PREFACE-PIRATA-CLIVAR Tropical Atlantic Variability Conference

28th November – 1st December 2016, UPMC, Paris, France

Table of Contents

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SESSION DESCRIPTION

Session 1: Oceanic and atmospheric processes affecting physical-biogeochemical interaction and climate

Conveners: Gregory Foltz, NOAA-AOML, USA; Rebecca Hummels, GEOMAR, Germany; Julien Jouanno, IRD, France; Nathalie Lefèvre, LOCEAN-UPMC, France; Frederic Marin, IRD, France

This session will focus on observational studies utilizing in-situ data sets from ship campaigns, subsurface moorings, PIRATA buoys, Argo floats and surface drifters, satellite remote sensing, as well as model output from process-oriented simulations. Of particular importance are processes affecting the upper ocean heat and freshwater balance, equatorial and coastal wave processes, and circulation variability with a particular emphasis on how these processes are represented in general circulation models. The effect of climate change and variability on the biologically highly-productive regions in the eastern tropics, deoxygenation, acidification, and the sequestration/outgassing of radiative and chemical active gases are important aspects to be addressed in this session.

Session 2: Mechanisms and simulation of tropical Atlantic climate variability

Conveners: Ping Chang, TAMU, USA; Alban Lazar, LOCEAN-UPMC, France; Joke Lübbecke, GEOMAR, Germany; Elsa Mohino, UCM, Spain; Hyacinth Nnamchi, UNN, Nigeria; Ingo Richter, JAMSTEC, Japan; Regina Rodrigues, UFSC, Brazil; Mathieu Rouault, UCT, South Africa; Aurore Voldoire, MF-CNRS, France

The tropical Atlantic is subject to pronounced sea-surface temperature (SST) variability that occurs on interannual to decadal time scales. Several patterns of tropical Atlantic variability (TAV) have been identified in separate locations of the tropical Atlantic, prominent among them the Atlantic Niño in the equatorial Atlantic, the Benguela Niño along the coast of southwest Africa, the South Atlantic Ocean Dipole, and the meridional mode with lobes in the subtropical North and South Atlantic. While there has been significant progress in understanding the mechanisms underlying these phenomena many questions remain. One concerns the extent to which these variability patterns are interconnected. Another regards the relative roles of dynamic and thermodynamic air-sea coupling and internal atmospheric variability. The impact of TAV on the surrounding continents and remote basins is another issue that awaits further research, as is the influence of remote basins on the tropical Atlantic and their possible change in time. On longer time scales, the role of external forcing also needs to be clarified. From a modelling perspective, many aspects of the tropical Atlantic climate remain poorly simulated in current general circulation models (GCMs), with the Benguela upwelling system being a prime example. Some key questions are how to alleviate model biases, and how biases might affect the simulation of TAV. We solicit studies that address the above questions through theoretical, observational or model analysis. Some areas of particular interest are upwelling systems and their representation in GCMs; mean state errors and their relation to the mechanisms of TAV; bias attribution through analysis of climate prediction drift; and bias mitigation strategies, such as parameterization development, resolution refinement, flux correction, or anomaly coupling.

Session 3: Towards realising socio-economic benefits of climate prediction in the Tropical Atlantic for marine ecosystems, fisheries, and continental climate

Conveners: Timothee Brochier, IRD, France; Heino Fock, TI, Germany; Noel Keenlyside, UiB, Norway; Jorge López-Parages, UNIVE, Italy; Chloé Prodhomme, BSC, Spain; Jörn Schmidt, CAU, Germany

Land use and fisheries are strongly affected by oceanic variability and are primary sectors in the response of sub-Saharan societies to Climate Change. TAV and associated precipitation can be, to a certain extent, predicted at several time scales from seasonal to multi-decadal. Several methods have been explored in the community, including in the EU-PREFACE project, to improve the representation of the TAV at those time scales in the climate models. The present session aims at discussing how improvements realized in the models and also in initialization, online correction methods but also to posteriori statistical correction translate to improved climate prediction. Another crucial question is how these skill improvements could be transferred into the skill for fisheries, crop yield and economic issues. In this respect, local and regional climate conditions can alter the processes affecting the provision of ecosystem services from physiological, individual to the food-web, ecosystem level. Accurate estimation of these process rates is as crucial as accurate climate predictions parameters for the understanding of potential changes in coupled human-nature systems. A particular grand challenge is the existing uncertainties associated with effective connections between the large-scale atmospheric/oceanographic conditions and the fish dynamics in the coastal upwelling regions off Africa. It is important to investigate the main remote forcings on fisheries in these regions, together with their related uncertainties. Special attention should be given to those possible non-stationary connections varying at decadal time scales. The better understanding of such processes will hopefully contribute to prediction skill improvements for fisheries in the area and hence, to a more effective prevention and mitigation of environmental effects. Coupling such predictions to socio-economic models is the next step in the prediction ladder, and towards better governance of environmental resources. We solicit contributions on climate prediction, processes understanding for ecosystems services, and the inclusion socio-economic understanding.

ORAL PRESENTATIONS (by order of presentation)

Session 1 – Oceanic and atmospheric processes affecting physical-biogeochemical interaction and climate

Title: Interannual tropical Atlantic variability modes: classification and Sea Surface Salinity signature

Authors and affiliations: Mesmin AWO [1,2]; Gael Alory <gael.alory@legos.obs-mip.fr>[1]; Thierry Delcroix [1]; Ezinvi Baloitcha [2]

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Abstract: Interannual climate variability in the tropical Atlantic is dominated by two internal modes: an equatorial and a meridional mode. The equatorial mode is partly responsible for the anomalies of sea surface temperature (SST) observed in boreal summer mainly in the Gulf of Guinea with a positive phase corresponding to a warming in this region. The meridional mode manifests in boreal spring as an inter-hemispheric SST fluctuation. By applying a principal component analysis and agglomerative hierarchical clustering method to combined SST, precipitation, surface winds and currents observations, we classified the years when different phases of these modes occurred during 1980-2012. A spring warming mode forced by the Pacific Niño also occurred in some years. We also identified in sea surface salinity (SSS) in situ data the signature associated to these modes. The results indicate the existence of a meridional SSS dipole between 5°S and 10°N related to the meridional mode. For the equatorial mode, negative (positive) SSS anomalies are observed along the northern part of the equatorial band (0-5°N), the northeast coast of Brazil and northwest coasts of Gulf of Guinea during positive (negative) phases. The mechanisms responsible for these observed SSS patterns will be discussed.

Title: Potential impact of Atlantic climate modes on the ventilation of the oxygen minimum zone in the eastern tropical north Atlantic

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Abstract: As a consequence of high biological productivity in combination with weak ventilation, oxygen minimum zones (OMZs) exist in the upwelling regions of the eastern tropical Atlantic and Pacific ocean at intermediate depth. For the ventilation of the Eastern Tropical North Atlantic (ETNA) OMZ it has been suggested that latitudinally alternating zonal jets (LAZJs) with large vertical scale play an important role as they advect oxygen-rich waters from the western boundary towards the OMZ. The North Equatorial Counter Current (NECC) is is one of the important eastward zonal currents in the tropical north Atlantic.

Variability in the strength and location of the LAZJs can be associated with oxygen variability in the ETNA OMZ. We here want to address the question whether the variability in the zonal current field can be partly attributed to the large-scale climate modes of the tropical Atlantic, namely the Atlantic zonal and meridional mode. An influence of these modes on the NECC has been found in previous studies. For the analysis we are using the output of a global ocean circulation model, in which a 1/10° nest covering the tropical Atlantic is embedded into a global 1/2° model, as well as reanalysis products and satellite data. Composites of the zonal currents for different phases of the Atlantic climate modes are compared and discussed.

Title: Oxygen minimum zones variability in the Atlantic Ocean over the last Millennium and the 21st Century in an Earth System Model

Authors and affiliations: Angélique Hameau <hameau@climate.unibe.ch> [1,2]; Fortunat Joos [1,2]; Juliette Mignot [1,2,3]; Kathrin Keller [1,2]

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Abstract: The dissolved oxygen is an essential element for marine environment. Modeling studies ([1] [2] [3]) predict a depletion of the oceanic dissolved oxygen content with global warming. These results are confirmed by observational studies ([4] [5]). The oxygen minimum zones (OMZs), which result from a combination of weak ventilation and sustained respiration by the microorganisms, may therefore expand, impacting the environment of marine species. But this statement is questioned by Deutsch [6], who relates the variations of Pacific OMZ to the strength of the tropical Walker circulation. Here, we study the evolution of dissolved oxygen in the Atlantic Ocean, with a focus on the oxygen minimum zones (OMZ), in a climate simulation of the Community Earth System Model (CESM) covering the last millennium and the 21st century.

The study focuses on the response of the OMZs to increasing anthropogenic emissions as well as the short-term response to volcanic eruptions in the context of internal variability. The global oxygen inventory decreases under anthropogenic forcing, in accordance with Frölicher [2]. The higher the temperature, the lowered the oxygen solubility is, reducing the oxygen air-sea flux, hence the oceanic oxygen inventory. The volume occupied by the OMZs expands during the 21th century but preliminary results suggest that the Atlantic ocean may be less sensitive to this forcing than the Pacific. The volcanic forcing induces an increase of the global oceanic oxygen content and a shrinking of the OMZs associated with the temperature decrease. Magnitude and timescales of these responses will be discussed and compared to natural variability of OMZs with a focus on the Tropical Atlantic.

Title: Influence of greenhouse gas concentration and Arctic sea-ice change on the West African Monsoon

Authors and affiliations: Paul-Arthur Monerie <pmonerie@cerfacs.fr>; Thomas Oudar; Emilia Sanchez-Gomez; Laurent Terray

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Abstract: The Sahelian precipitation is projected to increase in the CNRM-CM5 coupled climate model due to a strengthening of the land-Sea temperature gradient, the increase in the North Atlantic temperature and the deepening of the Heat Low. Arctic sea-ice loss impacts the low-level atmospheric circulation through a decrease in the northward heat transport. Some authors have linked the sea-ice loss to a poleward shift of the InterTropical Convergence Zone. Within the CMIP5 models the effect of these mechanisms are not distinguishable and it is difficult to understand the effect of the Arctic sea-ice loss on the West African Monsoon so far. We performed several sensitivity experiments with the CNRM-CM5 coupled climate models by modifying the arctic sea-ice extent and/or the greenhouse gas concentration. We then investigated separately the impact of Arctic sea-ice loss and greenhouse gas concentration increases on the West African Monsoon. The increase in greenhouse gas explains the northward shift and the strengthening of the monsoon. Its effect is stronger with a sea-ice free Arctic that leads to an increase in North Atlantic temperature and in Sahelian precipitation at the end of the rainy season (September-October). We argue that the decrease in sea-ice extent, in the context of the global warming, may moisten the Sahel during the rainy season by changing the pressure, winds and moisture fluxes at low-level.

Title: Changes in the ecosystem structure of the algae Sargassum in the tropical Atlantic Ocean

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Abstract: Since 2011, mass strandings of the brown algae *Sargassum* (*Sargassum natans* and *fluitans*) have been reported along the West Indies, the Caribbean and the West Africa coasts. These strandings have important consequences for the marine ecosystems, the biology, the water quality, the health of the population and the tourism. As such, it is important to understand and identify the causes of the bloom and strandings of the *Sargassum* algae in the tropical Atlantic Ocean. Recent studies have highlighted the North Equatorial Recirculation Region of the Atlantic Ocean (NERR, located between the North Equatorial Counter Current and the equator) as one new tank of *Sargassum* pelagic algae. In this work, we use observational datasets of hydrological parameters and seasonal climatology of ocean conditions (winds, ITCZ position, SST, surface currents, rivers discharge, nutrients, Chlorophyll, climate indices) in order to investigate climate trends or events and their potential feedback on the recent bloom and mass strandings of the *Sargassum*. The analysis of the Amazon and Oricono Rivers discharge, indicates that the volume of water flowing is not the dominant control of the changes in the *Sargassum* ecosystem. However, a good agreement is found between nutrient inputs, predicted by a linear regression model based in particular on the surface runoff, and the *Sargassum* bloom of the years 2011, 2012 and 2014. Results further suggest that the subsurface intake of nutrients from the equatorial upwelling, the increase of both SST in the western basin and the zonal velocity, have contributed in the bloom and the mass strandings of the *Sargassum* algae in the Atlantic Ocean.

Title: The Angola Current at 11°S: observations and response to tropical Atlantic variability

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Abstract: With R/V Meteor cruise 98 in July 2013 an observational program in the eastern boundary upwelling system off Angola was started. The measurements consist of repeated shipboard and glider surveys providing amongst others temperature, salinity, oxygen and current velocities as well as moored observations at the shelf at 11°S. Moored velocity measurements are performed with two 75-kHz Longranger ADCPs profiling the upper water column between 50 and 500m at two positions on and near the shelf break in 500m and 1200m water depth, respectively. Following the first cruise, a second cruise was performed in October 2015; a third cruise will start in October 2016.

Here we analyze the interannual variability of the eastern tropical Atlantic during the observational period. From mid-2013 to mid-2015 mostly weak cold sea surface temperature anomalies (SSTAs) were present in the Angola-Benguela area (ABA, 20°S to 10°S, 8°E to 15°E). During this period the moored velocity observations were dominated by intraseasonal and seasonal variability. In austral spring 2015 a positive SSTA developed near the Angola Benguela Front (ABF) that became strongest in January 2016, thereby establishing the strongest anomaly since the last Benguela Niño in 2010/11. SSTA at the equator and in the ABA were weak from March to May 2016. In June, associated with a late onset of the Equatorial Cold Tongue following westerly wind anomalies in the western equatorial Atlantic during April, a positive SSTA developed at the equator and propagated eastward along the equator and further southward into the ABA. The response of the Angola current at 11°S to these warm events also in comparison to moored observations along the equatorial wave-guide will be the focus of our studies after the recovery of the moorings in October 2016.

Title: Current variability and wave propagation along the south-west African coast as revealed by mooring observations

Authors and affiliations: Tim Junker <tim.junker@io-warnemuende.de> [1]; Volker Mohrholz [1]; Martin Schmidt [1]; Lydia Siegfried [1]; Anja van der Plas [2]

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Abstract: The present study investigates the sub-inertial wave propagation and current variability along the south-west African coastal wave guide by means of concurrent mooring observations off Namibia (18°S, 20°S, 23°S). The latitudinal variability of the alongshore velocity and its energy spectra are studied. It is shown that the variance in the sub-inertial frequency range decreases remarkably from north to south.

Moreover, the propagation of continental shelf waves is analyzed in terms of the amplitudes of the gravest empirical mode of the alongshore velocity accounting for about 90% of variability. Prominent peaks in the coherence and phase spectra between the different moorings are identified and corresponding phase speeds are deduced. Estimated propagation speeds of continental shelf waves are of the order of 6 m/s. The results obtained are compared with the dispersion relations derived from simplified analytical and advanced numerical shelf models. Finally, the influence of shelf topography and stratification on the propagation characteristics is discussed in the present work.

In brief, the study provides insight into the poleward wave propagation along the south-west African shelf and thus may shed some light on the dynamical linkage between the tropical and subtropical South-East Atlantic.

Title: TKE dissipation and turbulent mixing in the Northern Benguela

Authors and affiliations: Volker Mohrholz <volker.mohrholz@io-warnemuende.de>, Toralf Heene, Martin Schmidt

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Abstract: Across the continental shelf small scale processes like breaking internal tides at the shelf edge, current shear, generation of nonlinear internal waves and shoaling of swell causes enhanced turbulent mixing at particular locations. Often these processes are not well represented in numerical models, and need an improved parameterization. We present a series of field observations, carried out off the central Namibian coast, to gather detailed information on the distribution of turbulent kinetic energy (TKE) dissipation and turbulent mixing across at the continental shelf. Hot spots and shadow zones of TKE dissipation were identified. The Interaction of internal tide with the bottom topography leads to enhanced TKE levels at critical slope angles, mainly located at the shelf edge. Here the bottom mixed layer can reach up to 100m thickness, characterized by high suspended matter concentration. Patches with enhanced TKE dissipation rates of about 10-8 to 10-7 Wkg-1 were observed throughout the water column. At the shelf edge nonlinear internal waves are generated frequently. A statistical analysis of satellite images revealed a region of enhanced NLIW generation near the Walvis Ridge. In contrast to the shelf edge the inner shelf off Namibia depict low TKE dissipation rates outside the boundary layers. Based on high resolution time series observations with moored instruments it is shown, that near bottom the eddy viscosity is mainly controlled by the mean currents and the law of the wall. Off the Namibian coast the locations of hot spots and shadow zones of TKE correlate with the distribution of carbon rich surface sediments, which points to a high impact of enhanced TKE near sea bed on resuspension of particulate matter.

Title: Role of Interannual Kelvin wave propagations in the equatorial Atlantic on the Angola Benguela current system.

Authors and affiliations: Rodrigue Anicet Imbol Koungue <rodrigueanicet@gmail.com >[1,2]; Serena Illig [1,3]; Mathieu Rouault [1,2]

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Abstract: We investigate the link between equatorial Atlantic Ocean variability and the coastal region of Angola and Namibia from 1998 to 2012. There is a significant correlation between monthly dynamic height anomalies derived from the Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) monthly Sea Surface Height anomalies (SSHA) derived from altimetry and SSHA calculated with an Ocean Linear Model SSHA. Major warm and cold events in the Angola-Benguela current system are remotely forced by ocean atmosphere interactions in the equatorial Atlantic. Wave dynamics along the equatorial wave guide is at the origin of their developments. Weaker than normal easterlies winds in the Western Equatorial Atlantic force equatorial downwelling Kelvin waves that propagate eastward along the equator and then polewards along the African coast triggering warm events. Conversely, cold events are driven by upwelling Kelvin waves associated with stronger than normal easterlies winds.

Title: Observations of Air-Sea interactions in the Gulf of Guinea during the OLACTA-DACCIWA 2016 field campaign

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Abstract: Clustered with the summer 2016 DACCIWA (EU FP7) field campaign, the OLACTA project is focused on the role of the air-sea interaction on the southern West-African climate dynamics. This project thus aims at advancing knowledge on the low-level atmospheric circulation in the Eastern Equatorial Atlantic in connection with air-sea interactions in the presence of significant sea-surface temperature (SST) gradients and highly variable background wind conditions. Three flights took place on 2, 7 and 14 of July 2016 on board SAFIRE ATR 42 with roughly 10 hours of flying time in total. The field campaign allowed for airborne measurements of SST that can be compared with satellite observations and observations of boundary layer structure with LIDAR instrument. The regions measured included cooling areas associated with coastal upwelling off the Southern West African coast and warm sea regions often observed to be collocated with regions of offshore afternoon convection, with the SST gradients being a potential source of instability.

Title: The upper layer circulation in the Gulf of Guinea revisited from in situ data and a high resolution numerical model

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Abstract: The oceanic circulation in the upper layers in two particular areas of the Gulf of Guinea is analyzed, as inferred from in-situ observations and a high resolution numerical simulation. S-ADCP and L-ADCP data collected from 2007 to present during cruises carried out in the framework of different international programs (e.g. EGEE/AMMA, PIRATA) have first been processed allowing to expand the dataset available in the area since 1997. A first analysis allowed showing the existence of an eastward flowing undercurrent in the north of the Gulf of Guinea, found under the Guinea Current, named the Guinea UnderCurrent (GUC). Numerical results allowed the description of the seasonal variability of GUC, and to depict its fate and the sources based on selected trajectories from numerical particle tracking. In particular, Lagrangian experiments show that the GUC is not an extension of the North Equatorial UnderCurrent and confirm that this current does not penetrate into the Gulf of Guinea. A second analysis is dedicated to the southeast of the Gulf of Guinea, off Gabon and Congo, between the equatorial band and the southeastern tropical Atlantic. After establishing the seasonal variability of the hydrology and circulation patterns, we investigate the potential mechanisms responsible for cold events that appear in this particular area before or simultaneously with the Atlantic Cold tongue establishment and the possible link with the equatorial cooling process.

Session 2 – Mechanisms and simulation of tropical Atlantic climate variability

Title: Origin of upwelled water in the Benguela system: source region, upwelling depth and propagation pathways

Authors and affiliations: Lydia Siegfried <lydia.siegfried@io-warnemuende.de>; Martin Schmidt

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Abstract: Upwelled water in the Benguela region is mainly fed by South Atlantic Central Water (SACW). The interplay between the tropical SACW and the ESACW (Eastern SACW) determines the physical and chemical properties of the Benguela ecosystem. We use a regional circulation model (MOM) to analyse the source region and depth of the upwelled water. Passive tracers instead of temperature and salinity are applied to study propagation pathways of Central Water Masses and their temporal and spatial variation. Upwelling and basin-wide circulation determine the transport of central water masses.

We show that passive tracers released in the equatorial undercurrent reach the northern Namibian shelf not only inside the coastal wave guide but also by advection inside the northern branch of the Angola Gyre. This passive tracer takes 1.5 years to travel from its point of release at 0°S,9°W to the Kunene Cell (18°S,12°E). During 15 model years, surface water in the Kunene Cell emanates not only from 200m or below but is also substantially of equatorial origin. In contrast, in the Lüderitz Cell upwelled water originating in 200m (300m) depth takes roughly 3 months (10 months) to reach the surface. Upwelling is strong there throughout the year, with the result that water transport parallel to the coast plays a minor role. The Northern and the Central Namibian Cell, which are located between the Kunene and the Lüderitz Cell, are influenced both by poleward transport and by wind driven upwelling.

Title: Pathways of the upwelled water in the Benguela Current

Authors and affiliations: Martin Krebs <mkrebs@geomar.de>; Arne Biastoch; Jonathan Durgadoo; Claus Böning; Mojib Latif

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Abstract: The Benguela Current is one of the most productive regions of the world oceans because of cold, nutrient rich water which upwells there. The properties of the water depend on its origin. We analyze the origin and the pathways of the upwelling water in a 1/30° nested ocean-only model. The mean meridional currents in the model are completely geostrophic, namely they are given by the pressure difference from the sea surface height gradient and the density gradient by the upwelling. This gives an equatorward coastal surface jet and a poleward undercurrent. To obtain the origin of the water we calculated the pathways of the upwelled water with ARIANE, a Lagrangian trajectories calculation tool. We seed particles at the coast near the surface and calculate their trajectory both backward and forward. North of 23°S, most particles originate from the equatorial Atlantic Ocean through the poleward undercurrent at about 150 m depth. South of 23°S, most of the particles stem from the Indian Ocean and about 300 m depth. These two upwelling water masses have almost the same density, but the southern water is fresher and colder. Overall, the relatively cool and fresh Indian Ocean central water is the largest source for the upwelling water, contributing more than half of the upwelling transport.

Title: Alleviating Tropical Atlantic Sector Biases in the Kiel Climate Model by Enhancing Horizontal and Vertical Atmosphere Model Resolution: Climatology and Interannual Variability

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Abstract: We have investigated the quality of simulating tropical Atlantic (TA) sector mean climate and interannual variability in integrations of the Kiel Climate Model (KCM) with varying atmosphere model resolution, ranging horizontally from T42 to T255 and vertically from L31 to L62. The horizontal ocean model resolution is kept fixed at 2° with an enhanced meridional resolution of 0.5° in the equatorial region. A reasonable simulation of TA sector mean climate and interannual variability including its seasonal phase locking can only be achieved at sufficiently high horizontal and vertical atmospheric resolution. Two major reasons for the improvements can be identified. First, the western equatorial Atlantic westerly surface wind bias in spring can be largely eliminated, which is explained by a better representation of meridional and vertical zonal momentum transport. The enhanced atmospheric circulation along the equator in turn greatly improves the thermal structure in the upper equatorial Atlantic with a much reduced warm sea surface temperature (SST) bias. Second, the coastline in the southeastern TA and steep orography associated with the Andes are better resolved at high atmospheric resolution, which leads to stronger alongshore winds and in turn much reduced warm SST bias in the Benguela upwelling region.

The strongly diminished wind and SST biases allows for a more realistic latitudinal position of the Intertropical Convergence Zone (ITCZ). The resulting stronger cross-equatorial winds, in conjunction with a shallower thermocline, enable a rapid cold tongue development in the eastern TA in boreal spring. This enhances simulation of interannual SST variability and its seasonal phase locking in the KCM, which is primarily the result of a stronger thermocline feedback. Our findings suggest that enhanced atmospheric resolution, both vertical and horizontal, could be a key to achieving more realistic simulation of TA mean climate and interannual variability in climate models.

Title: Growth and decay of the equatorial Atlantic SST mode by means of closed heat budget in a coupled general circulation model

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Abstract: Tropical Atlantic variability is strongly biased in coupled General Circulation Models (GCM). Most of the models present a mean Sea Surface Temperature (SST) bias pattern that resembles the leading mode of inter-annual SST variability. Thus, understanding the causes of the main mode of variability of the system is crucial. CGCM control simulation with the IPSL-CM4 model as part of the CMIP3 experiment has been analysed. Mixed layer heat budget decomposition has revealed the processes involved in the origin and development of the leading inter- annual variability mode which is defined over the Equatorial Atlantic (hereafter EA mode). In comparison with the observations, it is found a reversal in the anomalous SST evolution of the EA mode: from west equator to southeast in the simulation, while in the observations is the opposite. Nevertheless, despite the biases over the eastern equator and the African coast in boreal summer, the seasonality of the inter-annual variability is well-reproduced in the model. The triggering of the EA mode is found to be related to vertical entrainment at the equator as well as to upwelling along South African coast. The damping is related to the air-sea heat fluxes and oceanic horizontal terms.

Cancelled - **Title:** WES feedback and the Atlantic Meridional Mode: observations and CMIP5 comparisons

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Abstract: The Atlantic Meridional Mode (AMM) is the dominant mode of tropical SST/wind coupled variability. Modelling studies have implicated wind-evaporation-SST (WES) feedback as the primary driver of the AMM's evolution across the Atlantic basin; however, a robust coupling of the SST and winds has not been shown in observations. This study examines observed AMM growth, propagation, and decay as a result of WES interactions. Investigation of an extended maximum covariance analysis shows that boreal wintertime atmospheric forcing generates positive SST anomalies (SSTA) through a reduction of surface evaporative cooling. When the AMM peaks in magnitude during spring and summer, upward latent heat flux anomalies occur over the warmest SSTs and act to dampen the initial forcing. In contrast, on the southwestern edge of the SSTA, SST-forced cross-equatorial flow reduces the strength of the climatological trade winds and provides an anomalous latent heat flux into the ocean, which causes southwestward propagation of the initial atmosphere-forced SSTA through WES dynamics. Additionally, the lead-lag relationship of the ocean and atmosphere indicates a transition from an atmosphere-forcing-ocean regime in the northern subtropics to a highly coupled regime in the northern tropics that is not observed in the southern hemisphere. A suite of CMIP5 models poorly simulate the latitudinal transition from a one-way interaction to a two-way ocean-atmosphere feedback, which may explain why they also struggle to reproduce spatially coherent interactions between tropical Atlantic SST and winds. This analysis provides valuable insight on how meridional modes act as links between extratropical and tropical variability and focuses future research aimed at reducing large tropical Atlantic mean state biases in CMIP5 models.

Title: Symmetry of the Atlantic Niño mode

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Abstract: In the eastern equatorial Atlantic Ocean, sea surface temperature (SST) anomalies occur on interannual time scales. Due to their similarity to El Niño and La Niña in the Pacific Ocean, warm events have been termed Atlantic Niños and cold events are called Atlantic Niñas. While several mechanisms have been suggested to contribute to their generation, it is generally understood that the atmosphere-ocean dynamics that give rise to the El Niño-Southern Oscillation (ENSO) mode in the Pacific, namely the Bjerknes feedback, play a central role.

ENSO is known to be asymmetric for warm and cold events with respect to amplitude, spatial patterns and time evolution. In this presentation we want to address the question whether the Atlantic Niño mode shows the same asymmetric behaviour, using two different ocean reanalysis products. It is shown that in the equatorial Atlantic, cold events are mostly mirror images of warm events. Calculation of Bjerknes feedback terms reveals that the strength of the feedbacks is very similar for warm and cold phases in the Atlantic while the relationships are non-linear with stronger responses for the warm phase in the Pacific. The comparatively high symmetry of the Atlantic Niño mode might be related to the smaller overall amplitude and the fact that in the equatorial Atlantic, interannual anomalies occur mainly as a modulation of the seasonal cycle.

Title: Observational evidence of Atlantic Niño decadal variability

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Abstract: Atlantic Niño, the dominant mode of the ocean-atmosphere coupled variability in the equatorial Atlantic Ocean, is generally considered an interannual mode. Here we show that the Atlantic Niño exhibits robust decadal variability in historical observations from 1870 to 2013. The decadal variability is robust only during the boreal spring and summer seasons (March to August). While the spring variability is related to the well-known inter-hemispheric meridional mode, the equatorial Atlantic decadal variability occurring in summer is clearly Niño-like pattern and may be more related to fluctuations of St. Helena subtropical anticyclone. The Atlantic Niño decadal variability is strongly related to decadal fluctuations of climates at the Guinea Coast of Africa.

Title: On the inter-annual tropical Atlantic variability modes under negative AMO phases

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Abstract: The Atlantic Multidecadal Oscillation (AMO) is the leading mode of internal Atlantic Sea Surface Temperature (SST) variability at decadal time-scales. Previous studies have indicated that negative phases of the AMO could modify the tropical Pacific climate, but without reaching a consensus about its role in the tropical Atlantic (TA) variability. Here, we demonstrate for the first time that during negative AMO phases, in comparison with positive ones, the inter-annual SST variability in the eastern equatorial Atlantic is enhanced associated with a shallower thermocline. Under these conditions, a second variability mode emerges in the tropical Atlantic basin forced by an ENSO phenomenon. The leading mode, Basin-Wide (BW), resembles an Atlantic Niño pattern and it is characterized by positive SST anomalies covering the equatorial band and south tropical Atlantic. The second mode, Horse-Shoe (HS), which is different from the Meridional Mode, presents an anomalous cooling in north and south TA, surrounding the eastern equatorial Atlantic. The BW and HS are driven by different wind patterns, controlled by the Subtropical High Pressure Systems. A weakening of the Azores and Sta Helena Highs, which induces a general reduction of the tropical trades, precedes the BW mode. The HS pattern is associated with a strengthening of both Subtropical Highs, which evolves in a zonal equatorial SLP gradient. This anomalous SLP configuration intensifies the subtropical trades and generates anomalous westerlies along the equatorial band. Our results give a step forward in the better understanding of the tropical Atlantic inter-annual variability and its predictability.

Title: SST bias development in the Tropical Atlantic in PREFACE coordinated experiments

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Abstract: Coupled climate model used for long-term future climate projections as well as seasonal forecasts models share a systematic warm SST bias in the Tropical Atlantic. One of the objective of the EU-FP7 PREFACE project is to better understand physical mechanisms responsible for the development of such systematic biases in the Tropical Atlantic. It has already been shown that these biases develop relatively fast and the idea is to analyze the drift of initialized coupled simulations to help pointing out the initial source of the bias. Several climate models have thus been run in seasonal forecast mode with the aim of analyzing the mechanisms at play during the drifting period. Five coupled models have participated to the coordinated analysis: CNRM-CM-LR (CNRM), CNRM-CM-HR (CERFACS), EC-Earth v3.1 (WU, BSC), ECMWFS4 (UREAD), NorESM (UiB). Seasonal hindcasts simulations have been performed for May and February start dates over the period 2000-2009.

The spread of the multi-model ensemble and speed of the drift set up depends on the region studied. Over the Equatorial Atlantic open ocean region, the model that simulate realistically the wind stress drift less severely than those having strong wind stress biases, and surface fluxes cannot explain a warm drift. On the contrary, in the southeast open ocean, surface fluxes are shown to play the leading role. Along the African coast, in the Benguela and Angola regions, the drift evolution is more dependent on the model.

As a second step, 4 of the models involved have performed a sensitivity experiment in which the equatorial surface wind stress has been replaced by the ERA-Interim wind stress over the Atlantic from 5S to 5N. This sensitivity experiment allows disentangling the role of the wind stress biases driving the setup of the SST bias locally and remotely over the southeastern Atlantic.

Title: A mechanism for the changing impact of the tropical Atlantic on the Pacific. Influence of bias

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Abstract: Predictability of ENSO from the tropical Atlantic has been found in observations during some particular decades. The multidecadal modulation of the connection seems to take place in phase with the evolution of the Atlantic Multidecadal Oscillation, being enhanced during negative phases of AMO. Nevertheless this multidecadal modulation has not been physically explained. In this work we analyse the connection in preindustrial control simulations from Phase 5 of the Climate Modelling Intercomparison Project. Simulations exhibit a strong interbasin connection with a 4 year cycle along the whole integration and for all models. For those periods in which the connection agrees with observations, simulations present an interhemispheric gradient of sea surface temperature and a weakening of the Pacific Walker Circulation. Models with a colder bias in the equatorial Atlantic tends to favour the connection. The results of this study put forward the influence of model bias in the representation of the Atlantic-Pacific connection.

Title: Disentangling atmospheric biases in the tropical Atlantic in the CNRM climate model

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Abstract: Most state-of-the-art coupled general circulation models have serious biases in the tropical Atlantic, which strongly impact their representation of the regional climate, in particular the West African monsoon. One of this bias consists of a westerly bias in the equatorial surface winds, which has been shown to already exist in the CMIP3/CMIP5 atmosphere-only simulations, forced with observed sea surface temperatures (AMIP). Using CNRM-CM5, an ad-hoc correction of this low-level wind bias has been shown to strongly reduce the SST warm bias in the equatorial Atlantic.

In the present study, an AMIP simulation performed with the CNRM-CM5 model and an ensemble of initialized experiments following the so-called Transpose-AMIP protocol are analysed to further understand the origin of this wind bias. As the wind bias develops in a few days, the Transpose-AMIP framework allows us to track the development of the model bias away from a well-defined initial state and relate it to other regional biases. The analysis of the zonal momentum budget highlights the important role of biases in the east-west pressure gradient, in agreement with previous studies. Biases in convection in some parts of the tropical Atlantic and adjacent continents appears to be critical, through a large-scale adjustment of the regional zonal circulation. Further sensitivity experiments are carried out to further assess the role of these convection biases. The results provide some indications on how to improve coupled climate models in the region.

Title: The complexity of climate model drifts

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Abstract: Sea-surface temperature (SST) drifts and biases are a major concern for decadal climate predictability and predictions due to the central role of SST properties for the dynamical coupling between the atmosphere and the ocean, and for the associated variability.

We propose a dynamic linear model based on a state-space approach and developed within a Bayesian hierarchical framework for probabilistic assessment of spatial and temporal characteristics of SST drifts in ensemble climate simulations. The state-space approach uses unobservable state variables to directly model the processes generating the observed variability. The statistical model is based on a sequential definition of the process having a conditional dependency only on the previous time step, which therefore corresponds to the Kalman filter formulas. In our formulation, the statistical model distinguishes between seasonal and longer-term drift components, and between large-scale and local drifts. We apply the Bayesian method to make inferences on the variance components of the Gaussian errors in both the observation and system equations of the state-space model. To this purpose, we draw samples from their posterior distributions using a Monte Carlo Markov Chain simulation technique with a slice sampler. In this contribution we will present results from an application of the statistical model on an ensemble of hindcasts with the MiKlip prototype system for decadal climate predictions, focused on the tropical Atlantic Ocean. We will demonstrate how our approach allows for a more reliable identification of sources of heterogeneity, non-stationarities and propagation pathways of SST errors. In particular, we will highlight the highly dynamical character of local seasonal errors generated offshore Cape Agulhas, in the Angola-Benguela front, and in the Brazil–Malvinas confluence zone, and illustrate how they propagate both horizontally, embedded in the larger-scale circulation, and vertically, interfering with errors generated in the subsurface ocean.

Title: Role of equatorial forcing in SST bias development in the South-Eastern Tropical Atlantic in a high resolution version of CNRM-CM CGCM

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Abstract: Based on seasonal hindcast simulations, we evaluate the role of errors at the equator in setting the warm SST bias in the Tropical South-Eastern Atlantic (SETA, 7°E-15°E, 5°S-20°S) in a High Resolution (HR) version of CNRM CGCM. The CGCM includes the atmospheric model ARPEGE-Climat (v5.3) in its T359L31 configuration and the ocean model NEMOv3.2 with ORCA025 grid. Two "control" integrations consist of 10 hindcasts for each year of 2000-2009 with start dates at 1 February and 1 May, respectively.

A comparison with the control integrations carried out using a Lower Resolution (LR) version of the model (T127L31 and ORCA1) reveals that increasing the resolution does not allow significantly improving the SST biases in the Equatorial Atlantic and SETA region and that similar remote processes are responsible for the SETA SST biases in the HR and LR versions. This, despite a local improving of the equatorward Benguela current in the HR version associated with better resolving of fine-scale atmospheric and oceanic processes controlling the coastal upwelling.

A mixed layer heat budget analysis indicates that the development of the SETA SST bias results, to a large extent, from an anomalous warm horizontal advection from the Equator. It appears in the middle of March, peaks in the beginning of May and decays in the middle of June and is associated with propagations of coastal-trapped Kelvin waves induced at the equator by anomalous westerly winds. A sensitivity experiment with the wind stress corrected over the equatorial region (5°S-5°N) shows a reduction of the SETA SST bias by 50%. It is also associated with a significant improvement of the representation of the relative contributions of the different terms to the total mixed-layer temperature tendency over the Equator, although the June-July SST bias in the cold tongue region is reduced only by 25%.

Title: On the possible sources of southeastern Atlantic warm bias

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Abstract: Using a set of ocean, atmosphere and coupled ocean–atmosphere models we explore the mechanisms responsible for the Southestern Atlantic (SETA) warm SST bias. Experiments with the regional atmospheric model REMO, the ocean model MPIOM and the regionally coupled model ROM show that biases are both of oceanic and atmospheric origin, and are influenced by ocean-atmosphere interactions in coupled runs. In austral summer biases are associated with a weaker South Atlantic Anticyclone, which weakens the winds over SETA, deepens the thermocline and prevents coastal upwelling of colder water. Biases in the basins interior could be related to the advection and eddy transport of the coastal warm anomalies. In winter, the deeper thermocline and atmospheric fluxes are probably the main biases sources. The biases, albeit of lesser extent are already present in the uncoupled MPIOM run and are exacerbated by the coupling.

To explore further the oceanic contribution to the SST bias in the Tropical Atlantic, we analyze high resolution (ca. 10 km) simulations with the global oceanic model FESOM forced by ERA-Interim. These uncoupled simulations show much smaller biases than MPIOM. The coupled ECHAM6/FESOM simulations show biases in SETA similar to our best results with ROM. Both uncoupled FESOM and coupled ECHAM6/FESOM experiments seem to confirm the important role of ocean advection for the generation of the warm biases. The Agulhas leakage in the higher resolution FESOM weakens the warm bias inside the basin and is responsible for a more realistic transport of southern colder water. The strong coastal warm bias in the Angola-Benguela front region typical of global coupled simulations seems to be improved by a better representation of the orography, reaching values of the biases similar or lesser than those of ROM. This hypothesis is further tested with global coupled simulations with a higher resolution atmosphere.

Title: The influence of ocean-SST-cloud feedback on the tropical Atlantic SST bias

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Abstract: Strong coupled ocean atmosphere interactions govern the mean state and variations of SST in the tropical Atlantic. In this study we focus on the role of the ocean-SST-cloud feedback in two regions: the ITCZ and the Angola-Benguela upwelling region. We compare observations, reanalysis data and seasonal coupled model predictions. The feedback acts in two different ways in the model predictions. First, positive SST anomalies act to decrease cloud cover in the Angola-Benguela region. Second, cloud cover is increased in response to positive SST anomalies in the ITCZ region. SST anomalies themselves are generated both by vertical mixing processes in the ocean as well as by incoming radiance. The latter is again influenced by the cloud cover anomaly. Together, this results in a closed feedback loop. We investigate the role of this feedback in the bias development in the models by means of a seasonal upper ocean heat budget. The state-of-the-art OAGCM EC-Earth3.1 is used to unravel triggers of and the system's reactions to the bias. Shortcomings in modelling the feedback dampen the SST bias in both regions. Similarities of EC-Earth to CMIP5 OAGCMs suggest that the representation of the feedback mechanism strongly influences the SST bias in CMIP5 models.

Title: On the influence of GCM biases on seasonal prediction skill in the tropical Atlantic

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Abstract: The link between mean state biases and the ability of models to reproduce surface wind and precipitation anomalies in the tropical Atlantic is examined using customized sensitivity tests with the SINTEX-F general circulation model (GCM) and atmosphere-only experiments from the Coupled Model Intercomparison Project Phase 5 (CMIP5). The control experiment (CTRL) for the SINTEX-F sensitivity test is a run in which SSTs are strongly restored to the optimally interpolated (OI) sea-surface temperature (SST) for the period 1982-2014. In the sensitivity experiment, called "Atl_bias", the OI SST climatology is replaced with that of a 500-year free running control simulation with SINTEX-F. Thus the anomalies are the same as in OI SST but the climatology is that of the free-running coupled SINTEX-F model. Despite the substantial warm SST bias in Atl_bias the anomaly correlation coefficients (ACCs) of equatorial surface zonal wind and precipitation deteriorate only moderately, with some months even seeing an increase in ACC. Comparison of spatial patterns in CTRL and Atl_bias suggests that the ACC of surface zonal wind tends to increase where climatological precipitation does, regardless of whether the precipitation increase improves the bias or not. Atmosphere-only runs from the CMIP5 archive with prescribed SST warming patterns of about 4 K confirm that ACC is relatively robust to mean state SST changes. The results suggest that, in the context of atmosphere-only simulations, improving SST and precipitation biases does not necessarily improve the ACC of surface wind and precipitation. The root mean square error (RMSE), on the other hand, deteriorates significantly as warmer SST in the eastern tropical Atlantic engenders more vigorous convection and unrealistically high variability.

Title: Impact of Sea Surface Temperature Biases on Tropical Cyclone Simulations

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Abstract: Sea surface temperature (SST) patterns both local to and remote from tropical cyclone (TC) development regions are important drivers of TC variability. Therefore, reliable simulations and skilful predictions of TC activity depend on a realistic representation of SST. However, severe SST biases are common to the current generation of global climate models, especially in the tropical Atlantic. Nevertheless, how these SST biases influence simulated TC activity is still not well understood. To investigate the impact of the SST biases in various ocean basins on TC simulations, several suites of 16-member ensemble simulations from a TC-permitting tropical channel model were conducted. Simulation results show that the Atlantic SST biases cause not only an underrepresentation of seasonal TC activity in the Atlantic (by ~ 60%), but also an overrepresentation (~by 200%) of seasonal TC activity in the Eastern North Pacific (ENP), as measured by accumulated cyclone energy. Furthermore, even though the magnitude of the warm SST bias in the Southeast Tropical Atlantic is far more severe than the cold bias magnitude in the North Tropical Atlantic, its impact on Atlantic hurricane simulations is much less. Moreover, despite similar spatial patterns and magnitudes between the Atlantic and Pacific SST biases, their respective influences on Atlantic and Pacific TCs differ markedly. The results of this study point to the importance of understanding SST bias effects on TC simulations in climate models and highlight key regions where reducing SST biases could potentially improve TC representation in climate simulations.

Title: Impact of dynamical regionalization on precipitation biases and teleconnections over West Africa

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Abstract: Socio-economic development of West African societies is strongly linked to the West African Monsoon (WAM). Thus, present and future climate projections of the WAM are of paramount importance for these communities. In this article, the capacity of General Circulation Models (GCMs) and Regional Climate Models (RCMs) to characterize the WAM dynamics and variability is assessed during the July-August-September 1979-2004 period. For this purpose, 8 GCM historical runs from the CMIP5 and 11 RCM simulations from the CORDEX Africa initiatives are analyzed. Uncertainties in individual RCM lateral boundary conditions and dynamics are considered through the use of two separated sets of experiments: 8 SMHI-RCA4/GCM and 4 RCM/MPI-ESM-LR runs, respectively. Simulations are compared with observations (GPCP, MERRA and HadISST). To characterize WAM interannual variability, the Sea Surface Temperature based Statistical Seasonal Forecast model (S4CAST) is utilized.

Regarding WAM dynamics, both GCMs and RCMs have difficulties to simulate the northward migration of the Intertropical Convergence Zone. However, RCM added value in seasonal precipitation biases is found over specific regions of West Africa. Regarding WAM variability, the added value of RCMs in simulating interannual teleconnections appears to depend on where the circulation anomalies are originated (inside/outside the RCM domain). On the one hand, the El Niño Southern Oscillation-WAM teleconnection is partially reproduced by GCMs. RCMs tend to follow the forcing from the lateral boundary conditions but no large-scale added value is generated. On the other hand, the Atlantic Equatorial Mode-WAM teleconnection is better reproduced by RCMs, which capture the Gulf of Guinea/Sahel precipitation dipole. Such improvement may be due to the ability of RCMs to represent dynamical processes of the Sahel area absent in GCMs (e.g., soil-atmosphere exchange, land use, etc.).

Title: Modelling surface and sub-surface temperature- and salinity variability in the south-eastern Atlantic Ocean - cancelled

Authors and affiliations: Martin Schmidt <martin.schmidt@io-warnemuende.de>, Tim Junker, Volker Mohrholz and Lydia Siegfried

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Abstract: We present and discuss model results for physical transport and mixing in the south-eastern Atlantic ocean. The model results are evaluated in the light of available hydrographic and satellite data. The aim is better understanding of the sources of model bias and a systematic enhancement of the model performance.

The ocean model is configured as a "forced model" and is driven with different commonly available atmosphere data sets. We discuss the following important processes:

- spatial and temporal variability of sea surface temperature (SST) and salinity (SSS) in relation to the surface heat and fresh water flux,

- coastal and curl-driven upwelling,

- the poleward transports in the coastal wave guide as a link between tropical and subtropical Atlantic in relation to the local wind field. Special attention is paid to the processes near the Kunene upwelling cell.

- surface and sub-surface zonal transport with the South Equatorial Current (SEC) and the South Equatorial Under Current (SEUC),

- vertical mixing and the resulting surface boundary layer thickness, salinity and temperature.

The forced model develops a bias in the SST, which can be understood in dependence on the different surface heat flux components, vertical mixing and wind driven lateral transports. The bias becomes limited, since the ocean-atmosphere heat flux depends on the ocean-atmosphere temperature difference and counteracts the SST bias. On the other hand, the fresh water flux is mainly independent off the SSS. Therefore, without restoring to climatological salinity data any SSS bias may grow large from errors in the prescribed precipitation. We discuss the model performance in light of satellite based and hydrographic data sets.

Title: Importance of marine boundary layer clouds for the mean climate and interannual variability over the Atlantic Ocean

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Abstract: Coupled atmosphere-ocean general circulation models (CGCMs) show important systematic errors in the tropics. Precipitation tends to be excessive over the oceans south of the equator, and marine low clouds are generally underestimated above too warm sea surface temperatures (SSTs). In the extratropics, SSTs are also too warm over the southern ocean. This presentation addresses the potential benefits of improving the simulation of marine clouds and related processes on the better simulation of the mean climate and internannual variability over the Atlantic Ocean. The presentation has two parts.

The first part focuses on two CGCMs that greatly differ in the strength of simulated SST/marine cloud feedbacks (UCLA CGCM and NorESM). The models are perturbed with an identical, time and longitude-independent decrease in solar radiation flux incident at the top of the atmosphere over the Southern Ocean. It is shown that local impacts of the perturbation are very similar in the two models, but the remote impacts on the major stratocumulus regions of the southern subtropics are stronger in the model with stronger SST/marine cloud feedbacks. In both cases, the perturbation impact is in the direction of reducing the models' systematic errors. It is argued that alleviating a CGCM's systematic errors in the Southern Ocean can contribute to reduce those in the tropics if the model captures successfully SST/marine cloud feedbacks. The second part argues that marine boundary layer clouds may amplify modes of climate variability found over the Atlantic Ocean via their strong coupling to SST. It is shown that, in general, models that simulate the strongest coupling between subtropical SST and shortwave CRE produce a higher amplitude of SST and net CRE variability over the subtropical northeast Atlantic, than that produced by models that simulate the weakest coupling.

Title: Climatological mean tropical Atlantic surface wind convergence : analysis of the drivers in reanalyses

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Abstract: Using a mixed layer model (MLM), satellites and reanalyses datasets over the 2000-2009 decade, we provide a comprehensive explanation of monthly-mean climatology as well as month-to-month change surface wind convergence budget over the tropical Atlantic. Relative influence of the SST (Sea Surface Temperature) forcing is also examined. MLM assumes a subcloud layer momentum force balance between pressure gradients, Coriolis acceleration, linearized friction and downward momentum mixing, and utilizes boundaries conditions from reanalyses. Diagnostics with this model are also extended by the approach of Takatama et al. (2012), which express the near-surface convergence as a sum of terms relating to pressure adjustment, downward momentum mixing, and horizontal advection. Pressure contribution is linearly decomposed into boundary layer (defined as the region below 850 hPa) and free tropospheric components. While month-to-month change is highly controlled by the geostrophy within pressure contribution tightly dominated by the free tropospheric component, for monthly-mean state budget, results subdivide the marine Inter-Tropical Zone (ITCZ) into two parts. An “open ocean ITCZ” (defined as region between 10-50°W and 5-12°N in July), where pressure contribution appears positive just over the ITCZ meridional flanks; and an “coastal one” (Gulf of Guinea and Northeastern Brazilian coasts), where horizontal advection and pressure contributions control the surface wind convergence, with the pressure as the first order driver. This pressure contribution has been shown largely dominated by its component below the boundary layer closely related to SST.

Title: Influence of decadal sea surface temperature variability on northern Brazil rainfall in CMIP5 simulations.

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Abstract: The Amazonia and Northeast regions of northern Brazil are characterized by very different rainfall regimes but have certain similarities in terms of their variability. The precipitation variability in both regions is strongly linked to the tropical Atlantic gradient of sea surface temperature (SST) and the tropical Pacific SST anomalies, which at decadal timescales are modulated by the Atlantic Multidecadal Variability (AMV) and the Interdecadal Pacific Oscillation (IPO) modes of SST, respectively. On the other hand, it has been found that state of the art models from the fifth phase of the Coupled Model Intercomparison Project (CMIP5) are able to reproduce some of the characteristics of the low-frequency SST variability modes. Following this, in this work we analyze how CMIP5 models simulate the observed response of precipitation in the Amazonia and Northeast regions to the AMV and the IPO and the atmospheric mechanisms involved. Results show that, in both CMIP5 simulations and observations, Amazonia and Northeast rainfall response to the AMV is the opposite, owing to the modulation of the intertropical convergence zone (ITCZ) position. Conversely, the IPO affects equally the two regions as a consequence of anomalous subsidence over the entire northern Brazil induced by warm SST anomalies in the tropical Pacific. Such results suggest that an improvement of the predictability of decadal SST modes will directly revert into a better prediction of changes in the Amazonia and Northeast rainfall at long timescales.

Title: Role of the Tropical Atlantic in ENSO variability

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Abstract: A number of recent studies have argue that tropical Atlantic variability (TAV) can influence variability in the Indo-Pacific, and may even enhance the predictability of major El Niño events. However, the influence of the Atlantic on the Pacific appears to be non-stationary, being present after the 1970's and absent during the period 1930-1970. Here we study the impact of TAV on the Indo-Pacific in partial coupled model experiments with the ECHAM5/MPIOM coupled model in which model sea surface temperature (SST) are restored strongly to observation over the tropical Atlantic while elsewhere the model is fully coupled. We show that the strengthening of Atlantic-Pacific relation leads to an enhancement of ENSO variability after the mid-70s, consistent with observations. The strengthening of the Atlantic-Pacific relation appears related to a warming of the South Atlantic during the period that leads to a southward shift of the ITCZ in the Atlantic and a corresponding enhancement of the atmospheric response to local equatorial SST variability. These results are supported by similar experiments from the SPEEDY model. The role of the Atlantic in the 2015/2016 El Niño event will be discussed.

Title: How sensitive are the Pacific–tropical North Atlantic teleconnections to the position and intensity of El Niño related warming?

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Abstract: The atmospheric teleconnections associated with the Eastern and Central Pacific El Niño events onto the tropical Atlantic Ocean are investigated. The Eastern Pacific El Niños drive significant warming of the tropical North Atlantic basin during boreal spring after its peak via the atmospheric bridge and tropospheric temperature mechanisms. However, the tropical Atlantic does not show a robust response to Central Pacific El Niños. Here our results suggest that the preconditioning of the tropical North Atlantic sea surface temperature (SST) anomalies in boreal winter plays an important role in the following season, not only during Eastern Pacific El Niños but also during Central Pacific El Niños. Additionally, we examine three other factors that could explain potential differences in the tropical Atlantic teleconnections from Central and Eastern Pacific El Niño events: (1) The distant location of the maximum SST warming in the Pacific; (2) The weak warming associated with this pattern; and (3) The SST pattern including a cooling in the eastern Pacific. Using numerical experiments forced with idealised SST in the equatorial Pacific, we show that the location of the Central Pacific El Niño SST warming during its mature phase could be favourable for exciting atmospheric teleconnections in boreal winter but not in the following spring season due to the seasonal shift of the Inter-Tropical Convergence Zone that modulates deep convection over the anomalous SST. This demonstrates the importance of the mean seasonal atmospheric circulation in modulating the remote teleconnections from the central-western Pacific warming in the model. However, it is suggested here that the cooling in the eastern Pacific associated with Central Pacific El Niño counteracts the atmospheric response driven by the central western Pacific warming. Finally we show that the modelled Pacific–tropical Atlantic teleconnections to an eastern Pacific warming depends strongly on the underlying seasonal cycle of SST.

Title: The effects of the El Niño duration on the climatic impact over the tropical North Atlantic

Authors and affiliations: Enzo Pinheiro <pinheiroenzo92@gmail.com>[1]; Diogenes Passos Fontenele [1]; Francisco das Chagas Vasconcelos Junior [1]; Eduardo Savio Passos Rodrigues Martins [1]; Jacques Maurice René Raymond Servain [1,2]

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Abstract: El Niño phenomenon affects the tropical North Atlantic (TNA) variability through a teleconnection known as Pacific North-America Mode. Although this remote influence over the TNA region is already well documented, some aspects of the oceanic response, particularly in terms of its subsurface dynamics, remain unclear. This study investigates how El Niño events of different durations might influence the subsurface temperatures and sea surface heights (SSH) in the TNA. In the present research, the GlORYS 1993-2014 reanalysis database from the Mercator Project is used over the tropical Atlantic (0.25° and 75 levels). The analysis was based on identifying the associated subsurface temperature and SSH responses to six El Niño events, which were divided in short and long durations' El Niños. The adopted classification considered a long El Niño event if the Niño 3.4 SST index is higher or equal to 0.5°C until the beginning of subsequent austral summer, and a short El Niño event if it had already been dissipated before that season. For the long duration events, westward propagation of positive temperature anomalies associated to Rossby waves was identified in the Atlantic region, specifically in the region 3°N-10°N; 50°W-20°W. Such wave pattern appeared also in the SSH anomalies. On the other hand, no clear Atlantic response was identified for years following the short duration events. Indeed, two of these short events were succeeded by neutral condition in the TNA, and one was even followed by negative temperature anomalies. Although a limited number of events was analysed, this suggests that long duration El Niño events can modulate the TNA variability, while short duration events cannot. Therefore, in theses last cases, the internal modes of the TNA variability prevail over El Niño's influence.

Title: External forcing links Atlantic multidecadal variability and the Indian summer monsoon

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Abstract: The instrumental records show a significant positive correlation between the Atlantic multi-decadal variability (AMV) and the Indian summer monsoon (ISM) rainfall, where a positive (negative) AMV is associated with more (less) ISM rainfall. We have used both proxy reconstructions and 25 models from the Coupled Model Intercomparison Project Phase 5 (CMIP5) to investigate if the observed AMV-ISM relation is a persistent internal climate signal or externally forced. A comparison of several annual resolution proxy records both from the Atlantic and for the ISM show that the multi-decadal variability in both indices is persistent, but the link between them is not. The analysis of CMIP5 simulations is consistent with these results. The significant AMV-ISM relation in observations is not simulated by any of the models in pre-industrial control simulations with fixed external forcing, but is captured by one model (GFDL- CM3) in the historical simulations including transient external forcings. Further analyses of GFDL-CM3 reveal that external forcing is linked to a strengthened land-ocean thermal gradient over South Asia consistent with an enhanced ISM, which also leads to a concurrent evolution of AMV. Thus the significant relationship found in observations may be associated with external forcing, instead of internal climate variability.

Session 3 - Towards realising socio-economic benefits of climate prediction in the Tropical Atlantic for marine ecosystems, fisheries, and continental climate

Title: Upper mesopelagic vertical and horizontal distributional patterns in relation to hydrographical conditions in the Eastern tropical North Atlantic

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Abstract: Compared to coastal regions marine pelagic ecosystems constitute a homogenous environment, however, mesopelagic species distributional patterns inferred from biological sampling and acoustic observations are far from being random, but exhibit patchiness that is generally related to local hydrographical regimes and derived patterns of productivity. In the horizontal plane, eddy formation, zones of divergence and local upwelling are important, while the vertical structure is governed primarily by a gradient in temperature, salinity, light and nutrients, as well as small density differences that slow down sinking food particles and constitute layers of concentration of mesopelagic organisms. Physiologically, differences in pressure, salinity and temperature values impact e.g. metabolic processes and ion regulation. Species respond with different life strategies, but under stable conditions generally optimize their energy budgets by close adaptation to their environment.

This study aims to demonstrate this close coupling in the pelagic region of the Eastern tropical North Atlantic, where dynamic current systems shape the productivity regime in the temporal, horizontal and vertical axis while further an oxygen minimum zone is aggravating with potential implications on metabolic and biogeochemical processes. We look at the degree of correlation between biological net catches, environmental parameters and hydro-acoustic backscatter strength and try to single out key processes determining local distributional patterns.

Title: Changes in the trans-equatorial distribution of Sherborn's basslet, *Howella sherborni*, and Atlantic pelagic basslet, *Howella atlantica*, in the northern tropical Atlantic

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Abstract: The trans-equatorial distribution of *Howella* species is reconstructed based on historical data from the 1970's and museum collections and compared to recent distribution patterns of material collected during the PREFACE cruises from 2015 and 2016. *H. sherborni* is a warm water species typically known from the equatorial Indian Ocean and the southern Atlantic. It has become much more abundant in recent PREFACE samples and thus expanded its range. *H. atlantica* as a warm-temperate species has declined in relative abundance. Opposite to previous data collections, *H. atlantica* was not only present as juvenile, but also as mature specimens, whereas only juvenile specimens of *H. sherborni* were found.

A species distribution model based on WOA decadal climatologies is presented to elucidate changes in distributions. Further species will be analyzed with more data becoming available.

Title: First insights on the impact of hydrology and currents on the horizontal and vertical distributions of fish and macrozooplankton in the Eastern tropical Atlantic Ocean

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Abstract: Acoustic tools allow for simultaneous acquisition of both quantitative and qualitative data at different spatiotemporal scales, providing information on biotic and abiotic ecosystem components. Since 2015, multifrequency acoustic data (18, 38, 70, 120, 200 and 333 kHz) have been continuously collected during PIRATA-FR25 & FR26 cruises performed in the Eastern tropical Atlantic, from Cabo-Verde islands to the equator and in the Gulf of Guinea. Here we present the first results obtained combining acoustic and physical data acquired during these cruises.

Acoustic data were echo-integrated onto 1 m layers over 0.1 nmi ESDU (elementary sampling distance unit) with a -100 dB threshold, from 9 m down to 1000 m depth. Using multifrequency techniques, we discriminated broad taxonomic groups such as fish and zooplankton. Concurrently SADCP data have been continuously recorded for current velocity measurements and a CTD-O2 was deployed during stations to profile temperature, salinity and oxygen down to 2000 m. Here we test the potential of these data for studying the impact of ocean structure on the pattern of vertical and horizontal distribution of marine life. For that purpose, we addressed two main objectives.

First, using the acoustic backscatter as a proxy of abundance we show how ocean features, such as the Intertropical Convergence Zone, the Congo River plume and oceanic fronts, can impact the horizontal distribution pattern of fish and zooplankton distribution. The two years of studies presented contrasted conditions with much warmer conditions in 2016 than 2015, which allowed us to study a variety of scenarios.

Second, using the CTD-O2 profiles, we show the potential influence of the vertical structure (including thermocline, oxycline, pick of fluorescence) on the vertical patterns of organisms distribution and migration. Such knowledge is critical since diel vertical migration plays an important role in carbon cycle and sink.

Title: Tropical Atlantic Variability and fluctuations of small pelagic fish off Angola: The role of the main upwelling season

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Abstract: *In situ* data from acoustic surveys and satellite imagery (1994-2014) are used to describe upwelling and drift patterns within the essential habitat of the Angolan sardinella (6° - 12°30'S). Ocean climate is in this region controlled the Tropical Atlantic Variability (TAV). Local upwelling (downwelling) favourable conditions are induced by the thermocline elevations (depressions) transmitted from the equator in the coastal waveguide. The austral winter upwelling season continues from June to August. Algal blooming, planktonic food concentrations and high densities of sardinella occur in the depth range 20-60 m, in connection with internal tide fronts. The onset of the spring downwelling season (September to November) sees the stratification strengthen and thermocline depressed. A poleward intrusion of low-salinity tropical water develops at the sea surface. The associated current serves as a transport mechanism for larvae and juveniles developed during the preceding upwelling season to reach nursery areas downstream. The tidal fronts vanish from the coast, repelling sardinella offshore. Late November sees the end of the spring downwelling and marks the beginning of the second semi-annual upwelling-downwelling cycle, which continues until April. In contrast to the winter-spring cycle, the minor upwelling in December-January and downwelling in February to April exhibit strong interannual variability, controlled by the TAV. There are no in situ observations in the sardinella habitat during the minor upwelling. During the fall downwelling season, the TAV forcing induces interannual variations in strength, timing and duration of the poleward current episodes. The effect on sardinella, observed during 1994-2014 inclusive of the strongest Benguela Niño episodes, was transient; affected fish behavior but not the population structure. As the coastal climate is warming, the population of the Angolan sardinella within its main habitat is rising. We attribute this to the climatologically stable conditions during the critical main upwelling season and a moderate fishing pressure.

Title: Vertical habitat use and diving behaviour of yellowfin tuna, *Thunnus albacares*, in CABO VERDE

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Abstract: Habitat quality changes with climate change, affecting water temperature and oxygen contents, and this change in habitat quality could trigger a shift in spatial distributions of the tuna species, i.e. yellowfin (YFT) and bigeye tuna (BET), in Cabo Verde with subsequent effects for the fisheries. The aim of PREFACE work package 12-2 is to investigate habitat use these species.

Stramma *et al*. (2012) show expanding Oxygen Minimum Zones (OMZs) in the eastern tropical seas. Possible consequences of OMZ expansion to the marine ecosystem include loss of vertical habitat for high oxygen demand tropical big pelagic fishes like tunas and the associated increased risk of overfishing of these species by surface fishing gear.

All fish were captured by means of hand line fishing and of rod fishing, applying circle hooks or J-hooks, depending on the fishermen's experience in using circle hooks.

In April 2016, under-sized BET were caught besides two specimens of YFT all with around 1 m in length, which were tagged with External pop-up satellite tags (WildlifeComputers MiniPAT) (SF1, SF2). Whereas SF2 suffered from post-tagging mortality, SF1 ran successfully for 30 days. Swimming depth rarely was deeper than 80 m. No deep dives were undertaken. SF1 was deployed south of the island Maio, Cabo Verde. The specimen swam north along the east coast of Maio and then turned west between Maio and Boa Vista. In July/August 2016, two specimens of sufficient size were caught, but one specimen could not be retrieved with consequently unsuccessful tagging. SF3 was released on August 1 off Sao Vincente. Expected tag release will be on September 4, 2016.

Title: Population traits in Small pelagic fish model: emergence from interactions between turbulent environment and individual behaviours in Upwelling Systems

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Abstract: Small pelagic fish (SPF) species are heavily exploited in the four main eastern boundary upwelling systems (EBUS), including both Atlantic African ones, as their transformation are increasingly used in the world food chain. Management rely on regular monitoring, but there is a lack of model for population traits emergence and evolution according to the variability of the environment. We attempt to extract some general rules based on the analysis of a life cycle biophysical individual based model applied to the round sardinella (*Sardinella aurita*, Clupeidae) population off North West Africa. Our analysis focused on the processes responsible for seasonal migrations, spatio-temporal body-length distribution, and inter-annual biomass fluctuations. These patterns were found at individual level in the dynamic change of preferred habitat, and variability in exploration capacities. The former resulted from complex interactions between natal homing behavior and environmental variability, while the last was determined by individual swimming capacities, the mesoscale structure of the habitat and the horizontal currents. Observed spatio-temporal abundance variability emerged from a superposition of numerous distinct individual life histories. This work also suggested an alongshore pattern in size distributions confirmed by in situ surveys. New insights about population structure are provided, with a focal area in Mauritania and mainly two migrating sub-populations centered at 18°N and 21°N, respectively. Inter-annual biomass fluctuations were linked to variability in Sahara Bank's fish recruitment, itself depending on southward current intensity. The identified processes constitute an analytical frame that can be transposed to study SPF in all EBUS and used to study potential effect of regional climate change.

Title: Climate change projections over West Africa: What would be the role of Ocean SST

Authors and affiliations: Mouhamadou Bamba SYLLA <sylla.b@wascal.org>, WASCAL

Abstract: Discussion and perspectives that that can be incorporated into the WASCAL research programme.

Title: Predictability of malaria parameters in Sahel under the S4CAST Model

Authors and affiliations: Ibrahima Diouf <ivedioufpc@yahoo.fr>[1,2]; B. Rodríguez De Fonseca [2]; A. Deme[1, 3]; M. Cisse [4]; J.-A. NDIONE [5]; A. T. GAYE [1]

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Abstract: The Sahelian part of Africa and Senegal in particular are affected by important outbreaks of diseases with destructive consequences on human population, livestock and country's economy. These vector-borne diseases such as malaria are largely modulated by seasonal and interannual climate variability. For this purpose, the analysis of the spatial and temporal variability of climate parameters and associated model simulations are important to assess the climate impact on malaria transmission. The results of this study based on observations over Senegal and simulations throughout the Sahel region with a particular focus on Senegal, including its Ferlo part (Sahel gate to Senegal) confirmed that the risk of malaria transmission is really modulated by climate parameters such as rainfall and its generated moisture, but also temperatures. Malaria transmission follows the seasonal and spatial behaviour of rainfall. The rainy season which usually takes place between May and October remains the most favourable period for mosquito development, therefore for malaria outbreaks.

Knowing that these climate parameters involved in the existence and spread of malaria could be predicted from ocean conditions (sea surface temperature), the aim of this study is first to characterize the climate conditions for malaria incidence in our area of study and try to develop a predictive bioclimatic model useful for health human issue. A causal or coincidence relationship between El Niño and low malaria transmission (associated with less rainfall) is found by coupling the LMM and S4CAST models. Indeed, El Niño seems to be related to significant decrease of mosquito vectors and malaria incidence.

The results of this research should be useful for decision makers in order to improve climate predictability in Senegal and remote regions in Sahel.

Title: Decadal prediction of Sahel rainfall: where does the skill (or lack thereof) come from?

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Abstract: Previous works suggest decadal predictions of Sahel rainfall could be skilful. However, the sources of such skill are still under debate. In addition, previous results are based on short validation periods (i.e. less than 50 years). In this work we propose a framework based on multi-linear regression analysis to study the potential sources of skill for predicting Sahel trends several years ahead. We apply it to an extended decadal hindcast performed with the MPI-ESM-LR model that span from 1901 to 2010 with one year sampling interval. Our results show that the skill mainly depends on how well we can predict the timing of the global warming (GW), the Atlantic multidecadal variability (AMV) and, to a lesser extent, the inter-decadal Pacific oscillation (IPO) signals and on how well the system can simulate the SST and West African rainfall patterns in response to such signals. In the case of the MPI-ESM-LR decadal extended hindcast, the observed timing is well reproduced only for the GW and AMV signals. However, only the West African rainfall response to the AMV is correctly reproduced. Thus, for most of the lead times the main source of skill in the decadal hindcast of West African rainfall is from the AMV. The GW signal degrades skill because the response of West African rainfall to GW is incorrectly captured. Our results also suggest that initialized decadal predictions of West African rainfall can be further improved by better simulating the response of global SST to GW and AMV. Furthermore, our approach may be applied to understand and attribute prediction skill for other variables and regions.

Title: Climate change: What kind of knowledge, what type of adaptation for what type of West African artisanal fisher folk

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Abstract: Senegalese artisanal fishermen have always been able to deal with variable weather and changing climate by adapting their knowledge, which is passed on from one generation to the next. The analysis of their perceived and realized threats on climate change and their associated adaptation strategies revealed that they are based on a mixture of magic-religious (animism and Islamism) considerations and empirical knowledge. Such considerations and knowledge lead to (1) divination sessions to address e.g. the lack of rain and too high winds, (2) taboos and prohibitions to preserve e.g. the resource, but also and especially (3) appraisal modes of climatic parameters including swell, winds, and the moon cycles. The observation of these parameters allows fishermen to know the sea state and to adapt their behaviour to it. However, an analysis per age group shows that most of the young fishermen tend to ignore or disbelieve the magic-religious considerations and move towards empirical considerations gained through the use of electronic marine equipment (e.g. sounder, GPS) and national weather forecast. However, the limited traditional knowledge of young fisher folk on atmospheric and marine climate parameters compared to older fishermen might be an important gap in developing adaptation strategies. This is also true for neglecting new scientific findings by part of older fisher folk. We underline the importance to consider the three main types of knowledge for developing adaptation strategies for the artisanal fisheries sector in West Africa.

Title: Climate change after the COP 21: economic aspects

Authors and affiliations: Anna Creti <creti.anna@gmail.com >, member of Climate Service Centre WASCAL scientific advisory board

Abstract: invited presentation.

POSTER PRESENTATIONS

Session 1 – Oceanic and atmospheric processes affecting physical-biogeochemical interaction and climate

Title: Seasonal variability of the Angola Current related to resonant equatorial basin modes

Authors and affiliations: Robert Kopte <rkopte@geomar.de>[1]; Peter Brandt [1,2]; Marcus Dengler [1]; Martin Claus [1]; Richard J. Greatbatch [1,2]

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Abstract: The boundary circulation off the coast of Angola is a key component in communicating oceanic variability between the equatorial Atlantic and the Benguela upwelling region in the south. Multi-year velocity observations of the Angola Current at 11°S reveal pronounced intra-seasonal to seasonal variability with velocity fluctuations in the range of ±40 cm/s that are superimposed on a weak mean southward circulation. The variability is dominated by 120-day, semi-annual, and annual oscillations with distinct baroclinic structures. In the equatorial Atlantic these periods were identified to be closely related to resonant basin modes of the 1st, 2nd, and 4th baroclinic mode. Such basin modes consist of equatorial Kelvin and Rossby waves as well as coastally trapped waves propagating poleward along the eastern boundary.

We apply a suite of reduced gravity models for the tropical Atlantic to investigate the intra-seasonal to seasonal variability along the equatorial and coastal wave-guides. The models are calculated for the first seven baroclinic modes with each mode being forced separately by harmonically oscillating wind stress at 120-day, semi-annual and annual periods. Derived model amplitudes are scaled with respect to amplitudes from a modal decomposition of surface-to-bottom velocities as recorded at the equatorial mooring at 23°W. By linear superposition of the dominant modes (including also higher-order basin modes) the pattern of the observed seasonality at 11°S can be reconstructed, although with lower amplitudes. Yet, this indicates the importance of transient equatorial forcing for the boundary circulation on intra-seasonal to seasonal time scales.

The applied method of amplitude scaling is validated by reconstructing available moored velocity observations along the equatorial wave-guide as well as AVISO sea level anomalies in the tropical Atlantic.

Title: Seasonal Mixed Layer Heat and Salinity Budget in the South Eastern Tropical Atlantic Ocean

Authors and affiliations: Jan Lüdke <jluedke@geomar.de> [1, 2]; Marcus Dengler [1]; Peter Brandt [1,2]; Willi Rath [1]

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Abstract: An extensive hydrographic dataset, compiled from public and previously unavailable archives, is used to quantify the physical processes contributing to the mixed layer heat and salinity budgets in the south eastern tropical Atlantic. This new climatology developed within the EU PREFACE project provides seasonal variations of mixed layer heat content and salinity. The surface heat and freshwater fluxes, horizontal advection from near-surface velocities, horizontal eddy advection, and vertical entrainment contributing to these variations are calculated for several sub-regions of the south eastern tropical Atlantic.

The most important cooling is caused by zonal heat advection in the off-equatorial areas for the whole year. Eddy advection is an additional major heat flux and provides the largest annual mean heating in the Benguela upwelling system and further offshore but exhibits large seasonal variations closer to the equator. The surface heat flux is identified as the main driver of seasonal heat content variations due to the large annual cycle of short-wave radiation. Throughout the off-equatorial areas the evaporation is larger than precipitation and their combined impact on the mixed layer salinity is balanced by zonal freshwater advection. Especially in the eastern equatorial Atlantic other oceanic processes, like entrainment and probably vertical mixing, contribute to the mixed layer salinity budget, too. However, not all regional budgets are closed within the uncertainty, therefore additional not resolved processes like vertical mixing have to close the remaining residual. In contrast to the mixed layer heat budget that is dominated by surface fluxes, the mixed layer salinity budget is more strongly influenced by ocean processes.

Title: An enhanced PIRATA data set for tropical Atlantic ocean-atmosphere research

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Abstract: The Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) provides measurements of the upper ocean and near-surface atmosphere at 18 locations throughout the tropical Atlantic. Time series from the moorings, some of which are nearly 20 years in length, are valuable for understanding and monitoring the tropical Atlantic Ocean and climate. However, instrumental biases, data drop-outs, and the course vertical resolutions of some oceanic measurements, complicate their use for research. Here an enhanced PIRATA data set (ePIRATA) is presented that corrects instrumental biases, fills temporal gaps, and maps the original PIRATA subsurface temperature and salinity time series to a uniform 5-m vertical grid. Important aspects of this data set are that all original PIRATA data, after application of quality-control, are retained without modification, and detailed error estimates are provided for each daily-averaged oceanic and atmospheric parameter. The terms in the mixed layer heat and temperature budgets are calculated and provided, with error bars, as part of the data set. It is anticipated that ePIRATA will be useful for research and for validating numerical models.

Title: Property Changes of Deep and Bottom Waters in the Western Tropical Atlantic

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Abstract: The flow of North Atlantic Deep Water (NADW) and Antarctic Bottom Water (AABW) is an essential part of the Atlantic meridional overturning circulation. Variations in its strength and characteristics impact global sea level rise and the ocean uptake of anthropogenic CO2. We compile historic and recent hydrography and current shipboard measurements to provide a comprehensive view on water mass distribution, pathways, along-path transformation and long-term temperature changes of NADW and AABW in the western South and Equatorial Atlantic. The available measurements sample the two major routes for deep and bottom waters in the northern Brazil Basin – one along the deep western boundary and the other eastward, parallel to the equator. Lower NADW is dominantly transported eastward with minor contributions following the DWBC. The southward flow in the DWBC is instead dominated by middle NADW with contributions of modified and recirculated water from the central to southern Brazil Basin. The AABW north of 5°S is relatively homogeneous with only lighter AABW being able to pass through the Equatorial Channel (EQCH) into the North Atlantic. Spanning 26 years, our data allows estimating long-term temperature trends in abyssal waters: In the northern Brazil Basin we find a warming of 2.5 ±0.7·10-3 °C yr-1 for waters colder than 0.6°C throughout the period 1989-2014 and can relate this to a thinning of the dense AABW layers. While isopycnal heave is the dominant effect defining the vertical distribution of temperature trends on isobars, we also find temperature changes on isopycnals in the lower NADW and AABW layers. Those exhibit decadal variations (warming in the 1990s, cooling in the 2000s) - contributions to trends on isobars range from ~50% within lighter AABW in the EQCH up to 80% in the transition layer the lower NADW/lighter AABW form in the northern Brazil Basin.

Title: Genesis dynamics of the Angola-Benguela Frontal Zone: Ocean frontogenesis function

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Abstract: We have demonstrated a diagnostic analysis on the annual mean and seasonal cycle of the Angola Benguela Frontal Zone (ABFZ) applying an ocean frontogenesis function (OFGF) to the ocean mixing layer (OML). The ABFZ locates at 16S and our OFGF reveals that the meridional confluence induced by the convergence of the Benguela and Angola currents and the vertical tilting terms are the most dominant contributors to the ABFZ frontogenesis and the entrainment below the ocean mixing layer is frontolytic in terms of annual-mean. The ABFZ shows a well-pronounced semi-annual cycle with two maximum (minimum) peaks in May and December (March and February). Our proposing OFGF is able to capture the semi-annual cycle of frontogenesis and frontolysis with 1-2 months leading time to the ABFZ. Interestingly, two peaks of frontogenesis are caused mainly by the tilting (March to May) and the confluence (September to October) respectively. The strong meridional confluence is closely related to the southward intrusion of tropical warm sea water to the ABFZ from September to November. This intrusion is due to the strong Angola Current that is associated with the well-developed centre of low sea surface height and the Ekman upwelling in the northwestern of the ABFZ. The strong tilting effect in March to May is attributed to the strong Ekman upwelling in the south of the centre of the ABFZ. Not only meridional wind stress, but zonal wind stress also forces the Ekman upwelling comparably. In addition, the OML depth is shallower (deeper) and the ocean stratification between the OML and the layer just below OML is more (less) stable from March (September) to May (October). Because these factors can also enhance (dilute) the tilting frontogenetic effect, the tilting effect is outstanding (modest) in March-to-May (September-to-October).

Title: Impacts of chlorophyll concentrations on the Tropical Atlantic Ocean

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Abstract: The influence of the chlorophyll on the upper Tropical Atlantic ocean is investigated with long term (1998-2012) regional oceanic simulations with 1/4° horizontal resolution based on the NEMO3.6 model. The model solar radiation penetration scheme depends on the chlorophyll concentration. Simulations with time and spatially varying concentrations obtained from satellite ocean color observations are compared with a simulation forced with constant chlorophyll concentration of 0.05 mg m-3, representative of chlorophyll depleted waters. Results indicate that regions of the Tropical Atlantic with high chlorophyll concentrations get warmer at the surface, at the exception of the main upwelling regions where high chlorophyll concentrations are associated with a significant cooling of the sea surface (~1°C in the Benguela upwelling). The analysis of the model heat balance shows that the biological differential heating causes negative subsurface temperature anomalies prior to their upwelling at the coast. The shallow mixed-layer in the eastern equatorial and tropical Atlantic favors the persistence of these subsurface anomalies and may explain that the Benguela is particularly sensitive to the biology. In spite of the presence of high chlorophyll concentrations in the upwelling regions, both the larger amount of shortwave radiation captured in the surface layers, and the modifications of the horizontal and vertical advection at the coast are found to play a secondary role in the SST change in the upwelling region.

Title: Atlantic Meridional Overturning Circulation: Variability of the Boundary Circulation Systems and AMOC at 11°S

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Abstract: The western boundary current system off Brazil is a key region for variations of the Atlantic meridional overturning circulation (AMOC) and the southern subtropical cell. In July 2013 a mooring array was installed off the Brazilian coast at 11°S similar to an array operated between 2000 and 2004 at the same location. Three research cruises and the moored observations between 2013 and 2015 are analysed in comparison to the observations a decade ago. Average transports of the North Brazil Undercurrent and the Deep Western Boundary Current (DWBC) have not changed between both observational periods. DWBC eddies, which are predicted to disappear with a weakening AMOC, are still present with similar characteristics. Interannual transport variability as assessed between 2000-2004 from observations is consistently found in the output of a forced ocean model. Upper layer changes in salinity and oxygen within the last decade are consistent with an increased Agulhas leakage, while at depths water mass variability is likely related to changes in the North Atlantic as well as tropical circulation. The Eastern Atlantic Boundary system is also investigated based on ship-board measurements and a moored array, which was also installed in 2013. Additionally, bottom pressure sensors were deployed at 300m and 500m depth on both sides of the Atlantic basin, in order to estimate the interior mid-ocean transport. Together, the boundary transport estimates, the mid-ocean transport and the Ekman contribution will be combined to give a comprehensive AMOC estimate for the tropical Atlantic at 11°S.

Title: Role of the Equatorial undercurrent salinity maximum in the seasonal variability of sea surface salinity in the Equatorial Atlantic Cold Tongue

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Abstract: The physical processes responsible for sea surface salinity (SSS) increase in the equatorial Atlantic Cold Tongue (ACT) region during boreal spring and the lag observed between boreal spring SSS maximum and sea surface temperature (SST) summer minimum are examined using mixed-layer salinity budgets computed from observations and model for the period 2010-2012. The boreal spring SSS maximum is explained by an upward flux of high salinity originated from Equatorial Undercurrent (EUC) core caused by increased vertical mixing and advection. The vertical mixing contribution to the mixed-layer salt budget peaks in April-May. It is controlled primarily by i) increased zonal shear between the surface South Equatorial Current (SEC) and the subsurface EUC and ii) the presence of large salinity stratification at the mixed-layer base from December to May. This haline stratification which is due to both high precipitations below the Inter Tropical Convergence Zone (that is at its southernmost position during boreal winter and early-spring) and zonal advection of low-salinity water from the Gulf of Guinea, explains largely the seasonal cycle of the vertical advection contribution to the mixed-layer salt budget. In the ACT region, the 1-month lag observed between the maximum of SSS in June and the minimum of SST in July is explained by the shallowing of EUC salinity core in June, then the weakening/erosion of the EUC in June-July which reduces the lateral subsurface input of high saline waters in the ACT region.

Title: A new dipole index for the tropical Atlantic from the PIRATA dataset

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Abstract: The original design of the PIRATA network was firstly elaborated for monitoring the two main modes of climate variability in the tropical Atlantic, i.e. the equatorial mode (similar to El Niño) and the meridional mode (or “dipole” mode), which is known to be connected with occurrences of abnormal seasonal rainfall in Northeast of Brazil (Nordeste). The two former meridional PIRATA sections along 38°W (4 buoys from 15°N to 4°N) and 10°W (3 buoys from 0°N to 10°S) were especially dedicated to survey the meridional mode. From 1998 (beginning of PIRATA), the daily difference of the sea surface temperature (SST) anomalies between the buoy 15°N/38°W (at north-west) and the buoy 10°S/10°W (at south-east) is currently used as a proxy of the tropical Atlantic dipole . That proxy is very well correlated with the “Servain dipole index”, a monthly representation of the dipole using the difference between the observed SST anomalies inside two parts of the whole tropical basin (28°N-5°N minus 5°N-20°S). Both indices are currently available at www.funceme.br. A south-west extension of the PIRATA network (PIRATA-SWE) was performed in 2005 with three buoys located off Brazil (8°S-30°W, 14°S-32°W and 19°S-34°W). Now, after more than 10 years of data available from the PIRATA-SWE, it is possible to test another representation of the Atlantic dipole using these buoys. All the coupled combinations between the four original buoys along 38°W (for the northern pole) and the three new buoys of the PIRATA-SWE (for the southern pole) were tested according to their performance to forecast the seasonal rainfall over the Nordeste. We found that the couple 4°N-38°W and 8°S-30°W is the best candidate to represent the real time Atlantic dipole, even better than the “classical” 15°N-38°W / 10°S-10°W index. Such new daily index will be then currently computed and will be added on www.funceme.br.

Title: The CO2 network in the tropical Atlantic: A contribution to the Integrated Carbon Observation System (ICOS)

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Abstract: A European research infrastructure has been established for monitoring carbon dioxide and greenhouse gases in order to better quantify the atmospheric, ecosystem and ocean fluxes (www.icos-ri.eu).

The main objective of the ocean CO2 network is to better quantify the CO2 flux across the air-sea interface, its seasonal and decadal variability as well as its long term trend. Here we focus on the observational network of the tropical Atlantic. The tropical Atlantic is a source of CO2 to the atmosphere characterized by strong ocean dynamics and river discharge. The evolution of the source of CO2 under increasing atmospheric CO2 remains unknown. Two merchant ships sailing from France to French Guiana and France to Brazil are equipped with an automated CO2 system. 46 voyages have been realized on the France-Brazil line from 2008 and 40 voyages on the France-French Guiana line from 2006. To complete the spatial coverage, two time-series stations of the PIRATA network have been equipped with a CO2 sensor CARIOCA: at 6oS, 10oW since 2006 and 8oN, 38oW since 2008.

The observations collected by the network highlight a north-south CO2 gradient, with higher CO2 concentrations observed south of the equator, CO2 undersaturations caused by the Amazon river plume, and interannual variability associated with climate variability such as ENSO event and south Atlantic cooling.

Title: Do the Amazon and Orinoco freshwater plumes really matter for hurricane-induced ocean surface cooling?

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Abstract: Recent studies suggested that the plume of low-saline waters formed by the discharge of the Amazon and Orinoco rivers could favor Atlantic Tropical Cyclone (TC) intensification by weakening the cool wake and its impact on the hurricane growth potential. The main objective of this study is to quantify the effects of the Amazon-Orinoco river discharges in modulating the amplitude of TC-induced cooling in the western Tropical Atlantic. Our approach is based on the analysis of TC cool wake statistics obtained from an ocean regional numerical simulation with 1/4º horizontal resolution over the 1998–2012 period, forced with realistic TC winds. In both model and observations, the amplitude of TC-induced cooling in plume waters (0.3–0.4ºC) is reduced significantly by around 50–60% compared to the cooling in open ocean waters out of the plume (0.6–0.7ºC). A twin simulation without river runoff shows that TC-induced cooling over the plume region (defined from the reference experiment) is almost unchanged (~0.03ºC) despite strong differences in salinity stratification and the absence of barrier layers. This argues for a weaker than thought cooling inhibition effect of salinity stratification and barrier layers in this region. Indeed, results suggest that haline stratification and barrier layers caused by the river runoff may explain only ~10% of the cooling difference between plume waters and open ocean waters. Instead, the analysis of the background oceanic conditions suggests that the regional distribution of the thermal stratification is the main factor controlling the amplitude of cooling in the plume region.

Title: A climatological analysis of the seasonal variability of surface temperature and circulation over the Canary current upwelling system

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Abstract: The seasonal climatological budget of the mixed layer temperature of the Canary Current upwelling system (CCUS) is described and analyzed using an eddy permitting numerical simulation of the Tropical Atlantic, vali- dated against observed surface temperature, winds and currents. During the so-called cooling period from Novem- ber to May, the maximum temperature decrease is observed over an area extending meridionnaly along Mauritania and Senegal and over about 1-2◦ of longitude from the coast .It is driven mainly by vertical turbulent mixing, due to the season strengthening of Ekman pumping and vertical shear of horizontal currents, and by horizontal advection of northern waters.. Farther offshore, except near the Cap Verde islands away from the direct influence of coastal upwelling, the SST drop is mainly governed by air-sea fluxes,. During the so-called warming season from June to October, the temperature increase is overall driven by air-sea heat fluxes, except south of about 10-12◦N. There, horizontal advection and vertical turbulent mixing control the temperature due to the influence of, respectively, the North Equatorial Counter-Current and temperature inversions just below the MLD. A more detailed analysis is proposed along the coastal region

Title: Variability of the Inter-Tropical Convergence Zone: Influence of the tropical Atlantic Warm Pool

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Abstract: The study of the influence of the tropical Atlantic Warm Pool (WP) on the ITCZ variability is done by studying the Mixed Layer (ML) heat budgets of the Tropical Atlantic Ocean With the regional ocean model, NEMO-ATL025. The WP of the tropical Atlantic is characterized by the 27 °C isotherm on both sides of the maximum of SST (Max-SST), called North (FN) and South (FS) fronts respectively in North and South of Max-SST. However, the migration speed of the WP of the tropical Atlantic is characterized by those of the Max-SST and these two fronts (FN and FS). Thus, migration speeds revealed two migration periods of the WP, one with positive speeds from April to September, this period is known as the period when the ITCZ is in the North (Monsoon season of West Africa) and the other with the negative ones of October To Mars corresponding to the season when the ITCZ is in the South (South American Monsoon). These migration speeds also show that the maximum latitudes reached by the WP are obtained in April (South) and September (North), V = 0 °lat/d. During these months a reversal of the migration speeds of the WP. The maximum speed (+0.7 °lat/d) is obtained in July-August, the ITCZ migration associated with that of the WP is stronger in July and August. However, the contribution of oceanic and atmospheric processes to the migration speed of WP is dominated by horizontal advection and vertical diffusion for the ocean and latent and solar fluxes for the atmosphere. In the remainder of this work, we will discuss the relative importance of these three processes (horizontal advection, vertical diffusion and air-sea flux) according to the longitudes and the season.

Session 2 – Mechanisms and simulation of tropical Atlantic climate variability

Title: Ocean data evolution along PIRATA sections from 1993 to 2016 using Mercator Project data base

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Abstract: This study analyses the temporal evolution of Mercator Ocean system reanalysis database along the PIRATA sections. The need of improvements on the tropical Atlantic climate monitoring in different time and space scales is the main motivation of this work. The analysis used two subsequent datasets provided by the Mercator Project. The first one is GLORYS2V3 1993-2014 reanalysis in a 0.25° resolution and 75 levels, while the second one takes part of the Mercator operational (2015 - present) forecasting system, and it is known as PSY3V3R3 (0.25° and 50 levels). Both datasets incorporated several observational data sources, including PIRATA dataset, and used as ocean model base the NEMO community code. The PIRATA zonal section along the equator and the three PIRATA meridional sections (38°W, 23°W and 10°W) were analyzed. The study was mainly conducted through space-time diagrams of standardized anomalies of sea surface temperatures (SST), zonal and meridional currents, subsurface temperature and mixed layer depths (MLD). The results showed that many climatic events occurred at a high frequency (a few months) and at a low frequency (many years). For instance, 1998, 2005 and 2010 were excessively warm in the north tropical Atlantic basin. The spatial-temporal continuity in the Mercator dataset permitted to get more insight of the climate variability along the PIRATA sections. Some interesting aspects of tropical Atlantic dynamics emerged, such as an equatorward convergence of positive SST anomalies at 23°W during 2010. Furthermore, the MLD anomalies along 38°W experienced a shallower period between 1996 and 2002 in the region north of 10°N, followed by a period of opposite sign that persisted until 2010. Thus, Mercator data provides a valuable tool to a better understanding of the tropical Atlantic climate variability.

Title: The intrinsic ocean variability in the Tropical Atlantic

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Abstract: Recent studies have shown that the nonlinear ocean circulation spontaneously generates low-frequency variability under constant atmospheric forcing. Idealized ocean-forced simulations reveal the imprint of the intrinsic interannual variability on various climate-relevant ocean variables, e.g. sea-level anomalies, sea-surface temperature, mixed layer depth, meridional overturning stream-function.

In order to investigate more in detail the intrinsic ocean variability, a new probabilistic version of the NEMO ocean/sea ice modelling system has been implemented. A large ensemble of 50 global ocean/sea ice hindcasts has been performed over the period 1960-2015 at eddy-permitting resolution (1/4°) within the OCCIPUT French project framework. This application is aimed to simultaneously simulate the intrinsic/chaotic and the atmospherically-forced contributions to the ocean variability, from meso-scale turbulence to interannual-to-multidecadal time scales. Such an ensemble indeed provides a unique way to disentangle and study both contributions, as the forced variability may be estimated through the ensemble mean, and the intrinsic chaotic variability may be estimated through the ensemble spread. In this study, a focus is done in the Atlantic tropical ocean, under the EU-PREFACE project framework, in order to characterize the spatio-temporal pattern of the SST and SSS intrinsic variability and theirs potential interactions with the deterministic part of the Atlantic Tropical ocean dynamics.

Title: Mechanisms of variability of the Atlantic Niño in an ocean model forced with an interactive atmospheric boundary layer.

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Abstract: The respective contributions of the dynamic and thermodynamic forcing to the variability of the Atlantic Niño are investigated using a set of 30-years simulations of the Tropical Atlantic based on the ocean model NEMO. The specification of atmospheric conditions (air temperature, humidity, and wind speed) when forcing an ocean model with bulk formulae strongly constrains the sea surface temperature and thereby may impact the processes controlling the interannual variability at the ocean surface. To partly overcome this issue, the evolution of the atmospheric boundary layer temperature and humidity are computed with the model CheapAML, letting the wind field prescribed. In addition to a better representation of the air-sea exchanges, such strategy allowed to properly assess the sensitivity of the Atlantic Niño to the interannual variability of the equatorial wind work. In contrast with recent results based on state-of-the-art coupled models, suggesting that Atlantic Niño variability mainly depends on the thermodynamic component, our results suggest that the interannual variability of the dynamical forcing significantly contributes too.

Title: Mixed Layer heat budget variability of the western tropical Atlantic from Argo floats (2007-2012)

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Abstract: Oceanic processes are investigated to explore the causes of the seasonal cycle and interannual variability of SSTs in the Western Tropical Atlantic. A mixed layer heat budget is performed with ARGO floats temperature and salinity profiles during 2007-2012. The basin was divided into five boxes, reflecting the spatial and temporal heterogeneities of the area.

In the northern boxes (5°N-20N°, 15°W-60°W) warming by solar radiation and cooling by latent heat flux govern the changes of SSTs. Here, warming up to 40 W/m2 occurs from March to September, while the cooling period (<-60 W/m2) is related to the intensification of the northeastern trades. In the equatorial boxes (5°S-5°N, 15°W-60°), surface fluxes modulate the semiannual cycle of the mixed layer temperature, but is strongly balanced by horizontal advection that reduces the amplitude of the SST annual cycle. Off the Amazon (5°S-10°N, 35°W-60W°) a strong annual variability of horizontal advection is detected, partly attributed to uncertainties of the surface currents. In the central equatorial Atlantic (5°S-5°N, 15°W-35°W), a significant cooling is observed from May to August driven by horizontal advection and undifferentiated processes reflecting the importance of the residual term in our budget. South of 5°S SSTs are driven by the surface fluxes, with a strong cooling from April to September. Entrainment has a weak contribution to the cooling in most boxes.

The interannual variability was also investigated. In 2010, strong positive SST anomalies were observed and warming in the northern boxes was in advance of one month, compared with the mean annual cycle of the six years (2007-2012). In the equatorial and southern boxes, the balance between horizontal advection, entrainment and surface fluxes explains the differences of the amplitude of the SST annual cycle.

Title: Role of Air-Sea-Land Interactions in Tropical Atlantic Seasonal Cycle

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Abstract: The state-of the art models poorly represent the seasonal cycle in the tropical Atlantic, to a large extent due to the lack of understanding of the ocean-atmosphere and land-atmosphere couplings. In this study, we investigate the role of equatorial SST and land surface processes in driving the seasonal cycle of the atmosphere in the tropical Atlantic basin. We run two sensitivity experiments for the historical period 1982-2013 using the atmospheric general circulation model CAM4 in the 1.25°x0.9° resolution configuration forced with an observed climatological SST and a time-independent SST, to understand the impact of the seasonal cycle of the SST in the atmosphere. Comparing the two runs for surface winds and precipitation shows the relevance of the seasonal cycle of the SST in driving the atmosphere. In addition, we use a Maximum Covariance Analysis (MCA) statistical technique to isolate and quantify the separate contributions of ocean- and land-processes to the variability of the atmosphere. The leading modes show that the land is the main driver of the monsoonal precipitation over west Africa, but the ocean variability also plays a role contributing to the northward shift of the ITCZ. The covariability patterns also show that the SST seasonal variability controls the low-level wind circulation over equatorial western Atlantic with less than 10% of the variance explained without the seasonal cycle in the SST. Our results suggest that the land-processes play a major role during the monsoonal season but the ocean-processes also play a significant role in determining the seasonal cycle of the atmosphere in the eastern tropical Atlantic; for instance, explaining around 30% of the variance of the precipitation.

Title: Oceanic processes involved in the development and decay of the Meridional Mode

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Abstract: The variability of the tropical Atlantic Sea Surface Temperature (SST) at inter-annual time scales is driven by two air-sea coupled modes: the Equatorial Mode (EM) and the Meridional Mode (MM). They are characterized by specific SST anomaly distributions, respectively with a maximum over the central-eastern equator during boreal summer, and with an inter-hemispheric gradient during boreal spring.

Previous studies have proposed dynamical (Bjerknes) and thermodynamical (Wind-Evaporation-SST) feedbacks, as the mechanisms responsible to develop and maintain these variability modes. Nevertheless, a detailed study of the air-sea interactions at work, as well as, the characterization of the wave activity during the growing and decaying phase of the MM and EM is required.

In the present study, the oceanic processes involved in the development of the Meridional Mode have been investigating, using a regional ocean model (NEMO-ATLTROP). The sensitivity experiment has been forced with a composite wind pattern associated with the development and decay of a general Meridional Mode pattern. The air-sea mechanisms at work, as well as, the equatorial and off-equatorial wave propagation are explored.

Title: The effect of external forcing on meridional modes in the tropical Atlantic

Authors and affiliations: Sebastian Milinski <sebastian.milinski@mpimet.mpg.de>; Johann H. Jungclaus; Jürgen Bader; Jochem Marotzke

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Abstract: Variability in the tropical Atlantic arises from coupled internal variability in the ocean and atmosphere and external forcing. Two major modes of variability have been identified: a zonal mode related to sea surface temperature (SST) anomalies in the southeastern tropical Atlantic and a meridional mode related to an anomalous inter-hemispheric SST gradient associated with latitudinal shifts in the ITCZ location. However, from the limited length of the observational record it is difficult to identify variability on decadal to multi-decadal timescales and analyse how external forcing affects the variability.

In our study, we use a 100-member ensemble of historical (1850-2005) model simulations with the Max Planck Institute for Meteorology Earth System Model (MPI-ESM) to identify patterns of coupled variability between precipitation, atmospheric circulation, and SST. The focus of our study is on anomalous meridional shifts of the ITCZ that are separated into different patterns using an EOF analysis. We analyse how the probability distributions of these patterns change under strong external forcing and how the spatial patterns change. To investigate these effects, we employ an additional ensemble of model simulations with stronger external forcing (1% CO2-increase per year for the same period 1850-2005) with 68 ensemble members.

The large ensemble allows us to do a statistically robust differentiation between the changes in variability that can be explained by internal variability and those that can be attributed to the external forcing.

This study provides an insight into the mechanisms of tropical Atlantic variability beyond what can be deduced from observations and thus contributes to a more profound understanding of the variability in the tropical Atlantic in the period since 1850.

Title: The ENSO - tropical North Atlantic teleconnection in CMIP5 models

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Abstract: In this study a new dynamical framework to understand the remote El Niño-Southern

Oscillation (ENSO) teleconnection to the tropical North Atlantic (TNA) in boreal spring is investigated in CMIP5 models. The teleconnection mechanism, previously identified from observational datasets, relies on the remote Gill-type response to the ENSO zonally-compensated diabatic heating over the Amazon basin, associated with changes in the Walker circulation. In response to El Niño forcing, a pair of anomalous cyclonic (anti-cyclonic) circulations is settled at upper (lower) tropospheric levels in the tropical Atlantic, displaying a characteristic baroclinic structure with height. In the TNA region, the anomalous anti-cyclonic circulation at lower-tropospheric levels weakens the north-easterly trade winds, leading to a reduction in evaporation and of the ocean mixed layer depth, and thereby to positive sea surface temperature (SST) anomalies, according to the WES (Wind-Evaporation-SST) feedback. The latter mechanism can explain the 'lagged' relationship between the mature phase of ENSO in winter and the occurrence of SST anomalies over the TNA in spring.

We investigate here whether CMIP5 coupled models correctly represent the ENSO-TNA springtime teleconnection and its associated dynamics. We suggest that the ability to simulate the remote Gill-type mechanism of this teleconnection, which is symmetric about the equator, can be connected to the representation of the Atlantic Meridional Mode (AMM) in coupled models.

Title: Relationship between CMIP5 models SST bias and coastal upwelling representation

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Abstract: In the present work we study the relationship between the sea surface temperature (SST) bias of 18 CMIP5 models and their representation of coastal upwelling. The empirical orthogonal function of the SST bias of each model is computed, and then regressed against the mean vertical sea temperature profile of said models for the equatorial region. The result is then projected onto the whole globe, so that we can relate the bias patterns and the representation of the coastal upwelling.

Title: Tropical Atlantic biases in CNRM-CM6: evaluation of the new atmospheric physics

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Abstract: Most state-of-the-art coupled general circulation models have serious biases in the tropical Atlantic, which strongly impact their representation of the regional climate, in particular the West African monsoon. The CMIP5 version of CNRM-CM has been shown to suffer from these typical biases, namely a westerly wind bias over the Equatorial Atlantic that prevents the development of the seasonal Atlantic cold Tongue, and a excess of solar radiation in the southeastern region.

Since CMIP5, a new atmospheric physics has been developed and implemented in the CNRM-CM model. It includes a new boundary-layer scheme based on a TKE prognostic equation, a detailed microphysics scheme prognostically describing liquid and ice cloud condensates as well as liquid and solid precipitating hydrometeors, and a new convective scheme aiming at representing in a unified way dry, shallow and deep convection. The representation of clouds and convection in the tropics is strongly impacted and the skills of this new version is assessed here more specifically in the tropical Atlantic in terms of mean climate and annual cycle. First we focus on AMIP-type simulations and short-term hindcasts (Transpose-AMIP) are used to better understand the mechanism at play. The skill of the new coupled model CNRM-CM6 is then further assessed.

Title: Reducing the Sea Surface Temperature Bias in the Kiel Climate Model to improve the Representation of Atlantic Niño Variability and Dynamics

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Abstract: The Atlantic Niño is the leading mode of interannual sea surface temperature (SST) variability in the tropical Atlantic. Current-generation coupled global climate models (CGCMs), however, struggle to capture the observed variability, rendering it virtually impossible to issue useful predictions of Atlantic Niño events. Recent research based on CMIP3 simulations suggested that the models' failure can be attributed to the Atlantic Niño being dominated by thermodynamic feedbacks, i.e. by atmospheric noise.

Here, we hypothesize that strong equatorial Atlantic SST biases common to many CGCMs prevent the models from reproducing the observed dynamical and variability characteristics of the Atlantic Niño. Using the Kiel Climate Model (KCM), we asses the impact of the SST bias on these features. Two assimilation runs are produced in partially coupled mode, one standard run and one run that employs additional surface heat flux correction to alleviate the SST bias.

In accordance with previous studies, heat flux correction substantially improves simulated Atlantic Niño variability, especially during the peak season May-July. Building linear models to capture the effect of the thermocline and zonal advection feedbacks on SST, we separate the total SST variability into dynamically driven and stochastically forced components. Bias alleviation allows the KCM to produce an Atlantic Niño that is largely consistent with observations: While stochastic forcing is dominant during boreal spring and early fall, dynamically driven SST variability prevails throughout early summer and winter. The standard run fails to simulate these features, suggesting that bias alleviation exerts a fundamental impact on simulated variability and dynamics. Implications of these findings on the predictability of the Atlantic Niño are discussed.

Title: Mean SST bias and variability at inter-annual time-scales in CMIP5 models

Authors and affiliations: Irene Polo <irene.polouk@gmail.com>; Julian Villamayor; Belén Rodríguez de Fonseca; Elsa Mohino; Teresa Losada

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Abstract: Analysis of model systematic errors in Sea Surface Temperature (SST) has generally focused on local processes and particular basins. Mean warm bias over the subtropical upwelling systems in coupled models are largely studied and local cloud cover, alongshore winds and ocean stratification are pointed out as the responsible processes. Mean errors may have impacts on the SST variability but this is less understood. In this study we investigate i) the relation between mean global bias and how models perform the variability at inter-annual time-scales. ii) the inter-model SST bias variability. Firstly, in order to understand the relation between bias and variability, we calculate the SST variability modes for the models and associated parameters are confronted with the mean bias variability among models, thus we conclude how realistic models simulate the variability depending on the mean SST bias. Results suggest that models with warmer than average SST mean bias over the equator reproduce better the inter-annual El Nino Pacific variability. The skill of simulating the Atlantic Nino is however more related to a colder bias over the south Atlantic, which is associated with an increase of the subtropical highs. Secondly, an inter-model (from 18 models in pre-industrial control cmip5 experiment) SST bias variability mode is found relating errors over the upwelling systems with cloud cover around 60S and equatorial precipitation shift. This inter-model SST bias variability mode summarizes some features in relation to inter-annual variability in CMIP5 models and thus represents a potential tool to understand future climate projections.

Title: Sources of EC-Earth bias in Tropical Atlantic

Authors and affiliations: Eleftheria Exarchou <eleftheria.exarchou@bsc.es>; Chloé Prodhomme; Virginie Guemas; Francisco Doblas-Reyes

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Abstract: The systematic biases in the Tropical Atlantic that are present in most CMIP5 models are a cold bias in the equator and a warm bias along the coast of Namibia and Angola. We use a suite of experiments performed with EC-Earth3.1 in order to investigate the mechanisms behind the systematic bias in the Tropical Atlantic. To assess the systematic model error we use a historical experiment. To analyse the fast growing error from the observed state we use retrospective predictions initialized from reanalysis. The predictions are performed at low and high resolution so as to assess the impact of resolution on this error. We also analyse uncoupled oceanic and atmospheric experiments in order to disentangle the role of the ocean and the atmosphere in the bias development. We find that EC- Earth3.1 exhibits biases that are very similar to the ones seen in most CMIP5 models, and that these biases are not improved with increased model resolution. We also find that the warm SST bias in the Eastern Atlantic coast originates in the atmosphere due to excessive solar fluxes, caused by reduced cloud cover. The warming at the ocean surface by the solar fluxes creates a positive feedback by stabilizing the water column, and inhibiting the proper upwelling of cold oceanic waters to the surface. The cold bias in the west equatorial region originates in the ocean and is dampened by the coupling. The ocean has stronger than the observed tropical overturning cell northern of the equator, and therefore stronger upwelling of colder waters to the ocean surface. In addition, the colder equatorial waters are not properly advected westwards due to the weaker surface westward current, thus further enhancing the cold bias. This cold bias is likely caused by the numerical formulation of the ocean model.

Title: Evaluation of the anomaly coupling technique in the UCLA CGCM

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Abstract: It is well known that coupled global climate models show important systematic errors that can preclude our confidence in their results. One important open question in this regard, is the relation between biases and variability in global climate models.

In this work, we describe the anomaly coupling technique implemented in the UCLA CGCM. With this technique the only information exchanged by the atmospheric and oceanic components of the model is the anomalous part of the fluxes and the SST, thus eliminating the model biases.

A preliminary comparison between the results of two simulations with and without the anomaly coupling gives an insight about the impact of the model biases in the simulation of the interannual variability of the model.

Title: A methodology for anomaly coupling in climate simulation

Authors and affiliations: Shunya Koseki <shunya.koseki@uib.no>[1]; T. Toniazzo [2]

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Abstract: We demonstrate a new methodology for anomaly coupling in general circulation models, on the basis of simulations with the Norwegian Earth System Model. The methodology achieves a significant reduction in the systematic biases of the coupled model climatology, especially over the tropical oceans. The representation of the inter-annual variability is also improved.

Title: Interdependence of Model Systematic Biases in the Tropical Atlantic and the Tropical Pacific

Authors and affiliations: Jon Shonk <j.k.p.shonk@reading.ac.uk>[1]; Thomas Toniazzo [2]; Steve Woolnough [1]; Eric Guilyardi [1, 3]

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Abstract: After several decades of model development, general circulation models are still affected by persistent, unresolved biases, particularly in the Tropics. The resulting model systematic drift in integration initialised from observed ocean-atmosphere states can dominate the signal in seasonal and decadal forecasts, greatly reducing their utility.

The most prominent systematic biases develop in the tropical Pacific, where strong air-sea coupling and permanent, intense ITCZ activity exert a strong influence on the global circulation. More regionally confined but equally intense biases also develop in the tropical Atlantic and affect the seasonal climatology of the surrounding tropical landmasses. One question is whether the biases in the two basins develop independently, or whether biases in the Pacific influence the development of those in the Atlantic via tropical-dynamics mechanisms. We present an initial analysis of ECWMF's System 4 hindcasts that addresses this question.

Title: Assessing climate model biases of the Tropical Atlantic using Bayesian hierarchical approach

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Abstract: Despite the continuing predictive improvement of the deterministic coupled atmosphere-ocean general circulation models (GCMs), assessment of climate features using the current generation of GCMs are affected by large systematic errors, or biases, i.e., discrepancies between observed and simulated characteristics. Climate model biases are, therefore, a crucial issue when climate model outputs are used to understand climate dynamics and related uncertainties. In this contribution, we provide probabilistic assessment and quantification of climate model biases based on the multi-model ensemble. The center of this approach is the Bayesian hierarchical method that allows for the combination of biases from a multi-model ensemble of GCMs simulations, overcoming the peculiarities of individual simulations and allows a unified assessment of the biases. We illustrate this method using spatially referenced near-surface air temperature bias data in the tropical Atlantic from the fifth phase of the Coupled Model Intercomparison Project. We obtained an overall common bias as non-stationary spatial field and associated uncertainty based on the assumption that the uncertainties of simulations from different models reflect similar spatial patterns as they try to capture the same large-scale features in a particular geographic region. Further, we obtained model-specific individual bias components that are characterized as non-stationary spatial fields capturing small-scale features. Our contribution is a step forward compared to the common ensemble averaging method where each ensemble member has the same weight. We account for variability of bias across ensemble members, and the role of each member to the overall common bias is determined based on the posterior inferences on each model's variability parameter. Thus, quantifying biases by taking into account the heterogeneity between GCMs provides an insight into the degree of uncertainties and how the uncertainties vary within the current generation of GCMs.

Title: Influence of the reduction of the incoming radiation over the southern ocean on the simulation of the tropical Atlantic variability by the UCLA CGCM

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Abstract: Coupled global climate models (CGCMs) show important biases in the simulation of SST, not only in the tropics, but also over the Southern Ocean. A recent work has shown that improving the errors in the Southern Ocean SST can result in a improvement of the tropical biases in the UCLA CGCM.

In this work, we analyse how this model simulates the main interannual modes of variability in the tropical Atlantic in a control run and we compare the results with the variability of a second simulation in which we apply an idealized reduction of the incoming shortwave radiation over the southern ocean.

Our results show an improvement of the simulation of the tropical Atlantic variability at interannual timescales in the idealized simulation. Not only the spatial pattern of the simulation resembles more the observed one, but also the fraction of variability explained by the mode is enhanced. The impact of this improvement in the representation of the interbasin tropical teleconections is also analyzed.

Title: On the Atlantic Multidecadal variability role on modulating Mediterranean impact on Sahelian rainfall

Authors and affiliations: Roberto Suárez-Moreno <Roberto Suárez<roberto.suarez@fis.ucm.es>[1,2]; Belén Rodríguez de Fonseca [1,2]; Marco Gaetani [3]; Cyrille Flamant [3]

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Abstract: Warm events in the Mediterranean basin are associated with increased Sahelian rainfall mainly due to enhanced moisture transport across the Sahara desert. Nevertheless, Mediterranean teleconnections with the Sahel have changed throughout the 20th century showing a nonstationary behaviour, with periods in which the teleconnection is enhanced. The impacts of the Mediterranean in the Sahel appear to have recently intensified being a key factor in the recovery trend after the severe drought experienced in the 1970s. The changes in the interannual co-variability patterns could be the result of counteracting effects due to remote teleconnections or to changes in the underlying climatology. In this study, the S4CAST model has been applied to assess Mediterranean-Sahel teleconnection from observational statistical analysis. Evidence of the aforementioned nonstationary link is provided. The inferred hypothesis obtained from observations are tested performing AGCM simulations with a general circulation model with the aim of exploring the role of the low frequency variability of the Atlantic on the recently enhanced Mediterranean impacts on Sahelian rainfall. The results suggest a modulation by different patterns of Atlantic low-frequency SST variability.

Title: Does the impact of Atlantic Niños on the Indian summer monsoon depend on the background state?

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Abstract: The El Niño-Southern Oscillation (ENSO) is used as one of the main predictors for the Indian summer monsoon (ISM) rainfall. However, studies have suggested that the relation between ENSO and the ISM has weakened since the 1970s. After the 1970s Atlantic Niño events during boreal summer have been accompanied by ENSO events in the Pacific of opposite sign the subsequent winter. Since Atlantic Niño events can impact the ISM in a similar way as ENSO, the impact of ENSO on the ISM can weaken when Pacific ENSO events and Atlantic Niños are out of phase. We hypothesize that the influence of Atlantic Niños on the ISM depends on the mean background state of the climate as Atlantic multidecadal variability (AMV) shifted from a positive to a negative phase around the 1970s as well. To test this hypothesis, we have analyzed 4 ensemble experiments with three different atmospheric general circulation models (CAM5, SPEEDY and UCLA). In the two first experiments mean observed SSTs for the period 1950-1960 when the AMV was in a warm phase and for the period 1975-1985 when the AMV was in a cold phase are prescribed globally. To investigate the impact of different mean states on the effect of an Atlantic Niño, two additional experiments with an Atlantic Niño SST pattern added to the two mean SST patterns, are analyzed. We find that during the cold AMV phase the Atlantic Niño is associated with a westward shift of the walker circulation compared to during a warm AMV phase, modifying the ISM circulation. These results also suggest that model simulations of teleconnections can be hampered by systematic model biases.

Title: How does ECHAM represent the annual cycle of central Africa rainfall system and its relation to zonal atmospheric heat transport?

Authors and affiliations: Georges-Noel T. Longandjo <longandjo@gmail.com >; Mathieu Rouault

Nansen-Tutu centre for Marine Environmental Research, University of Cape Town; Department of Oceanography, University of Cape Town

Abstract: Due to poor meteorological observations network over central Africa, water resources are not well evaluated yet. In this paper, we used both observations and a state-of-art atmospheric climate model forced by SST (ECHAM version 5.3) to figure out what are mechanisms and how central Africa rainfall are represented in term of spatial distribution, seasonality and intensity. So ECHAM5.3 does well capture the westward (eastward) migration of central Africa rainfall annual cycle as well as its spatial distribution, but it fails to simulate its seasonal intensity. This displacement of ITCZ location is related to the intensification of Walker circulation over central Africa, which in turn is controlled by the zonal atmospheric heat transport. Nevertheless, this situation leads to crucial role play by the surrounding Oceans – the Atlantic Ocean seems to maintain the central Africa overturning circulation, while the Indian Ocean regulated the westward (eastward) propagation of Walker cell over central Africa. However, the seasonal variation of ITCZ location of the thermally-driven central Africa rainfall is strongly related to the convective moist stability location. Interestingly, the local (remote) atmospheric water vapor and the low level convergence differentiate the stronger rainy to the drier seasons.

Title: Seasonal and decadal variability of th senegalo-mauritanien upwelling in the climate models and influence of the global warming

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Abstract: The upwelling system located off the Guinean, Senegalese and Mauritanian coasts is one of the most productive region in the world ocean. It is crucial for the socio-economical development of the populations of the surrounding region, whose the food and the revenue strongly depend of the halieutic resources. Understanding its dynamic, variations of its intensity and duration have been the focus of several studies based on the observations and on high resolution oceanic models. However the comprehension of the interannual and decadal variability are still poorly understood. Climate models generally show a decrease of the upwelling intensity in response to global warming. This tendency is not yet clear in observations and reanalysis, but it deserves more analysis since it may have severe consequences for the local populations.

I propose a precise characterization of the representation of the senegalo-mauritanian upwelling and its seasonal variability in the CMIP5 climate models, as compared to ocean reanalysis and observations. This characterization is based on (i) the SST seasonal evolution in this region, (ii) the difference between SST at the coast and offshore, and (iii) the seasonal cycle of the Ekman transport along the coast. These three indices allow a classification of the models according to their representation of the upwelling seasonal cycle. Simulations of climate change are then used to evaluate changes of this seasonal cycle in the future.

Title: What caused the 2009 cold event in the Atlantic Cold Tongue region?

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Abstract: Interannual sea surface temperature (SST) anomalies in the eastern equatorial Atlantic have a large impact on the marine ecosystem and rainfall variability over adjacent land regions. It is thus important to understand what generates these anomalies. In boreal summer of 2009, an extreme cold event occurred in the Atlantic cold tongue region. It was preceded by a strong negative Atlantic meridional mode event associated with north-westerly wind anomalies along the equator from March to May. Classical equatorial wave dynamics suggest that westerly wind anomalies should be followed by a warming in the eastern equatorial Atlantic, but instead in 2009 an abrupt cooling took place. Two mechanisms—meridional advection of subsurface temperature anomalies and planetary wave reflection—have been discussed in the literature as potential causes of such an event. Here, for the first time we use in situ measurements in addition to satellite and reanalysis products to investigate the contribution of both mechanisms to the 2009 cold event. Our results suggest that meridional advection is less important in cold events than in corresponding warm events, and, in particular, did not cause the 2009 cold event. Argo float data confirm previous findings that planetary wave reflection contributed to the onset of the 2009 cold event. Additionally, our analysis suggests that higher baroclinic modes were involved.

Title: Effects of river discharge on Atlantic Climate

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Abstract: The effect of the Amazon, Orinoco and Congo rivers discharges on the Tropical Atlantic Ocean are evaluated in a couple of 100 year long simulations of the Brazilian Earth System Model in both: coupled ocean-atmosphere and ocean-solo configurations. Its shown that the river discharges excite oceanic modes of variability not present on the ocean-solo runs. The mechanisms for such diverse modes of variability are speculated.

Title: The current 2015-2016 warm event in the tropical Atlantic: A little twin brother of the 2015-2016 El Niño in the Pacific?

Authors and affiliations: Jacques Servain [1,2],; Guy Caniaux [3]; Diogenes Fontenele [1]; Dominique Dagorne [2]; Bernard Bourlès [2]; Aubains Hounsou-Gbo [4,5]; Moacyr Araújo [6]; Mathieu Rouault [7]

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Abstract: The tropical Atlantic experienced a warm event since the boreal summer 2015, i.e. from the beginning of the mature phase of the very strong 2015-2016 El Niño in the Pacific. The long-term warming (> 2°C) was first detected in August 2015 along the north-western African coast where it remained until February 2016 with episodic westward extensions throughout the northern tropical basin. The south-western (close to Brazil) and south-eastern regions (close to Angola) experienced similar warmings from September 2015. Initially limited in space, these two warmings converged progressively throughout the southern basin until January 2016 when all the entire tropical Atlantic was warm, especially in its oriental part (> 2.5°C). From February to April 2016, large parts of the tropical Atlantic basin stay warm (> 0.5°C). Positive SST anomalies returned to be in excess of 2°C in June 2016 in the eastern equatorial basin (at the emplacement of the cold tongue) and again off south-western Africa, and such a situation was still observed in early September 2016. The course of this event is described at the surface (SST, SLP), subsurface (T), as well as in the atmosphere (wind, OLR, …). Based on previous published works, some elements of discussion are proposed to determinate which part of the 2015-2016 Atlantic warm event is supposed to be purely local and which part has been forced by the 2015-2016 Pacific El Niño event.

Session 3 - Towards realising socio-economic benefits of climate prediction in the Tropical Atlantic for marine ecosystems, fisheries, and continental climate

Title: Seasonal Prediction in the Tropical Atlantic

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Abstract: Here we report on the current level of skill in seasonal prediction for the tropical Atlantic, using primarily data from the WGSIP Climate-system Historical Forecast Project. The prediction over the North Tropical Atlantic shows significant skill in several seasons. Skill is low in the equatorial and south Atlantic, and in the West African upwelling region it is generally worse than the persistence forecast. However, some model forecasts starting in May show high levels of skill for predicting Atlantic equatorial cold tongue anomalies in boreal summer and this translates to skill in predicting Gulf of Guinea precipitation.

These results are being complemented by a set of predictions with the Norwegian Climate Prediction model (NorCPM), which is based on the Norwegian Earth System model and implements an Ensemble Kalman Filter data assimilation scheme. We compare the impact of mean state errors and forecast drift by comparing the skill of full field and anomaly initialized, and also by using an anomaly coupled model. We further assess the benefit of assimilating subsurface temperature and salinity data, versus only SST data.

Title: Highlighting the impacts of the tropical Atlantic over the rainfall seasons of Northeast Brazil

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Abstract: Oceanic climate conditions over the tropical Atlantic are used for forecasting the seasonal rainfalls in the Brazilian Northeast (NEB) with a delay up of 12 months ahead. February-to-May (FMAM) and April-to-July (AMJJ) are considered to represent the rainfall seasons of northern part of NEB (NNEB) and eastern part of NEB (ENEB), respectively. The South tropical Atlantic presents a strong influence on both NNEB and ENEB rainy seasons. However, the mechanisms associated with their variability's are fully different. For the NNEB, the lagged relationship initiate about 12 months ahead between SST anomalies (FMAM (-1)) and rainfall anomalies of the next year (FMAM (0)). A positive signal initiates in the southwestern tropical Atlantic. It subsequently moves eastward inside the equatorial and southeastern tropical Atlantic upwelling, with a mature phase occurring in JJAS (-1). Then, the phenomenon turns up into the classic inter-hemispheric mode, which is sustained by the Wind-Evaporation-SST feedback in the tropical Atlantic, and develops as the principal mechanism responsible for the rainy season in NNEB. This lagged correlation, from JJAS (-1) to FMAM (0) also agrees with the already known connection between the Atlantic-Pacific Niños events on the predictability of NNEB rainfall. For the strong rainfall events over the ENEB, a large positive SST signal, which initiates in the southeastern tropical Atlantic in SOND (-1) and propagates westward to AMJJ(0) with a wind relaxation, is the main mechanism influencing the AMJJ rainy season. When reaching the northeastern coast of Brazil, especially the southwestern Atlantic warm pool, these SST positive anomalies, associated with anomalous convergence of surface wind, excess of humidity, and abnormal vertically integrated moisture flux convergence, induce excess of rainfall over the ENEB. It should be noted that positive and negative SST anomalies linked to wet and dry rainfall events present an asymmetry on their westward propagation.

Title: Climate influence on North West African fisheries: a large-scale perspective

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Abstract: There are still many questions about the environmental forcings on marine biological ecosystems that need to be addressed. Of special relevance are those associated with the so-called Eastern Boundary Upwelling Systems (EBUS) due to their great climatic and socio-economic importance, being the latter specially crucial for some regions along the globe such as the North West African region (hereinafter NW Africa). In this study, some possible teleconnections involving large-scale climatic phenomena and the small pelagic fish dynamic in the NW Africa, have been addressed. These possible teleconnections would be interesting on their own, but those associated with the Sea Surface Temperature (SST) processes are of special importance, since they could noticeably contribute to the development of a seasonal prediction system of fisheries.

To this aim, we have used data provided by the couple model compounded by the Regional Oceanic Modeling System ROMS configured for the NW African upwelling system and by the biogeochemical model PISCES, which simulates plankton productivity and carbon biomass based upon the main nutrients. This coupled model has been run over the period 1980-2009 using interannual atmospheric forcings and consistent oceanic boundary conditions (from NCEP Climate Forecast System Reanalysis). Finally, an evolutionary individual-based Lagrangian model has been used to simulate the spatio-temporal behaviour of the small pelagic fish, at different stages, according to the environmental constraints obtained from ROMS.

The results obtained, though preliminary, point out that well known variability modes such as the North Atlantic Oscillation (NAO) and the El Niño-Southern Oscillation (ENSO), could act as possible large-scale climatic forcings of the NW African fishes, which could open a window of opportunity for the development of an effective seasonal prediction system in the aforementioned region.

Title: Linking local fisheries observations to climate - a first analysis of historical data from Cabo Verde

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Abstract: Highest catch rates of yellowfin tuna (YFT) in the tropical Atlantic are linked to water temperatures of 24-25°C. We correlate the north tropical Atlantic SST index (NTA), a measure of SST anomalies in the north tropical Atlantic, with Japanese long-line catch-per-unit-effort from 1964-1973 (CPUE). The R package cross-correlation function is applied as first step to investigate whether historical catches around Cabo Verde were correlated with SST data in the area. NTA has increased during the last 50 years.

The results reveal that at intra-annual scale catches increase during warm months, although this relationship was not significant. At inter-annual scale, catches are significantly correlated at lag0 and lag1 with NTA; the lag1 correlation was high (0.61). The lag0 correlation is consistent with the fact, that YFT generally have lower CPUE in waters influenced by the cold Canary Current system, whereas the lag1 relationship indicates that recruitment processes are also augmented by higher NTA in the area.

Historical CPUE relationships will be further applied to analyse current CPUE patterns around Cabo Verde.

Title: Aspects of the trophic structure of mesopelagic sound scattering layers in the Eastern tropical North Atlantic

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Abstract: Tropical mesopelagic communities constitute the highest migrating biomass on earth; hence their major relevance in driving energy flows in biogeochemical cycles and as a link in food webs. The relatively stable temperature environment in the tropics allowed the development of a well-adapted mature mesopelagic community where a large degree of omnivory, connectivity, realized niche segregation, but potential niche overlap lead to a highly complex food-web structure, that is difficult to sample and therefore, poorly understood. Better knowledge is urgently necessary to be able to assess quantitatively the consequences of changes in oceanography and an envisioned removal by fisheries on its role in ecosystem functioning.

Using net trawl data collected in 2014/2015 we study the trophic ecology of the upper mesopelagic community in the Eastern tropical North Atlantic using multiple proxies. We characterize trophic niches occupied by abundant fish species distinguishing stronger and weaker migrators in relation to the regional hydrographic regime as well as zooplankton prey availability by using nitrogen and carbon stable isotope analysis. Preliminary results show that small-scale spatio-temporal variability in isotopic signature differs between feeding and migration types. While highly migratory herbivorous species show a close correlation to the local isotopic base line values, deeper living higher trophic species do not correspond in sync. Fatty acid analysis provides additional information to elucidate natural variability from trophic effects.