development. The relative roles of atmospheric and oceanic processes in the bias development are also discussed for the LR model.

Second, we address the general question if air-sea coupling contributes to attenuate or to amplify the SST errors. In particular, we evaluate potential impact of SST diurnal cycle on the SETA SST bias development by analysing two initialized decadal hindcasts integrations with different coupling frequency (3 hours versus 1 day).

4- Title: Toward a better understanding of the role of wind stress on SST anomalies in the Atlantic cold tongue

Authors and affiliations: Yann PLANTON (1), Aurore VOLDOIRE (1), Hervé GIORDANI (1), Guy CANIAUX (1)

1) Météo-France/CNRS, CNRM-GAME, Toulouse, France

Abstract: The link between wind stress anomalies and SST anomalies in the Atlantic Cold Tongue (ACT) as been established in several studies (Servain et al. 1982; Keenlyside and Latif 2007; Burls et al. 2012). In a recent study, Planton et al. (2015), we have shown that anomalously cold (warm) ACT events are linked with negative (positive) zonal wind stress anomalies in the Western equatorial part of the basin and the mechanisms at work have been described. Here, we perform a thorough analysis of the spring wind stress distribution preceding anomalous events of the ACT. It is evidenced that extremely intense wind stress events are more frequent on ACT cold years than on average.

A global version of the NEMO ocean model at 1° resolution is then used to perform sensitivity experiments to the wind stress distribution during cold years. It is shown that without extremely intense wind stress events, SST anomalies are lessened during cold ACT events, particularly around 10°W. The role of the location and timing of wind stress anomalies during cold ACT events is also investigated.

5- Title: A model study of the seasonality of sea surface temperature and circulation in the Atlantic Northeastern Tropical Upwelling System

Authors and affiliations: Saliou Faye(1,2), Alban Lazar(3,1), Bamol Ali Sow(4,1) et Amadou Thierno Gaye(1)

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Abstract: The climatological seasonal cycle of the sea surface temperature (SST) in the northeastern tropical Atlantic (7-25°N, 26-12°W) is studied using a mixed layer heat budget in a regional ocean general circulation model. The region, which experiences one of the larger SST cycle in the tropics, forms the main part of the Guinea Gyre. It is characterized by a seasonally varying open ocean and coastal upwelling system, driven by the movements of the intertropical convergence zone (ITCZ). The model annual mean heat budget has two regimes schematically. South of roughly 12°N, advection of equatorial waters, mostly warm, and warming by vertical mixing, is balanced by net air-sea flux. In the rest of the domain, a cooling by vertical mixing, reinforced by advection at the coast, is balanced by the air-sea fluxes. Regarding the seasonal cycle, within a narrow continental band, in zonal mean, the SST early decrease (from September, depending on latitude, until December) is driven by upwelling dynamics off Senegal and Mauritania (15°-20°N), and instead by air-sea fluxes north and south of these latitudes. Paradoxically, the later peaks of upwelling intensity (from March to July, with increasing latitude) essentially damp the warming phase, driven by air-sea fluxes. The open ocean cycle to the west, is entirely driven by the seasonal net air-sea fluxes. The oceanic processes significantly oppose it, but for winter north of ~18°N. Vertical mixing in summer-autumn tends to cool (warm) the surface north (south) of the ITCZ, and advective cooling or warming by the geostrophic Guinea Gyre currents and the Ekman drift. This analysis supports previous findings on the importance of air-sea fluxes offshore. It mainly offers quantitative elements on the modulation of the SST seasonal cycle by the ocean circulation, and particularly by the upwelling dynamics.

6- Title: Multi-configuration sensitivity experiments with the IPSL-CM5A-LR coupled model

Authors and affiliations: A.K Traoré[1], Gainusa-Bogdan, A.[2], Braconnot, P.[2], Dufresne, J.-L[2], F. Hourdin[2]

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Abstract: In the framework of the preparation of CMIP6 and Preface project, we are revisiting the SST biases in the IPSL-CM5A model. Three kind of tests were carried out: (1) nudged wind to have a better general circulation in order to improve surface fluxes in the stand alone atmospheric simulations and the SSTs in the ocean-atmosphere coupled mode, (2) adjusting of heat drag coefficient experiments to try to mimic latent heat flux identified in the stand alone atmospheric simulations, (3) wind drag modified experiments as defined for inter-comparison in the framework of the PREFACE project. Those simulations are compared in terms of both latent heat flux biases in the stand alone atmospheric simulations, and SST biases in coupled ocean-atmospheric experiments. Simulations were carried out either in climate mode or initialized (hindcast) mode in both the atmosphere and ocean components. From this set of experiments, some conclusions are drawn on the priorities for the development of the IPSL-CM model.

7- Title: Intraseasonal variability in the tropical Atlantic and southeastern upwelling region as seen in observations and reduced gravity simulations

Authors and affiliations: Robert Kopte, Peter Brandt, Richard J. Greatbatch, Martin Claus

GEOMAR Helmholtz Centre for Ocean Research Kiel

Abstract: The variability of observed zonal velocity at the equator, 23°W shows several spectral peaks. Those at the annual and semi-annual periods are associated with the 4th and 2nd baroclinic modes, respectively. Another peak, related to the 1st baroclinic mode, is found in the intra-seasonal band at about 120 days. These peaks correspond to resonant equatorial basin modes in the Atlantic, composed of equatorial Kelvin and Rossby waves as well as coastally trapped waves. Particularly the intra-seasonal basin mode is clearly visible in observed sea level anomalies (SLA), revealing a basin-wide structure with variability detectable as far as 10°S along the southwestern coast of Africa.

Reduced gravity model simulations are used to quantify how much of the observed intra-seasonal variability in zonal velocity and SLA can be reproduced by different baroclinic modes. The model is forced separately for each baroclinic mode with interannually varying wind stress for the Atlantic region from 20°S to 20°N, using sponges at the northern and southern ends of the domain to inhibit Kelvin wave propagation along these boundaries. The interannual simulations reveal the existence of resonant equatorial basin modes at annual, semi-annual, and intraseasonal period for the 4th, 2nd, and 1st baroclinic mode, respectively. Sensitivity experiments with varying wind forcing might assist in identifying the relative importance of different aspects of the forcing, e.g. its temporal and spatial structure.

8- Title: Diurnal variability in the Atlantic cold tongue at 10°W

Authors and affiliations: Marcus Dengler (1), Peter Brandt (1), M. McPhaden (2), B. Bourles (3), R. Hummels (1), S. Thomsen (1), T. Fischer (1) and G. Krahmann (1)

(1) GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany, (2) NOAAs Pacific Marine Environmental Laboratory, Seattle, USA, (3) IRD/LEGOS, Centre IRD de Bretagne, Plouzane, France

Abstract: Glider based hydrographic data and microstructure measurements from a glider mounted turbulence package from three deployments within the equatorial cold tongue and near-surface current measurements from moorings are used to investigate the diurnal variability of stratification, turbulence, and velocity in and below the mixed layer. The gliders' hydrographic data reveals the development of elevated stratification due to strong vertical temperature gradients in the upper 5 meters of the water column from 10am to 8pm due to differential solar heating during day time. Concurrently, elevated turbulent dissipations rates in this depth range are observed with peak values exceeding 1x10-6 m2s-3 close to the surface and westward velocities of the South Atlantic Currents below the stratified layer up to 40m depths significantly reduce toward the end of the surface ocean stratification period. A dynamical explanation of the observations is that the day time stratification of the near-surface layer inhibits the vertical transfer of momentum that is input by the wind and the trapping of momentum lead to a highly sheared near-surface diurnal jet. The elevated dissipation rates at the near-surface are caused by Kelvin-Helmholtz instabilities occurring within the jet. In the evening when the solar heating reduces the jet and associated velocity shear descents triggering elevated mixing in the thermocline. The results from the observations are compared to models of the diurnal warm layer.

Session 2 - Climate variability, modelling and prediction - Block 1) Climate variability and its prediction

9- Title: Variations of the Tropical Atlantic and Pacific SSS minimum zones and their relations to the ITCZ and SPCZ rain bands (1979-2009)

Authors and affiliations: M. Tchilibou1, T. Delcroix 2, G. Alory1,2, S. Arnault3, G. Reverdin3 (1) CIPMA, Cotonou, Bénin, (2) LEGOS, Toulouse, France, (3) LOCEAN, Paris, France

Abstract: This study focuses on the time-space variability of the low Sea Surface Salinity (SSS) waters extending zonally within 2°N-12°N in the Atlantic and Pacific and within 6°S-16°S in the western third of the Pacific. The analysis is based on a combination of in situ SSS observations collected in the last three decades from voluntary observing ships, TAO/TRITON and PIRATA moorings, Argo floats and (few) CTD profiles. The mean latitudes of the Atlantic and Pacific low SSS waters appear 1-3° further poleward than the Evaporation minus Precipitation (E-P) minima linked to the Inter Tropical Convergence Zones (ITCZ) and South Pacific Convergence Zone (SPCZ). At the seasonal time scale, the E-P minima migrate poleward in summer hemispheres, leading the migration of the SSS minima by 2-3 months in the Atlantic ITCZ, Pacific SPCZ, and in the eastern part of the Pacific ITCZ. On the other hand, the seasonal displacements of E-P and SSS minima are in anti-phase in the central and western parts of the Pacific ITCZ. At the interannual time scale, the E-P and SSS minima migrate poleward during La Nina events in the Pacific and during the positive phase of the Atlantic Meridional Dipole (AMD) in the Atlantic (and vice versa during El Nino and the negative phase of the AMD). We further document long-term (1979-2009) meridional migrations of the E-P and SSS minima, especially in the SPCZ region, and discuss whether or not they are consistent with documented SST and wind stress trends.

10- Title: On the relationship between surface wind convergence and SST in the Tropical Atlantic

Authors and affiliations: Moussa Diakhate1, Alban Lazar2, Gaelle de Coetlogon2, Amadou T. Gaye1

1) Université Cheikh Anta Diop, Senegal; 2) Université Pierre et Marie Curie, France

Abstract: The seasonal migration of the Marine Inter-Tropical Convergence Zone (MITCZ) modulates the rainfall distribution in the tropical Atlantic and surrounding coastal regions. The surface wind convergence, expected to be the dominant source of moisture for precipitations under this ITCZ, is supposed to be primary controlled by the SST gradients, according to Back and Bretherton (2009). This is re-examined using NCEP CFSR and ECMWF ERA-interim reanalyses in the Tropical Atlantic at the seasonal timescale in the decade 2000-2009. The surface wind convergence budget is computed using a simplified atmospheric mixed-layer model. Results show that SST gradients forces the surface convergence and precipitation in the ITCZ, dominantly close to the continents (Eastern basin and Northeastern Brazil), and weakly in the central basin.

11- Title: Estimating Wind Power Input to near-inertial currents in the North Atlantic with a regional coupled model

Authors and affiliations: Tina Dippe1, Xiaoming Zhai2, Richard Greatbath1, Willi Rath1

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Abstract: In a recent study, the interannual variability of Wind Power Input (WPI) to near-inertial currents in the North Atlantic has been investigated, using a combination of atmospheric reanalysis products and a high-resolution ocean model. An additional statistical modelling approach yielded robust and cheap estimates of basin-wide WPI and showed that the relationship between WPI and the North Atlantic Oscillation is an inverse one, with the correlation coefficient of -0.42 being statistically significant at the 95% level. This indicates that enhanced storminess in the subtropical (subpolar) North Atlantic increases (decreases) basin-wide WPI. Indeed, WPI is found to be more effective in the subtropical ocean basin, owing to a variety of mechanisms. Chiefly, the variation of the Coriolis parameter with latitude allows stronger near-inertial currents in the subtropics. This leads to an asymmetry in the response of subtropical and subpolar WPI to NAO forcing in the sense that enhanced subtropical WPI during negative NAO phases is roughly an order of magnitude larger than enhanced subpolar WPI during positive NAO phases. Although both subtropical and subpolar WPI are strongly correlated with the NAO index, it is subtropical WPI that has a significant impact on the relationship between basin-wide WPI and the NAO, while subpolar WPI is effectively negligible. Here an overview of the methodology is presented, stressing the importance of using a full climate model for the study of near-inertial wave processes compared to the traditional slab model. Possible applications for the tropical Atlantic are discussed.

12- Title: The Spatial and temporal variability of the rainfall distribution over Ethiopia in relation to the El NIÑO Southern Oscillation (ENSO)

Authors and affiliations: Birhanu Liben, National Meteorological Agency of Ethiopia

Abstract: It is known that Ethiopia has high spatial and temporal variations in its rainfall distribution. Therefore, in order to study these variations, an examination of the seasonal rainfall on regional scale has been carried out so as to study the ENSO impact on the Ethiopian rainfall. In this study, Ethiopia is divided into three seasons, that is, Kiremt (main rainy season), Belg (short rainy season) and Bega (dry season) seasons, the study areas influenced by the two seasons with respect to rainfall which is Kiremt and Belg.

Further research has been carried out to study the relationships between the ENSO phenomenon and the 1-month, 2-month as well as 3-month rainfall lags over these seasons. It is found that the ENSO impact is prominent during north-east monsoon especially over Sabah region. The lag-relationships between the SOI and rainfall are also found to be significant in the seasons during which the ENSO impact is pronounced.

13- Title: Decadal Changes in the Atlantic Equatorial Mode and Tropical Impacts.

Authors and affiliations: Teresa Losada(1); Belén Rodríguez-Fonseca(1,2)

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Abstract: It has been shown that the atmospheric response to the Atlantic Equatorial Mode is non-stationary. After the 1970's, Sea Surface Temperature (SST) anomalies in the tropical Atlantic are able to alter the atmosphere in the tropical Pacific via modifications of the Walker circulation. Such changes could be related to the differences in the background state of the global SSTs before and after the 1970's, but also to changes in the interannual Equatorial Mode itself.
In this work we first describe the multidecadal variations in the spatial pattern of the Atlantic Equatorial Mode and its possible modulator. Then we use an AGCM to perform different sensitivity experiments, changing the spatial structure of the Equatorial Mode and we explore the differences in the atmospheric response over the tropical Pacific region to each of the SST patterns considered. It is shown that the changes in the Walker Atlantic-Pacific cell produced by the EM are stronger after the 1970's, and are reinforced by the change in the impact of the EM over the Indian Ocean and the Maritime Continent.

14- Title: Two different configuration of the Atlantic Niño phenomenon under negative AMO phases

Authors and affiliations: Marta Martín-Rey (1-2), Irene Polo (2-3), Belén Rodríguez-Fonseca (1-2), Alban Lazar (4)

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Abstract: An air-sea coupled mode of inter-annual variability akin to ENSO emerges in the tropical Atlantic basin, named as Atlantic Niño. Here, we demonstrate that two different Atlantic Niño patterns coexist in the tropical Atlantic basin during negative phases of the Atlantic Multidecadal Oscillation (AMO): one characterized by positive SST anomalies covering the entire tropical Atlantic, Basin-Wide (BW) mode, and another one, the Canonical (C) mode, characterized by an equatorial warming flanked by negative SST anomalies in north and south Tropical Atlantic. The C- and BW-Atlantic Niño are associated with different atmospheric forcings driven by the Subtropical High Pressure Systems. The C-Atlantic Niño is preceded by a zonal Sea Level Pressure (SLP) gradient, while a weakening of both Azores and Sta Helena High seems to trigger the BW-Atlantic Niño phenomenon. This different SLP configuration induces anomalous surface winds that activate diverse oceanic mechanisms. The present study analysed the air-sea interactions involved in the development of the Canonical and Basin-Wide Atlantic Niño phenomenon.

15- Title: Impact of SST and surface heat fluxes in the low level dynamics of the Eastern Equatorial Atlantic

Authors and affiliations: Rémi Meynadier (1,2), Gaëlle de Coëtlogon (2), Alban Lazar (3), Lala Kounta (4), Moussa Diakhate (4) and Laurence Eymard (3)

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Abstract: The north-eastern Tropical Atlantic sea surface temperature (SST) becomes very warm in boreal summer, north of the seasonal equatorial cold tongue, with a maximum in the vicinity of the Inter Tropical Convergence Zone (ITCZ). Using the regional Weather Research and Forecasting Model (WRF), this study aims to describe and quantify the influence of the warm SST band on the ITCZ: two simulations examine independently the cases when the SST is not warming or not cooling regarding its regular seasonal evolution. It then allows to separate the influences of northern and southern SST fronts (where the meridional gradients are most intense) on surface winds and precipitation. The interactions between marine boundary layer dynamics and surface fluxes of sensible and latent heat are also investigated here with WRF. Two experiments are performed: a control run where the model had full physics, including sensible and latent heat fluxes from the surface, and a no flux run which turned off both surface sensible heat and latent heat fluxes. Objectives here are to quantify the effect of the latent heat flux in the boundary layer dynamics versus the free tropospheric air effect. Impact on the low level cloud structure and surface energy budget will also be investigated.

16- Title: Impact of the Madden Julian Oscillation on summer rainfall over West Africa in AMIP simulations

Authors and affiliations: NIANG Coumba (1, 2, 3, 4), Elsa Mohino (3), Amadou T. Gaye (1)

(1) Laboratoire de Physique de l'Atmosphere et de l'Ocean Simeon Fongang (LPAO-SF), ESP, Dakar, Senegal, (2) WASCAL, Department of Meteorology, Federal University of Technology Akure (Nigeria), (3) Departamento de Fisica de la Tierra, Astronomia y Astrofisica I, Geofisica y Meteorologia, Universidad Complutense de Madrid (UCM), Madrid, Spain, (4) Instituto de Geociencias (IGEO), CSIC, Madrid, Spain.

Abstract: At intra-seasonal timescales, convection over West Africa is modulated by the Madden Julian Oscillation (MJO). In this work we investigate the simulation of such relationship by 11 state-of-the-art Atmospheric General Circulation Models run with prescribed observed Sea Surface Temperatures (SST). In general, the simulations show good skill in capturing the main characteristics of the summer MJO as well as its influence on convection and rainfall over West Africa. Most models simulate an eastward spatiotemporal propagation of enhanced and suppressed convection similar to the observed MJO, although their signal over West Africa is weaker in some models. In addition, the ensemble average of models gives a better performance in reproducing the main features and timing of the MJO and its impact over West Africa. Our analysis of the equatorial waves suggests that the main impact over West Africa is established by the propagation of low-frequency waves within the MJO and Rossby spectral peaks. Results from the simulations confirm that it may be possible to predict anomalous convection over West Africa with a time lead of 15-20 day.

17- Title: S4CAST: SST-based Statistical Sesonal ForeCAST . Description and Applications within PREFACE

Authors and affiliations: Roberto Suarez Moreno (1), Belen Rodríguez-Fonseca (1)

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Abstract: Sea surface temperature is the prevailing variable when tackling seasonal to decadal climate prediction. Thus, links between anomalies in sea surface temperature in remote areas with other climate-related variables determine predictability. Nevertheless, dynamical models suffer from important bias in the tropical Atlantic and efforts to implement new prediction models, either dynamical or statistical, capable of reproducing tropical Atlantic variability, are the cornerstone for many institutions. In this work, the recently developmed S4CAST model (SST-based Statistical Seasonal ForeCAST model) is described. Some examples are shown regarding applications of S4CAST to study the predictability of the anomalous Pacific sea surface temperature, Sahelian and Angola rainfall, and anomalous Mauritanian upwelling from remote SST forcing and different lead times. In most cases, results show how the predictability is not stationary and depend on the study period.

18- Title: Tropical Atlantic influence on the Pacific under different ocean background states

Authors and affiliations: Belen Rodríguez-Fonseca (1), Elsa Mohino (1), Teresa Losada (1), Juergen Bader (2)

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Abstract: Tropical Atlantic SST interannual variability is dominated by the Equatorial Atlantic Mode, Zonal Mode or Atlantic Niño. The remote impact of this mode has been demonstrated to be non stationary in a way that observations show how, during certain periods, the mode is able to impact on the Pacific surface winds but not in others. Although changes in the spatial configuration of the mode could explain its changing response, the abrupt alteration of the oceanic background state during these periods could modify the mean flow and non linear processes could also emerge. Using different simulations in which an equatorial warming in the Atlantic is superimposed to different climatological SSTs we explore how the interbasin teleconnections can be modified.

19- Title: Tropical Atlantic variability and the South Atlantic high pressure system

Authors and affiliations: Dmitry Sein1, William Cabos1, Qiang Wang2, Thomas Jung2, Daniela Jacob3

1) University of Alcala, Madrid, Spain, 2)AWI Bremerhaven, Germany 3)CSC2.0, Hamburg, Germany

Abstract: Using a regionally coupled ocean–atmosphere model ROM we explore the importance of the South Atlantic high pressure system (SAH) for the simulated Tropical Atlantic variability. In the ROM the coupling is active in the region covered by the atmospheric model REMO. The rest of the global ocean model MPIOM is driven by prescribed atmospheric forcing.
We analyse two set of simulations that differ by the coupled area. In one of the setups, the REMO domain includes the SAH, whereas in the second, the core and the southernmost part of the SAH are outside the coupled region.

The first set of simulations shows warm biases in sea surface temperature (SST) in the equatorial Atlantic and in the Angola-Benguela Front zone (ABFZ) similar to those that are characteristic of Global Coupled Models. In the second set these biases are substantially reduced.
The ROM biases seem to have ocean and atmospheric origin. The uncoupled simulations with MPIOM and REMO show biases that are in some cases stronger and can be corrected by the coupling. The strong SST biases are associated to a weaker austral summer SAH and an anomalous cyclonic circulation that weakens the winds in the ABFZ deepening the thermocline and preventing the upwelling of colder water in the ABFZ.

Weaker advection of colder water to the interior basin by the Benguela current due to the weaker winds could contribute to the summer biases. In winter the deeper thermocline and atmospheric fluxes seem to be the main sources for the biases.

To explore the oceanic origin of the SST bias in the Tropical Atlantic, we set up a regionally coupled model with the finite element global oceanic component FESOM. The flexibility of FESOM spatial resolution allows more detailed investigation of ocean circulation and ocean interaction with the atmosphere.

20- Title: Investigating the role of the Atlantic and Pacific in the early 20th century warming

Authors and affiliations: Lea Svendsen1, Noel Keenlyside2, Ingo Bethke3, Yongqi Gao1

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Abstract: Instrumental records show that there have been two periods of enhanced global warming in the 20th century, the early warming from 1920-1950 and a later period from the end of the 1970s. State-of-the-art coupled models are not able to simulate this early century global warming, and the causes of these variations are not well understood. To improve our understanding of the early warming, we have performed an ensemble experiment with a global coupled model, the CMIP5 version of the Norwegian Earth System Model (NorESM). The experiment consists of 6 ensemble members of historical all-forcing 20th century simulations where daily momentum flux anomalies from the 20th century reanalysis are prescribed to the ocean globally. We find that by prescribing momentum flux anomalies in NorESM, we are able to constrain sea surface temperatures to observations. ENSO events are reproduced, as well as multi-decadal variability in the North Atlantic, which neither the pre-industrial control nor the fully coupled 20th century historical simulations of NorESM can simulate. While the fully coupled 20th century historical simulations with NorESM capture the observed linear warming trend, our partially coupled experiment is also able to reproduce the early century warming. Additional experiments are being performed to investigate the impacts of the different ocean basins on the early warming and their connections on decadal timescales.

21- Title: Recent climatic trends in the tropical Atlantic: Further analyses from the Servain's data base

Authors and affiliations: Jacques Servain[1,2], Antonio Geraldo Ferreira[2], Demetrius Gomes[3], Guy Caniaux[4] and Leandro Valente Jacinto[2]

1)IRD, 2)FUNCEME, 3) UFC, 4)Météo-France, CNRS

Abstract: In-situ observed sea surface temperature (SST) and pseudo wind stress (PWS) over the tropical Atlantic, previously analysed by Servain et al. (2014), indicated a sea surface warming accompanied by a strengthening in the trades in the whole basin from the 1960's. This study is an update of the previous analysis, focusing on the slow variations of SST and PWS decade per decade between 1964 and 2013. Long-term occurrences of variability are regionalised and anomaly propagations are identified. The Servain's SST dipole index using this data base is compared with other observational indexes using the PIRATA data set.

Session 2 - Climate variability, modelling and prediction - Block 2) Model evaluation and bias studies

22- Title: Investigating the impact of observed wind stress forcing on the SST bias in the tropical Atlantic - sensitivity experiments with ECEarth3.1

Authors and affiliations: Anna-Lena Deppenmeier, WU, Rein Haarsma, KNMI, Wilco Hazeleger, WU/KNMI/eScience

Abstract: The erroneous simulation of tropical Atlantic variability (TAV) remains a problem in state of the art general circulation models (GCMs). Our recent study confirms what others have found earlier: that subsurface structures are not simulated well by the models. This poses a major problem for correctly simulating the observed TAV. In order to investigate whether atmospheric errors are the origin of the wrongly simulated subsurface, we perform several sensitivity experiments using the state of the art coupled GCM EC-Earth3.1. We force the ocean component directly with ERAInterim wind stresses over different boxes, and with different levels of noise. One set of simulations is forced over a band on the equator, while another corrects the wind stress over the Angola Benguela region. The wind stress corrections is applied a) directly as obtained from ERAInterim with a frequency of three hours, and b) after smoothing with a 24h running mean. The influences of applying these forcings differ greatly, depending on the box chosen and the frequency of variability of the forcing field. While direct three hourly wind stress forcing applied to the equator leads to a slight equatorial cooling compared to the control experiment, applying 24 hourly smoothed wind stress forcing increases the warm bias over the whole region where the forcing is applied. The Angola Benguela region, on the other hand, is much less sensitive to wind stress forcing. We are investigating the reasons for the observed behaviour of the model bias and aim to identify the source of this response, thereby gaining insights into the processes that modify the tropical Atlantic bias in the first place.

23- Title: Impact of dynamical regionalization in precipitation biases along West African coast

Authors and affiliations: Domínguez, Marta, Rodríguez de Fonseca, Belén and Mohino, Elsa

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Abstract: General Circulation Models (GCM) present prominent systematic biases in sea surface temperatures over the Tropical Atlantic. Part of these biases have been related to continental rainfall biases. In this work we analyse the effect of dynamical downscalling on rainfall biases over the African continent. A set of CMIP5 GCMs and a CORDEX-Africa regional climate simulations (50 x 50 km of horizontal resolution) has been used. It has been taken into account two uncertainty sources to give reliability to the results: the GCM uncertainty (one RCM (RCA4) nested in 8 GCMs) and that associated with RCMs (one GCM (EC-EARTH) forcing 4 RCMs). Two observational datasets (MERRA and GPCP) have been used to compare the output of the models, highlighting the uncertainty that also these products can introduce.

We have addressed biases in mean state by comparing seasonal precipitation biases between the GCMs and the corresponding RCMs nested in them, dividing the African continent in 7 subregions with homogeneous precipitation. Taylor diagrams have also been used to analyse the spatial pattern of the precipitation (variability and correlation) in the selected regions between models and observations.
Our results suggest that dynamic regionalization can improve the seasonal mean simulated precipitation with respect to GCM direct outputs, but also that this improvement seems to be model dependent.

24- Title: Impact of tropical Atlantic sea-surface temperature biases on the simulated atmospheric circulation and precipitation: an atmospheric model study

Authors and affiliations: Astrid Eichhorn, Jürgen Bader

Max Planck Insitute for Meteorology, Hamburg (Germany)

Abstract: The majority of current coupled atmosphere-ocean general circulation models (AOGCMs) suffers from substantial biases in simulating sea-surface temperatures (SSTs) in the tropical Atlantic in terms of climatological seasonal cycle and climate mean state. To better quantify the impact of tropical Atlantic SST biases in changing precipitation and atmospheric general circulation we performed a set of SST sensitivity experiments with the atmospheric model component ECHAM6 of the MPI-ESM AOGCM. The model is forced by a climatological seasonal cycle of observed SSTs to focus on simulated seasonal variability and annual mean state climate. In several configurations the climatological monthly time-series of tropical Atlantic SST biases extracted from the MPI-ESM is added to the observed SST field. Through varying bias patterns in the model experiment setup this study investigates the relevance of the seasonal evolution and spatial structure of tropical Atlantic SST anomalies for the simulated precipitation and circulation response. Results show that the position and structure of the Atlantic Intertropical Convergence Zone (ITCZ) is significantly affected. Due to warmer than observed SSTs in the South Eastern Tropical Atlantic (SETA), the annual mean precipitation maximum of the Atlantic ITCZ shifts to the east of the basin leading to drier conditions along the South American north-west coast and increased precipitation over the SETA. The precipitation changes are mainly caused by atmospheric dynamics, while thermodynamic changes play only a minor role. In particular, tropical Atlantic SST biases weaken zonal near-equatorial surface winds causing changes in low-level convergence and divergence. Besides local precipitation changes across the Atlantic, a teleconnection to rainfall over the Indian Ocean is found in boreal summer showing an intensification of precipitation near the Indian Coast as well as a decrease over the Indian equatorial region.

25- Title: A first look at wind stress sensitivity experiments with CNRM-CM5 within the framework of PREFACE WP6 coordinated experiments

Authors and affiliations: Claudia Frauen and Aurore Voldoire

CNRM-GAME (Météo-France/CNRS), Toulouse, France

Abstract: The aim of PREFACE WP6 is to identify leading-order mechanisms responsible for the development of systematic coupled model biases in General Circulation Models (GCMs) in the tropical Atlantic region and to develop strategies to reduce such model biases. In order to identify possible sources of bias development and to assess similarities and differences between different models it was decided to perform coordinated sensitivity experiments to try to improve our understanding of the formation of SST biases, especially focussing on the Angola-Benguela upwelling region, where the model biases have been poorly studied until now despite their robustness among different models.

To contribute to this effort we have started to perform ensembles of seasonal hindcast experiments with the coupled model CNRM-CM5 and sensitivity experiments, in which we prescribe observed wind stress fields over different regions in the ocean component of the model in order to identify the role of local and remote wind biases for the formation of SST biases in the Angola-Benguela region. Here, we want to give an overview of the experiments performed so far and show some first results from these experiments.

26- Title: Enhanced Vertical Atmosphere Resolution improves Climate Model Simulation of Tropical Atlantic SST and Interannual Variability

Authors and affiliations: Jan Harlaß[1] , Mojib Latif[1 2] and Wonsun Park[1]

[1]GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany, [2]Kiel University, Kiel, Germany

Abstract: A long-standing problem in climate modelling is the inaccurate simulation of tropical Atlantic (TA) sea surface temperature (SST), known as the TA SST bias. Basically all state-of-the-art global climate models suffer from a reversed equatorial zonal SST gradient in the Atlantic, too warm SST´s in the Benguela upwelling region and erroneous precipitation patterns over both the ocean and the surrounding continents. These biases have far-reaching consequences for climate prediction. We use the global coupled atmosphere-ocean-sea ice Kiel Climate Model (KCM) to conduct experiments with varying atmosphere model resolutions, while keeping the coarse resolution ocean component unchanged. Atmosphere model resolution is increased not only in the horizontal from ~2.8° to ~0.75°, but also the number of model levels are doubled (top at 10hPa). We show that the TA SST bias can be largely reduced by increasing both the atmospheric horizontal and vertical resolution. In particular, the zonal SST gradient along the equator is simulated with the correct sign. At high horizontal resolution, enhanced vertical resolution is indispensable to substantially improve the simulation of TA SST by enhancing the surface wind stress. This also reduces biases in the upper ocean thermal structure and meridional currents along the African coast, which specifically stands out since the ocean component has only a very coarse resolution. A further major step forward is a more northward position of the Intertropical Convergence Zone and hence improved variability over the Sahel region.

Notable changes in the pattern of interannual SST variability occur with increased resolution. Seasonal phase locking is captured only at high vertical resolution, as are the 3 components of the Bjerknes feedback, although with a phase lag.

Our study highlights the importance of sufficiently high atmospheric model resolution and, equally important, a consistent choice of horizontal and vertical model resolution.

27- Title: Initial performance of the Norwegian Climate Prediction model in the Atlantic

Authors and affiliations: Noel Keenlyside (1,2), Mao-Lin Shen (1,2), Francois Counillon (2,3), Ingo Bethke (2,4), Shunya Koseki (1,2), Teferi Demise (2,4), and Thomas Toniazzo (2,4)

1) University of Bergen, Bergen, Norway, 2) Bjerknes Center for Climate Research, Bergen, Norway, 3) NERSC, Bergen, Norway, 4) UniResearch, Bergen, Norway

Abstract: The Norwegian Climate Prediction model (NorCPM) is based on the Norwegian Earth System model and implements an Ensemble Kalman Filter data assimilation scheme. Perfect prediction experiments have indicated the potential of SST for initialization of seasonal-to-decadal predictions. Initial experiments using only observed SST anomalies show skill in the initialization and prediction of decadal variations of oceanic heat content variations over the North Atlantic. Seasonal predictions using full field SST as well as nudging to atmospheric reanalysis have been tested. The performance in the tropical Atlantic in terms of forecast drift and skill will be presented.

28- Title: Causes of the large warm-bias in the Angola-Benguela Frontal Zone in Norwegian Earth System Model

Authors and affiliations: Shunya Koseki1, Noel Keenlyside1, Teferi Demissie2, Thomas Toniazzo2, François Counillon3, Ingo Bethke2, Mao-Lin Shen1, Mehmet Ilicak2

1) Geophysical Institute, University of Bergen, 2)Uni Research, 3) Nansen Environment and Remote Sensing Centre

Abstract: We have investigated the causes of warm sea surface temperature (SST) bias in the southeastern Atlantic Ocean, the Angola-Benguela Frontal Zone (ABFZ) simulated by Norwegian Earth System Model (NorESM). Similar to other models, NorESM exhibits the warm bias in the ABFZ of up to 8K in the annual mean. Our analyses on results of NorESM simulation show that an erroneously strong local clockwise surface wind anomaly around the ABFZ drives the anomalous Angola Current and displaces the ABFZ southward. The demonstration of standalone experiments of atmosphere and ocean with control configuration (AMIP5/COREv2-IAF) shows that both the uncoupled models have basic errors around the ABFZ: the atmospheric mode exhibits a similar erroneously strong local clockwise surface circulation anomaly and the ocean model has the warm SST bias that is a half of NorESM full bias in the ABFZ. Another sensitivity experiment shows that the local clockwise surface wind error generates the anomalously strong Angola Current and consequently, the warm SST in the ABFZ is amplified by 2K (equal to a quarter of NorESM full bias). In NorESM, the remote effect via equatorial and coastal Kelvin Waves does not appear to be exposed in the ocean surface, but only ocean subsurface. The thermal atmospheric damping contributes to reduce the ocean surface fluxes and enhances the warm SST bias by about 2K in the coupled system.

29- Title: Biases in the UCLA-MIT global model

Authors and affiliations: Antonio Castaño-Tierno(1); Elsa Mohino(1); Teresa Losada(1); Belén Rodríguez-Fonseca(1,2)

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Abstract: In this work we present an evaluation of the main biases of the UCLA-MIT global model in the tropical Atlantic region. First we describe both the atmospheric and oceanic uncoupled components. We assess the biases in a 110 year-long simulation of the UCLA v.7.1-SsiB atmospheric global model, prescribing observed monthly SST from 1900 to 2010. In a similar way, we describe the biases in a sixty-year long simulation performed with the MIT-OGCM, from 1950 to 2010. Then, we compare these results with the outputs of a 100 year-long fully coupled simulation, focusing on the amplification of the biases with respect to the uncoupled runs.

Finally, we make a description of the variability of the coupled model at interannual and decadal scales, identifying the main modes of variability of the simulated SST.

30- Title: Understanding the variability of the SST errors in seasonal forecasts hindcasts

Authors and affiliations: Irene Polo (1,2), B. Rodriguez-Fonseca(1), E. Mohino(1) T. Toniazzo (3) N. Keenlyside(3)
1) Facultad CC Fisicas, UCM, Spain, 2) Department of Meteorology, University of Reading, UK, 3) University of Bergen, Norway

Abstract: Boundary conditions are largely the source of predictability in the atmosphere. Thus, seasonal forecast systems are often assessed by their performance of skill of Sea Surface Temperature (SST) predictions, using standard deterministic ensemble-mean scores such as anomaly correlation coefficient and in particular regions as in the Tropical Pacific. However, a proper representation of the SST mean state seems to be important to develop an accurate seasonal to decadal forecast. Some SST biases are particularly dramatic in the current systems (i.e. eastern upwelling regions) with multiple sources still under investigation.

Here we want to understand the variability of the model errors in the tropical SST and their possible sources by using seasonal hindcast sets mainly based on EC-Earth forecast system. From the analysis of the error variability over 30 years of hindcast period we answer the following questions: i) Are there periods/years with smaller SST errors? if so, why? ii) How much of the mean bias over tropical Atlantic is due to external inter-annual variability?

Results suggest that EC-Earth forecast system is over-responsive for El Nino-Southern Oscillation (ENSO) episodes and this is the main variability mode of the errors. Further analysis of the different ENSO phases reveals that La Nina phase contributes more to the mean bias with higher intra-ensemble spread than neutral/El Nino years. This suggests that a positive feedback is working in the Pacific creating errors. We present preliminary results about the importance of the ENSO phases to connect mean errors in other tropical regions.

Finally, we take advantage of a set of experiments performed to understand the impact on skill of improvements of EC-Earth parameterizations, observational uncertainty and initialization approaches, to separate the different contributions (i.e. model physics and initialization) to SST errors. We present a first approximation to this problem applied to the Atlantic and Pacific.

31- Title: Investigating Model Initial Drift in the Tropics in Seasonal Hindcasts

Authors and affiliations: Jon Shonk (NCAS-Climate/University of Reading), Eric Guilyardi (NCAS-Climate/University of Reading; LOCEAN-IPSL), Steve Woolnough (NCAS-Climate/University of Reading), Thomas Toniazzo (Uni Research/Bjerknes Centre for Climate Research), Teferi Demissie (Uni Research/Bjerknes Centre for Climate Research)

Abstract: Despite several decades of development, general circulation models are still affected by persistent, unresolved systematic biases, particularly in the Tropics. The problems caused by these biases are especially acute in seasonal and decadal forecasting, where any drift in the model can dominate a forecast. Fixing these biases requires correction algorithms for which the physical basis is difficult to justify.

In this study, we identify the causes of systematic biases present in the tropical Pacific in the ECMWF's seasonal prediction System 4 model, via the detailed analysis of the initial drift away from observations in retrospective forecasts ("hindcasts"). Specifically, we examine the chain of events that lead to the spurious northward displacement of the West Pacific intertropical convergence zone by a few degrees in operational seasonal hindcasts.

By comparing hindcasts both with a coupled ocean and sea-surface temperatures prescribed from observations, we are able to trace the source of this drift back to a pulse of easterly wind bias in the atmosphere component of the model that lasts for the first 40 days and extends over much of the western Pacific.

32- Title: A Bayesian approach for climate model bias assessment using spatially heterogeneous data

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Abstract: One crucial aspect of the complexity inherent in the assessment of climate model biases refers to spatial misalignment between observations and simulations, sparseness or incompleteness of observational data, and the use of multi-model ensembles on heterogeneous grids. These complications are often addressed via data preprocessing including, e.g., regridding or interpolation to a common spatial domain, or aggregation over large areas.

In this contribution, we propose a Bayesian hierarchical model based on a multivariate approach to estimate model biases and related uncertainties using spatially misaligned data. The estimation can be therefore based on both observational and simulated data as provided by the source, with no assumption of spatial domain homogeneity. In the proposed formulation, the statistical model is multivariate including three components: bias, observations and climate model output. The spatial pattern of bias is modelled as a non-stationary spatial field, with large-scale features captured by a set of spatial basis functions.

An ensemble of historical simulations from the Coupled Model Intercomparison Project 5 and NCAR reanalysis data are used to illustrate the benefits of the proposed approach, with focus on the climatological bias in surface air temperatures over the tropical Atlantic and bordering regions.

Session 3 - Marine ecosystems, fisheries and climate change

33- Title: Multifrequency acoustics measurements during the PIRATA FR25 cruise in the Eastern tropical Atlantic Ocean

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Abstract: Acoustic tools allow a simultaneous acquisition of quantitative and qualitative data at different spatio-temporal scales, providing information about biotic and abiotic ecosystem components. For the first time in 18 years history, a PIRATA cruise allowed to get such measurements in the Eastern tropical Atlantic, from Cabo-Verde islands to the equator and in the Gulf of Guinea. We present here first data sets acquired during the Pirata-FR25 cruise and some preliminary results. Several potential scientific analyses could be carried out using such data in the general framework of PREFACE, AWA & PIRATA programs. Such data will allow calibrating and validating ecosystem model developed in the Gulf of Guinea, taking into account the mesopelagic compartment. The organization of the micronekton layers could be described including diel vertical migration taking into account hydrological parameters and currents vertical distributions. Lastly, such data will allow characterizing the micronekton layers according to equatorial zonal currents system as well as inside the Guinea Dome. Along the survey path several other oceanographic structures were susceptible to trigger an effect on micronektonic layers as the contrasted salinity (32 to 36 ‰) within the Gulf of Guinea, oceanic fronts and Tropical instability waves.

34- Title: Sooner or later: Reproductive strategies in Electric lanternfish, *Electrona risso* (Cocco)

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Abstract: *Electrona risso* specimens from the subtropical North Atlantic in a size range from 39 mm to 82 mm are analyzed with respect to sex-ratio, fecundity and maturity. The size range represents specimens from 0.6 to 2 years age. Sex-ratio reveals that in larger specimens female individuals prevail, while the proportion of male increases in smaller size classes (5-mm size classes). All size classes comprosed mature as well as immature specimens, thus Lmat50 could not be estimated (Length at 50% maturity in a population*). Electrona risso* appears to be an iteroparous batch spawning species with multiple spawning events.

35- Title: Acoustic backscattering strength of plankton predicted from in-situ digital holographic microscopy in an East Border upwelling

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Abstract: Ocean planktonic organisms are diverse in species, versatile in time and space. In-situ observations are acoustical and optical methods, but the difficulties exist on the consistency of these two methods. In this paper, a survey trial microorganism results, off the Senegal coast, combined the acoustic (scientific echosounder EK60) and optical (HoloFlow@Sea digital holography microscope DHMHoloFlow@Sea) present the information about the horizontal and vertical profile, size of objects,theobjects, the classes of microorganisms. For the identified objects through DHM, equivalent size of each kinds classes are used to process the acoustic backscatter strength according to scattering theory. Assuming the same observation value of EK60 scientific echosounder, prediction of backscatter strength is applied via integrated volume scatter. Trial results show that prediction method makes the combined use of acoustical and optical observation a promising way to reveal the fine and micro scale pattern of the zooplankton.

36- Title: First tridimensional pelagic fish school observation from scientific multibeam echo sounder in Africa

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Abstract: Since the 70's, numerous fisheries acoustic surveys have been carried out in Africa, particularly off West African coast. Traditional echo sounders, single and split beam, usually only detect a slide of fish schools occurring over the continental shelf, due to their low depth or and wide size as well as the avoidance reaction in front of a cursing vessel. The Simrad ME70 (70–120 kHz), is a high resolution scientific multibeam echo sounder, characterized by calibrated narrow beams and low sidelobe levels, which allow tridimensional rebuilt of an entire fish school. Early trials were performed in the middle of 90's using a Reson Seabat 6012 multibeam sonar (455 kHz) in vertical beaming, in Senegal and Ivory Coast. In this work we present preliminary result obtained during the AWA cruise off Senegal, Gambia and Mauritania. The upwelling during March 2014 was strong and seldom schools were observed in the beginning of the survey over Mauritanian shelf, but cluster of large schools were detected in Senegal. Using dedicated software (movies3D) we have extracted fish school descriptors. Consistency in fish school descriptors was validated between the Reson sonar and Simrad SM 20 ones in previous study, i.e. schools descriptors extracted are comparable, we assume that also could be the case with ME70. Such hypothesis will allow comparing the change in Senegalese fish school characteristics since early records in 1997-99. Such new scientific multibeam system (ME70) will allow new fishery research applications on African small pelagic fish schools for stock assessment and behavioural studies.

37- Title: Oxygen variability over the continental shelf of southern Senegal

Authors and affiliations: E. Machu (1), X. Capet (2), T. Gorgués (1), P.-A. Auger (3), A. Lazar (2), P. Brehmer (3)

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Abstract: South Atlantic Central Waters in the eastern subtropical Atlantic Ocean are characterized by an oxygen minimum zone which borders the shelf where coastal upwelling occurs. Hence waters depleted in oxygen are advected over the shelf where they undergo changes related to both physical and biological processes. Occurrence of hypoxia associated to demersal fish has been reported in the past. Since 2012, four oceanographic cruises have been carried out in Senegalese waters during the upwelling season. Two months of bottom oxygen variability has also been recorded between February and April 2015 at Melax buoy's location (14°20'N-17°13'W). These observations are completed with regional physical-biogeochemical modelling. In this study, we present the variability of bottom oxygen observed across the shelf and provide the context for hypoxic or even anoxic events to occur, which most likely impact demersal and pelagic habitats.

38- Title: Dynamical functioning of the southern Senegal upwelling as a new explanation of small pelagic spawning pattern

Authors and affiliations: S. Ndoye (1), X. Capet (2), T. Brochier (3), E. Machu (4) and P. Brehmer (3)

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Abstract: In the south at part of the large marine ecosystem of the Canary Current, off Southern Senegal is situated a peculiar upwelling sector characterized by a major coastline irregularity in its northern part (the 'Cap-Vert' peninsula) and a wide continental shelf further South. The southern Senegal coastal Ocean plays a major role in the national ecosystem production. Its dynamical functioning is investigated using ROMS (regional oceanographic Oceanic Modeling System) numerical simulations at horizontal resolution ~ 2km, i.e. resolving fine-scale details of the frontal system present over the continental shelf during the upwelling season. The presence of Cap-Vert peninsula in the North exerts a major influence over the mesoscale activity, Ekman coastal divergence and upwelling patterns, and more generally over the pathways followed by cold subsurface water feeding the coastal divergence. Our dynamical analysis offers important new insight into the spawning patterns of major exploited fish species observed in the region, e.g. during the recent surveys at sea.

39- Title: Resilience of key biological parameters of the Senegalese flat sardine in the context of overfishing and climate change

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Abstract: The Senegalese flat sardine, Sardinella maderensis is a highly exploited fish in Senegal, West Africa; thus, its growth and reproduction parameters are used as key biological parameters to improve fisheries management. Here, we studied these parameters using landing data from the Senegalese small-scale fisheries and a review of the published literature dating back over more than 20 years. Age was estimated from length frequency analysis, from which growth parameters were calculated and the growth performance index was assessed. In the context of global climate change such as the increase of the average sea surface temperature along the Senegalese coast, we found that the length-weight parameters, sex ratio, size at first sexual maturity, period of reproduction, and condition factor of S. maderensis have not changed significantly in Senegal. The biological parameters of S. maderensis remained highly consistent, despite high exploitation and the fluctuations in environmental conditions that affect the early phases of the small pelagic fish in West Africa. This lack of plasticity by this species should be incorporated into fisheries management plans.

40- Title: Senegalese *Sardinella aurita* from 1995 to 2011: Review of size spectra, sex ratio, gonadal somatic and condition indexes from small scale main national landing sites

Authors and affiliations: Mor Sylla, Timothée Borchier, Laure Pecquerie, Omar Ndiaye, Mélissa Richaume, Patrice Brehmer

Abstract: *Sardinella aurita* is the main abundant fish species in Senegal and of major socio economics interest in West Africa. This species follow the r selection theory i.e. low cost for reproduction, short lived fish, large number of offspring at a time, low offspring survival and no parental care; thus they are sensitive to climate fluctuation which impact their pelagic habitat. A monthly data base started from 1995 to 2011 have been compiled by the CRODT mixing landing site sampling with some data collected in situ using fisheries research vessel. The relationship between LT and LF is linear and appear as consistent, which allow future integration of other basis using different metric for fish individual size. From this basis, we analyse the change in individual fish size spectra, their sex ratio, maturity stage and gonadal somatic index as well as the condition factor. The change, are scrutinized per size class and geographical location associated to different pelagic habitat in Senegal.

41- Title: A socio-economic analysis of the Senegalese Sardinella small scale fishery : A review over the last 20 years

Authors and affiliations: Aliou Bâ1, Jörn Schmidt2, Lorena Fricke2, Moustapha Deme1, Adama Mbaye3, Christian Chaboud4, Philippe Cury4, , Patrice Brehmer5

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Abstract: Sardinella (*Sardinella aurita* and *Sardinella maderensis*) is the main target species for the small-scale pelagic fisheries along the Mauritanian and Senegalese continental shelf. Income of these fisheries has decreased between 1993 and 2011 due to high variability in sardinella abundance and an increase in fishing capacity and subsequent effort. Data on effort and basic economic information have been collected regularly between 1993 and 2011 by the Centre de Recherches Océanographiques de Dakar-Thiaroye (CRODT) and the Food and Agriculture Organization (FAO). The latest study carried out in 2010 has reported a financial hardship for this fisheries sector. To investigate the current situation of the small-scale pelagic fisheries targeting Sardinella, we carried out an extensive interview survey among Senegalese fishermen in 2015, covering 450 skippers and vessel owners. Using historical data as baseline, we analysed the development of the last 20 years with respect to (1) technical, economic and social characteristics of vessels; (2) invested capital; (3) operating costs (fixed and variable costs); (4) income (5) overall profitability and (6) effect of changes in regulations on the sector.