OS33C CC: 524 C Wednesday 1330h

Scientific Results From the PIRATA Program (1997-2004) I

Presiding: **J Servain,** Fundacao Cearense de Meteorologia e Recursos Hidricos (FUNCEME)**; S Xie,** IPRC/SOEST, University of Hawaii

OS33C-01 1330h

PIRATA and our Understanding of the Tropical Atlantic

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In this talk we concentrate on the mean seasonal cycle of the mixed layer heat and salt balances as well as air sea surface fluxes produced by the pirata moorings in comparison to other products. The tropical Atlantic has a number of interesting features. The main band of tropical rainfall is displaced north of equator throughout most of the year, approaching the equator only in boreal spring. As it migrates it modulates surface thermodynamic, radiative, and momentum fluxes, as well as net freshwater input. The tropical Atlantic is influenced by continental effects such as massive river discharge. On longer year-to-year timescales the tropical Atlantic atmosphere and ocean exhibit variability with features resembling El Nino, as well as interactions that involve primarily thermodynamic exchanges. The records from the PIRATA moorings provide our first opportunity to examine observationally the key exchanges in this scientifically intriguing region.

OS33C-02 1350h

An Overlooked November-December Cooling in the Equatorial Atlantic: PIRATA Observations

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Seasonal cycle of sea surface temperature (SST) in the equatorial Atlantic is characterized by a rapid cooling from April to July. With the onset of summer monsoon over West Africa, enhanced cross-equatorial southeasterly winds cool the equatorial ocean through Ekman upwelling and thermocline shoaling in the east. Previous studies suggest that the ocean dynamics plays more important role in this Atlantic seasonal cooling than in its Pacific counterpart. Surface winds over the ocean, on the other hand, are strongly influenced by the surrounding continents. Our GCM experiments show that the summer easterly acceleration is largely forced by the continental rainfall distribution in the Gulf of Guinea while the air-sea interaction is essential in the central/western basin, much like in the Pacific (Okumura and Xie, 2004). Whereas the annual harmonic is dominant in equatorial Atlantic SST, the easterly wind and thermocline depth show significant semiannual signals in the east. The easterlies accelerate in October-November, resulting in a shoaling of the thermocline. Using high-resolution satellite data, we show that the central Atlantic SST decreases from late November to early December in response to the accelerated easterlies and the shoaling thermocline. This secondary cooling has not been captured well in some widely used climatologies because of their low monthly resolution. The six-year PIRATA observations support the existence of a secondary seasonal cooling in November-December, suggesting a stronger thermocline feedback on SST than previously thought. Further studies will be needed to elucidate the mechanism for the easterly reacceleration and its influence on the ocean. **Reference**

Okumura, Y. and S.-P. Xie, 2004: Interaction of the Atlantic equatorial cold tongue and African monsoon. *J. Climate*, revised.

OS33C-03 1405h

Mechanisms of northeastern Brazil rainfall anomalies due to Southern Tropical Atlantic variability

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Observational studies have shown that the rainfall anomalies in eastern equatorial South America, including Nordeste Brazil, have a positive correlation with tropical southern Atlantic sea surface temperature (SST) anomalies. Such relationships are reproduced in model simulations with the quasi-equilibrium tropical circulation model (QTCM), which includes a simple land model. A suite of model ensemble experiments is analysed using observed SST over the tropical oceans, the tropical Atlantic and the tropical southern Atlantic (30S-0), respectively (with climatological SST in the remainder of the oceans). Warm tropical south Atlantic SST anomalies yield positive precipitation anomalies over the Nordeste and the southern edge of the Atlantic marine intertropical convergence zone (ITCZ). Mechanisms associated with moisture variations are responsible for the land precipitation changes. Increases in moisture over the Atlantic cause positive anomalies in moisture advection, spreading increased moisture downwind. Where the basic state is far from the convective stability threshold, moisture changes have little effect, but the margins of the climatological convection zone are affected. The increased moisture supply due to advection is enhanced by increases in low-level convergence required by moist static energy balances. The moisture convergence term is several times larger, but experiments altering the moisture advection confirm that the feedback is initiated by wind acting on moisture gradient. This mechanism has several features in common with the recently published "upped-ante" mechanism for El Nino impacts on this region. In that case, the moisture gradient is initiated by warm free tropospheric temperature anomalies increasing the typical value of low-level moisture required to sustain convection in the convection zones. Both mechanisms suggest the usefulness of coordinating ocean and land in situ observations of boundary layer moisture.

OS33C-04 1420h

Comparison of the 2003 Atlantic Ocean Warm Event With Previous Warm Events

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The tropical Atlantic Ocean exhibits warm events in the eastern region of the basin bounded by the Gulf of Guinea to the north and extending to the Benguela region. Since 1982 about eight warm events have shown sea surface temperature anomalies (SSTA) greater than 1 degree Celsius with meridional asymmetry and variable time evolution among them. These events occurred in 1984, 1988, 1991, 1995, 1997, 1998, 2001 and 2003 and varied in strength between the eastern equatorial region and the Benguela region. In this presentation we discuss the recent Atlantic Ocean warm event of 2003 within the context of previous warm events in the basin. PIRATA observations of this event, and even more so in the past, are limited by the point wise distribution in time and space of the data record. PIRATA data are complemented with other data sets of sea surface temperature (SST), sea level, surface currents and surface wind stress to provide a larger spatial and longer historical context. In particular, PIRATA, AVHRR and TMI SST observations, Topex/Poseidon-Jason-1 sea surface height anomalies, altimetry-derived surface currents, and remotely-sensed wind stress observations are used to characterize the 2003 SSTA magnitude, evolution, possible links to the relaxation of the equatorial wind stress in the western portion of the basin, and related response of the equatorial subsurface thermal structure. The attributes of this event are then compared with previous warm events captured by these same data sets.

OS33C-05 1435h

Impacts of PIRATA Mooring Observations in the MERCATOR Operational Ocean System

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Since January 2003, PIRATA mooring data in the tropical Atlantic are assimilated routinely in the Mercator operational ocean model. A series of 4 experiments have been carried out to test the impact on PIRATA data on the MERCATOR system (http://www.mercator-ocean.fr/). The control run is basically the operational system, assimilating in a multivariate scheme the temperature and salinity profiles (XBT, ARGO floats and at PIRATA moorings), and altimeter data. A second experiment is run assimilating in-situ data only outside the tropics (20^{o}N-20^{o}S). In a third experiment, we assimilated only PIRATA data, while in a fourth assimilation system excludes PIRATA data. We want to address on which processes and at what scales the assimilation of profiles of temperature and salinity of PIRATA mooring have an impact. Do they also improve the ocean interior below the depth of PIRATA profiles? Assimilation of PIRATA data leads to better equatorial dynamic constraints. The multivariate assimilation in the tropics of temperature and salinity profiles and sea level anomalies allows to constrain the equatorial dynamics and the mesoscale features, and to rectify the mass fields. Compared to altimeter-only assimilation run, it leads to a more realistic thermocline with a warming of the surface layer and a cooling below the thermocline. The improvements are visible in the mixed layer and below down to 300meters. When a lack of PIRATA occurred (if a sensor at a depth does not transmit), the impact is immediate but is more sensitive mainly between 200 and 400 meters. We also discuss the changes in the current system, mainly on the strength of the equatorial undercurrent and on the current system of the western boundary, the North Brasilan Current, regions where we usually found strong error growths.

URL: http://www.mercator-ocean.fr

OS33C-06 1450h

The Variability of Sea Level in the North Atlantic and North Pacific in 1993-2002 Observed With Satellite Altimetry.

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To compare the variability of sea level in the North Atlantic and North Pacific over nine years of the combined Topex/Poseidon and ERS-1/2 altimetry data (from October 1992 to February 2002) are studied. The study is focused on the northern areas with low kinetic energy. The sea level anomaly signal is represented as a composition of inter-annual, annual and mesoscale (mainly eddies) components. In spite of different spatial scales of the oceans, the pattern of sea level change appeared to be similar. In both oceans the inter-annual change in the subpolar gyre was found to be in anti-phase to the subtropical gyre. The impact of the North Atlantic Oscillation and El Nino Southern Oscillation events on the inter-annual variations are also considered. The magnitude and relative contribution of the inter-annual, annual and mesoscale signals are estimated.

OS34A CC: 524 C Wednesday 1530h

Scientific Results From the PIRATA Program (1997-2004) II

Presiding: **E Campos,** University of Sao Paulo**; J A Carton,** University of Maryland

OS34A-01 1530h

A Real-Time Diagnostic Analysis of the PIRATA Observations

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The PIRATA observations are analysed to diagnose the climatic variability in the tropical Atlantic from 1997 until present. Calendar daily climatologies for each meteorological parameters, and for each level of oceanic temperature and salinity, are computed and updated from the daily data available in real-time on the PIRATA NOAA/PMEL Web site http://www.pmel.noaa.gov/pirata/. Simple and standardized daily anomalies are deduced by retrieving the daily observations from these climatologies. The computations are made either for each one of the 10 sites of the PIRATA present array, or for 2-D analyses along the two meridional and the equatorial lines. Proxies of climatic indexes of the meridional and equatorial modes are proposed using the PIRATA data at selected stations. The largest climatic episodes during the study period are discussed and placed in the context of other regional and global analyses. This product is continuously updated and placed on the PIRATA Web maintained at FUNCEME (Brazil) http://www.funceme.br/. It complements the information already available on the other PIRATA Web sites.

OS34A-02 1545h

30-70 day Oscillations in the Tropical Atlantic

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The strongest mode of decadal climate variability in the tropical Atlantic is the so-called interhemispheric or "dipole" mode. Here we present evidence of intraseasonal (30 – 70 day) oscillations in the northern and southern tropical Atlantic trade wind systems, which may contribute to the timing and intensity of the interhemispheric decadal fluctuations. Intraseasonal oscillations in near-surface winds reach 5 m s^{-1} and force changes in sea surface temperature (SST) of up to 0.25 °C through their effect on latent heat loss and oceanic circulation. Oscillations of the northern tropical Atlantic trade winds are part of a larger spatial pattern that resembles the North Atlantic Oscillation. Furthermore, the northern tropical Atlantic intraseasonal oscillations are significantly correlated with the Madden-Julian oscillation (MJO) in the tropical Indo-Pacific Ocean when the MJO leads by 20 – 25 days. Possible links between the Indo-Pacific and Atlantic, as well as the potential role of the tropical Atlantic intraseasonal oscillations in the evolution of decadal tropical Atlantic SST anomalies, will be discussed.

OS34A-03 1600h

Analysis of the remotely sensed winds : Sensitivity of ORCA model to the scatterometer wind forcing

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Numerical Weather Prediction and analysis outputs are usually used to investigate oceanic and climatic processes and to run ocean models in a forced mode. This oceanic forcing function might be validated and improved, particularly for wind stress and turbulent heat fluxes, directly by the use of scatterometer high-resolution surface wind data. Indeed, enhanced global turbulent flux fields are constructed from ERS and Seawinds on board QuikScat with a spatial resolution of 0.5° in longitude and latitude, and a temporal resolution of 12 -hour, daily, weekly, and monthly. The quality of the remotely sensed fluxes is investigated through comparisons with data from buoys operated by the Pilot Research moored array in the Tropical Atlantic (PIRATA) project. The correlation coefficients exceed 0.85, the biases are less than 0.5 m/s and the root-mean-square (rms) are less than 1.7 m/s. For wind direction the difference standard deviation is less than 20°. For latent heat flux estimates, the bias in quit small and not significant, while the rms difference, and the correlation coefficient are about 22W/m^2 and 0.79, respectively. The PIRATA buoy data are then used to assess the quality of flux properties (spatial and temporal patterns) estimated from satellite as well as from NWP analyses (ECMWF) and re-analysis (ERA40) for the time period 1996 - 2003. For instance, the wind large-scale characteristics from satellite and models compare well. However, significant discrepancies are found in the tropical areas, and especially between satellite and ECMWF analysis.

OS34A-04 1615h

Tropical Instability Waves and the warming of the Atlantic cold tongue : Analysis of the ATLAS and ADCP PIRATA moorings data from 0n, 23W

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Temperature, salinity, and recent velocity records from the PIRATA moorings at 0oN, 23oW collected during 2002, as well as accompanying satellite SST and winds are used to examine the Tropical Instability Waves (TIW) and their role in the mixed layer heat balance of the central equatorial Atlantic. The TIW appear as periodic 20-30 day fluctuations in currents which intensify beginning in June in phase with the strengthening of the southeasterly trade winds and the seasonal appearance of the equatorial cold tongue. Zonal velocity fluctuations are largest in July-August, while meridional velocity fluctuations are largest in August-September. The meridional component of velocity is also distinguished from the zonal component in that fluctuations of the meridional component extend coherently in the vertical to at least 120 m while zonal fluctuations are coherent within the mixed layer only. Our estimate of horizontal eddy heat advection in the mixed layer averaged June-September is 100 W m-2 with meridional advection dominating and peaking in late boreal summer. Averaged over the whole summer the contribution of the TIW events to the warming of the mixed layer is of 0.5oC, which corresponds to a modest value of the eddy heat advection of 15 W m-2. Since this value is very much less than the estimates of the summer mean eddy horizontal heat advection of 50 - 100 W m-2 this indicates that horizontal and vertical eddy heat advection balance in part.

OS34A-05 1630h

The impact of tropical instability waves on the eqautorial mixed layer heat budget

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Several different OGCMs of the tropical Atlantic are used to study the effect of tropical instability waves (TIWs) on the equatorial mixed layer heat budget. We will report especially on two new and important results: Firstly, the often reported large meridional heat flux convergence of the TIWs is partly compensated by the associated vertical heat flux divergence. Secondly, the TIWs do not move heat from the tropical warmpool to the equatorial cold tongue but they take their heat from the atmosphere and do not cool the warmpool. This is consistent with the additional result that the TIWs are generated by barotropic and baroclinic instability.

OS34A-06 1645h

North-South Versus East-West Ocean Freshwater Balance Disruptions and Global Ocean Conveyor

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A disparity in redistribution of freshwater between the Atlantic and Pacific Oceans, both by the atmosphere and by the global ocean thermohaline circulation or "global ocean conveyor" itself, has long been recognized as a major cause of the observed asymmetry in SSS. However, it has not yet been examined whether this asymmetry accounts for the functioning of the global ocean conveyor, and whether the longitudinal, inter-basin freshwater balance is more or less important than the meridional, intra-basin freshwater balance. Recently, we have shown that even if SSS is zonally averaged and thus retains only schematic inter-basin contrasts, it can yield a reasonable global conveyor. In a subsequent series of sensitivity experiments, we have also shown that despite the southern (versus the northern) freshwater impacts are important control of THC dynamics, the inter-basin SSS contrasts may be even more important. Our results favor zonal versus meridional SSS contrasts as most critical for building up and maintaining the global THC. We have used an ocean circulation model in a series of sensitivity experiments with an idealized SSS that mimics either meridional, or zonal freshwater disparity, or both. Our experiments have revealed the Atlantic-Pacific SSS asymmetry being one of the most critical elements. Next to this major factor is the Southern Ocean freshwater balance, which, in our experiments of moderate freshwater discharges, has stronger impact on the overall THC functionality than the impacts in the North Atlantic. However, geologic record shows that the strongest freshwater balance disruptions occurred in the post-glacial North Atlantic. Yet we argue that it is the Atlantic-Pacific freshwater balance shift rather than local freshening is the main cause of the THC collapse following the North Atlantic meltwater events.

URL: http://www.personal.psu.edu/bjh18

OS41A CC: 220 C-E Thursday 0830h

Ocean Sciences Posters I

Presiding: **T Qu,** IPRC/SOEST, University of Hawaii**; F J Maurrasse,** Florida International University

OS41A-01 0830h POSTER

A Visual Basic Program to Generate Sediment Grain-Size Statistics and Extrapolate Particle Distributions

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Methods that describe and summarize grain-size distributions are important to geologists because of the large amount of information contained in textural data sets. Therefore, to facilitate reduction of sedimentologic data, we have written a computer program (GSSTAT) to generate grain-size statistics and extrapolate particle distributions. Our program is written in Microsoft Visual Basic 6.0, runs on Windows 95/98/ME/NT/2000/XP computers, provides a window to facilitate execution, and allows users to select options with mouse-click events or through interactive dialogue boxes. The program permits users to select output in either inclusive graphics or moment statistics, to extrapolate distributions to the colloidal-clay boundary by three methods, and to convert between frequency and cumulative frequency percentages. Detailed documentation is available within the program. Input files to the program must be comma-delimited ASCII text and have 20 fields that include: sample identifier, latitude, longitude, and the frequency or cumulative frequency percentages of the whole-phi fractions from 11 phi through -5 phi. Individual fields may be left blank, but the sum of the phi fractions must total 100% (+/- 0.2%). The program expects the first line of the input file to be a header showing attribute names; no embedded commas are allowed in any of the fields. Error messages warn the user of potential problems. The program generates an output file in the requested destination directory and allows the user to view results in a display window to determine the occurrence of errors. The output file has a header for its first line, but now

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