PIRATA-12 Meeting Report
D R A F T
Miami, FL USA
1—3 November 2006
http://www.aoml.noaa.gov/phod/pirata/pirata12.html

OVERVIEW

The PIRATA-12 meeting was hosted by the National Oceanic and Atmospheric Administration (NOAA) laboratory Atlantic Oceanographic and Meteorological Laboratory (AOML) and the University of Miami's Rosenstiel School of Marine and Atmospheric Research (RSMAS). The meeting was held in Miami, Florida USA on November 1-3, 2006, at AOML and the RSMAS/University of Miami campus on Virginia Key.

The overarching goal of all PIRATA meetings is to allow participants in the PIRATA project to provide updates regarding the various components of the project, to discuss the future of the array, and to provide the opportunity to evaluate and modify the Memorandum of Understanding between the PIRATA partners. A particulare goal of the PIRATA-12 meeting was for representatives of the OOPC and CLIVAR communities to present their review of PIRATA, including recommendations for the future of the project. These review comments appear as Appendix 1 (CLIVAR) and Appendix 2 (OOPC) of this report.

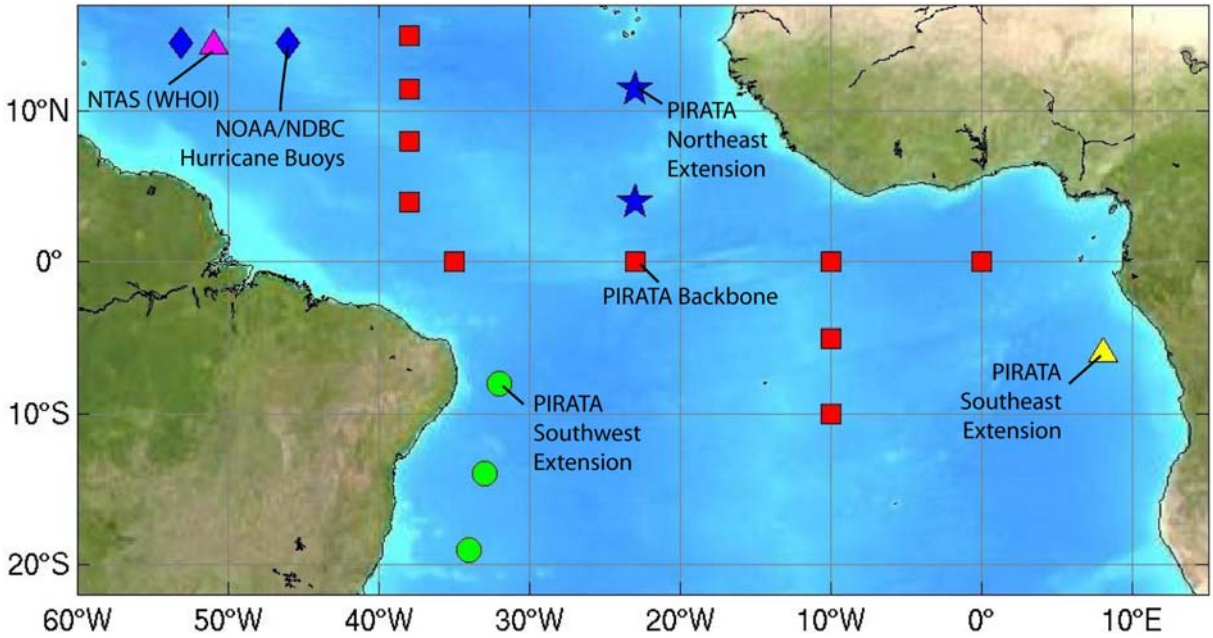

Figure 1: location of Tropical Atlantic data buoy moorings in November 2006, including the PIRATA backbone (red squares) and its extensions.

Wednesday, November 1

Session 1 – Institutional and International Organization.
Chair: R. Lumpkin; Rapporteur: E. Campos

The meeting was opened by S. Garzoli, who welcomed the participants and expressed the AOML interest in supporting and collaborating with PIRATA. Following, R. Lumpkin took over with logistic information and update of the meeting agenda. After that, the first speaker of the morning, Wilco Hazeleger, was introduced.

In his presentation Hazeleger made a summary of the CLIVAR and OOPC evaluation of the PIRATA Review document, after a brief introduction of the PIRATA Project and its objectives. First of all, he highlighted that both CLIVAR and OOPC are definitely supportive of PIRATA and believe that the failure of maintaining the Project would be a disaster. Both climate programs reaffirm their endorsement to PIRATA and understand that PIRATA is the backbone for various programs in the region. Following, he went through a list of comments and recommendations, the most of important of them being that PIRATA should seek a more integrated approach with other ongoing programs or projects in the Tropical/Equatorial Atlantic and that more attention should be dedicated to vessel support and vandalism issues. He also pointed out that the understanding of the Equatorial and Gradient Modes are important issues for CLIVAR in the Atlantic sector and it is recommended a reassessment of how PIRATA could help in the improvement of topics such as prediction skills of the cold tongue and the role of anthropic influence. In another point of his talk, Hazeleger acknowledged that PIRATA presents a gook level of data return, which makes a positive contribution in the Tropical Atlantic. However, he mentioned that comparisons of EUC with and without PIRATA data assimilation still performs poorer than expected. However, PIRATA data has been important in validation and calibration of NCEP and satellite data. Gaps in the data constitute one of the major problems.

Hazeleger ended his presentation reaffirming the need for a more integrated observing system in the Equatorial/Tropical Atlantic, which could demands a more integrated cooperation between TAV, PIRATA and other programs in the region. With respect to this topic, Bob Molinari commented that all actions in the region are being conducted in isolation and asked how is CLIVAR trying to integrate them. To that, McPhaden added that PIRATA is probably isolated because it was the first. In the discussions that followed, there was a suggestion that the next PIRATA SSG meeting should happen during of an integrated PIRATA/AMMA/TAV workshop. Another issue that was discussed after Hazeleger's talk was the need for a synthesis of the contribution of PIRATA to the climate modeling efforts. Also during these discussions, it was agreed that if PIRATA will attend CLIVAR/OOPC recommendations in, for instance a two-year timeline, an integrated work with the Atlantic Panel should be done in the near future.

The second presentation was a report on the Brazilian PIRATA activities, by Paulo Nobre. In a brief summary, he commented the rescue of the 8S-30W buoy and the postponing for late 2006 of the cruise initially scheduled for July, due to a problem with the Antares vessel. The new dates for the BR-IX cruise was Oct/23 – Dec/15/2006 and, in addition to the buoy deployments, it will include CTD stations, the collection of ADCP data and release of meteorological radiosondes. He also informed the following: data PIRATA data collection in Brazil is being helped with the ARGOS system; The effort for having a PIRATA base in the city of Natal is progressing, having completed the construction of the mechanical workshop with funds from the Brazilian Ministry of Science and Technology; the tide gauge in the St.

Peter and St. Paul Archipelago has been integrated with INPE's automated meteorological stations. He finalized highlighted that the annual expenses of PIRATA in Brazil increased to about US$ 812K.

The following presentation was given by Ives DuPehnhoat, representing Bernard Bourles. It included a list of the French PIRATA cruises in 2006, which were funded by Meteo-France, IRD and ORE. A highlight of his presentation was the communication that the 0E-Equator buoy was being working continuously for one entire year, fact never registered before. On the other hand, the 10W-Equator had to be redeployed on Jan 6, due to vandalism. With respect to data retrieval, he informed that 10S-10W is OK, 6S-10W presents a few gaps and 0E-Eq. I OK, and that all the data is available at the website. He also informed that IRD's vessel Antea has been repaired and will be available to serve PIRATA at least for two years. The Anteal will be available for servicing the South-Eastern Extension buoy. Answering a question by W. Hazeleger, he said that France's next year budget will be cut down by about 10% but believe it will not affect the level of commitment of Franc to PIRATA.

The 4th talk was given by Mike McPhaden, representing the PIRATA U.S. He started with a highlight of the PMEL PIRATA related activities in the past year. This included: support to core activities such us field work, equipment and instrument preparation, data processing and dissemination; convertion of the 0-23W and 10S-10W buoys to Flux Reference Sites as part of OceanSITES program; and the shipment of buoys and support in the deployment of the three PIRATA extensions. With respect to data, he informed that PMEL has served the number of 47,354 PIRATA data files though its web site, nearly twice as much as last year and increased to about 4-5 times the hourly met data throughput on GTS resulting from Argos multi-satellite transmission.

He stated that PMEL will continue to support PIRATA core activities. Specifically: support PIRATA cruises in 2006-07; continue data processing, web display and data distribution; additional technician training; increase PIRATA NE extension from 2 to 4 sites with NOAA/AOML; instrument 15°N, 38°W as the third PIRATA Flux Reference Site for OceanSITES and the next upcoming Brazilian cruise; archive PIRATA Flux reference Site data at OceanSITES GDAC (Coriolis); and continue scientific analysis of PIRATA data.
Mike's presentation ended with a brief report on the state-of-the-art of the PICO developments: Ten PICO systems have been deployed in deep water without incident; more testing needed to refine mooring hardware and electrical components. significant development effort needed for low power, efficient profiler technology and compact vandal resistant met sensors.

In the original agenda, the three following presentations were dedicated to reports on the PIRATA extensions. However, due to lack of time, the third one by R. Lumpkin was moved to the morning of the second day. In the first of the other two, Paulo Nobre made a quick report of the status of the Southwestern extension, repeating that other that the rescue and redeployment of the 8S-30W, everything is going smoothly with the SW extension. He mentioned that there are some type of wave activity being captured the SWE buoys, which are note reproduced by the models. The proper assimilation of these data will improve predictability. The second presentation on Extensions, Mathieu Rouault started with a brief history of the SE extension, which ended up with the deployment of one buoy with the financial help of BLCME. This first deployment was made as a Demonstration Project at 8E-5S, extending to July 2007. He reported that the buoy is having a good data return. However,

he informed that BCLME is finishing and there is slim chance of getting new funds for continuation beyond July 2007.

Session 2 – Institutional and International Organization.
Chair: R. Lumpkin; Rapporteur: S. Planton

National Institutions supporting PIRATA:

IRD – Yves Du Penhoat:

As an introduction, Y. Du Penhoat says that J. Boulegue apologizes for being unable to be present due to another commitment. IRD will continue to support PIRATA at the same level than before, however there is some concern about a possible budget cut of up to 10% for 2007. The RV Antea is now again operational and will be used for two EGEE cruises in June and September 2007. The first one might be used to operate as a PIRATA cruise. IRD also plan to buy gliders to be deployed in the Guinean Gulf. In addition, IRD will act to support the inclusion of PIRATA in GEOSS and will try to involve more African countries in PIRATA.

Météo-France – Serge Planton :

The Météo-France interest in PIRATA is related to operational activities (weather and seasonal forecast forecasting) and to research activities (ocean-air interaction and climate variability). Concerning seasonal forecasting, a new seasonal forecast bulletin elaborated every month with MERCATOR-OCEAN and CERFACS, that includes an analysis of Atlantic ocean temperatures, is now partly available on the Météo-France web site. Météo-France, also participated to the AMMA-EGEE experiment including turbulence fluxes measurements at five PIRATA mooring locations onboard the RV Atalante. Cross validation of SST, radiative and turbulent fluxes from the ship, from satellites and from the PIRATA mooring are in progress. Météo-France support to PIRATA is consolidated for the next two years in a convention signed with IRD.

INPE – Paulo Nobre :

Paulo Nobre first made a reference to his morning presentation and to the involvement of INPE in the funding of PIRATA activities. Among the different interests of PIRATA data, he mentioned that it brings valuable information on high resolution structures in ocean-air interactions. Concerning the Oceanic Buoy Laboratory (LNBO) at INPE/Natal, he insisted on the need to develop capacity building and training in order to establish the regional data centre. He underlined the cooperation with NOAA that is crucially important and the positive role played by the France-Brazil-USA cooperation for the success of PIRATA.

DHN – Janice Trotte :

Janice Trotte first made an overview of operations and logistic support to PITATA. This year, in spite of difficulties, was productive with 59 days of operation allowing the replacement of 8 ATLAS buoys. Three vessels could support PIRATA and DHN envision the support from two other ships, “Amorin do Valle” and “Alimirante Graça Aranha”, if extra funds are found to upgrade them for PIRATA operations. DHN is willing to continue its support to PIRATA

with ship time, provided financial arrangements are kept and hopefully improved. Ocean Observing Systems is still a top priority, so the enhancement of the PIRATA backbone and Extensions to collect other data is greatly sought (currents, waves etc.). Capacity Building is a "must" to help improve use of PIRATA data in the region.

IOUSP – Edmo Campos :

E. Campos presented the Oceanographic Institute of the University of São Paulo (IOUSP). IOUSP is an autonomous unit of University of São Paulo (USP) It's primary goal is the conduction of research and training of personnel, both at undergraduate and post-graduate levels. IOUSP is structured in two Departments, the "Physical, Chemical and Geological Oceanography Dept." and the "Biological Oceanography Dept.". IOUSP contribution in PIRATA concern different activities: the calibration of oceanographic sensors, the development of buoy technology, numerical modelling, data analysis, training and education, ship time. Concerning this last point, IOUSP is working on the possible replacement of R/V W.Besnard in the near future and the new vessel could be used by PIRATA.

OCO/NOAA - Mike Johnson :

Mike Johnson firs recalled the mission of the Office of Climate Observation (OCO) that is to build and sustain a global climate observing system that will respond to the long-term observational requirements of the operational forecast centers, international research programs, and major scientific assessments. OCO and the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) have the same goals and priorities, i.e. to implement the ocean domain of GCOS-92. The organizing framework is in place, all six global (in situ) implementation programs being now linked internationally through WMO/IOC JCOMM coordination. PIRATA continues to be a top priority for OCO. NOAA ship time for NE Extension and for NDBC and NTAS mooring deployment is planned through 2009 with a budget of $1387 for PIRATA in 2007. Transition of Pacific TAO operations from PMEL and AOML to NDBC is underway.

NDBC/NOAA - Don Conlee :

Don Conlee presented recent "piratization" of Hurricane Expansion Buoys ("NDBC Observations Supporting Pirata, or NOSP, program"), consisting in the addition or upgrade of rain and radiation sensors on some of them and in the deployment of a new mooring including CT profile and 10m current measurements. PIRATA Met were added to NDBC primary website. Concerning the TAO transition status, the information technology transition is now complete with a new web (ww.tao.noaa.gov) and the operations responsibility begins in 2007. Active TAO refresh engineering and testing is underway at NDBC. The plans consist in continuing the NOSP program and adding full PIRATA data to NDBC TAO DAC operations website.

CORIOLIS – Fabrice Hernandez :

Coriolis has for main tasks to collect data in real time, to inform on this data, to apply quality control, to archive and up-date the data, to perform daily objective analysis and to compute a new climatology. In-situ and daily PIRATA data are provided weekly by Coriolis for operational oceanography, using the NetCDF Argo format.

MERCATOR – Fabrice Hernandez :

MERCATOR is one of the three operational ocean data assimilation systems operating in Europe. New configurations of model and assimilation will be implemented in 2007: a high resolution (1/12° from 20°S to 80°N) ocean model including sea ice with a multivariate assimilation scheme and a global eddy permitting (1/4°) also including sea ice and using a multivariate assimilation scheme. A working group is currently analysing new forcing from ECMWF analyses. A new ocean re-analysis covering the period from 1950 to the present, is also planed. Validation are performed in European (MERSEA) and international (GODAE) working groups. The global metrics will be re-visited. Some indicators are currently implemented operationally (sea level, heat content, transport) using, whenever possible, the agreed validation metrics.

International programs contributing to PIRATA:

IOC/GOOS – Albert Fischer and Janice Trotte :

Albert Fischer gave a quick introduction to international coordination of ocean observations. The Intergovernmental Oceanographic Commission is a forum for governmental coordination of marine science and marine observations. In the domain of ocean observations and services the IOC program GOOS (Global Ocean Observing System) is in charge of the international coordination of sustained observations of the oceans, a platform for the generation of oceanographic products and a forum for interactin between research, operational and user communities. The Ocean Observations Panel for Climate (OOPC) advises the open ocean component of GOOS. PIRATA is a critical element of the global ocean observing system defined by GOOS and coordinated by the Joint WMO-IOC Commission for Oceanography and Marine Meteorology (JCOMM). The challenges are to obtain national commitments for sustaining ocean observing systems often funded by research, and to integrate networks to create a true system.

Janice Trotte then presented the IOC/WMO support to PIRATA. PIRATA appears as a major GOOS pilot project extending the TAO array. It also plays a leading role for observing systems in the South and Tropical Atlantic. She illustrated this role by presenting the regional alliance in oceanography for the upper southwest and Tropical Atlantic (OCEATLAN). All PIRATA data sets are available for download at the experimental OCEATLAN web page, from where other data can also be available: http://www.oceatlan.org. It is part of the Brazilian contribution to GOOS and a backbone to other observations in the region. It is also part of a bilateral agreement with the USA for Science and Technology. The fact that OCEATLAN encompasses external cooperation with partners from outside the region, is deemed as essential.

OOPC – Albert Fischer :

OOPC develops recommendations for a sustained global ocean observing system in support of WCRP, GOOS, and GCOS climate objectives, including recommendations for phased implementation. It helps at developing a process for ongoing evaluation and evolution of the observing system and its recommendations. It supports global ocean observing activities by involved parties, through liaison and advocacy for the agreed observing plans. As part of the

Observing system evaluation, in the long term, the development of ocean forecasting and ocean reanalyses, and observing system simulation experiments (OSSEs) will provide specific feedback. Right now, one objective is to estimate the uncertainty in the measure of climate indices from data, chosen to communicate about the ocean observing system and the ocean's role in climate and climate variability. OOPC working with CLVAR Atlantic would welcome direct feedback on the way to define Tropical Atlantic indices and their uncertainty. Existing indices are available on the OOPC website: http://ioc.unesco.org/oopc/.

TACE/CLIVAR – Wilco Hazeleger :

The main TACE (http://www.clivar.org/organization/atlantic/TACE/tace.php) goal is to advance understanding of coupled ocean-atmosphere processes and improve climate prediction for the Tropical Atlantic region. The observing system will be enhanced for the period 2007-2012, to provide the data needed for research and operations, and to improve the coupled predictive systems, ocean synthesis and transfer from science to operations. PIRATA is an observational backbone of TACE while TACE is an enhancing observational network temporarily. An OBS WG coordinates and tracks various international contributions to the envisioned TACE observational strategy. It promotes collaboration between various observational groups, identifies gaps in the observing system, evaluates possible means to implement the required enhancements and monitors data availability and usage by the climate user community. The modelling and synthesis WG will contribute in determining oceanic processes important in regulating SST, improving SST forecast on seasonal to interanual time scales, providing parameterizations and model improvements to global and regional prediction centers, investigating response of tropical Atlantic region to global warming, and improving the design and performance of the required ocean observing system.

Thursday, November 2

Session 3 - PIRATA scientific data and its contribution to climate forecasting and prediction.
Chair and rapporteur: R. Lumpkin

NOTE : all presentations are available for download at the PIRATA-12 web page, http://www.aoml.noaa.gov/phod/pirata12.html

Rick Lumpkin, "PIRATA Northeast Extension preliminary results".
Abstract : In June 2006, the first two moorings of the PIRATA Northeast Extension were deployed at 11.5°N, 23°W and at 4°N, 23°W. Both mooring deployments were successful, and the buoys are transmitting daily data revealing the seasonal migration of the ITCZ, the passage of several easterly waves past 11.5°N, and the intense eddy heat fluxes associated with tropical instability waves (TIWs) at 4°N. At 4°N, a preliminary heat budget of the mixed layer (work with M. McPhaden and G. Foltz) indicates that fluctuations exceeding 400 W/m^2 are associated with cold water advection by TIWs, dominating the budget at intraseasonal time scales.

Fabrice Hernandez, "CO_2 budget in the Tropical Atlantic" (presented for Nathalie Lefèvre)
Abstract : The ocean is a strong sink of CO_2 for the atmosphere absorbing about 2 GtC/ yr. CO_2 observations are necessary to understand the role of the ocean under increasing

atmospheric CO_2. One of the main objectives of the European project CARBOOCEAN is to better estimate the CO_2 flux at the air-sea interface for the Atlantic Ocean using an observational CO_2 network. In this context, we are setting up two time-series stations in the tropical Atlantic. During the EGEE 3 cruise in the Gulf of Guinea, we installed a CO_2 sensor and an oxygen optode at the PIRATA mooring at 6ºS, 10ºW. Hourly CO_2 and O_2 data are transmitted by Argos since the 7th of June 2006. The spreading of the cold tongue from June to September leads to an outgassing of CO_2 during that period.

Chunzai Wang, "Atlantic Warm Pool and its impacts on the Summer Climate of the Western Hemisphere"

Abstract : The NCAR community atmospheric model and observational data are used to study the Atlantic warm pool (AWP) of water warmer than 28.5°C that is comprised of the Gulf of Mexico, the Caribbean Sea, and the western tropical North Atlantic. The AWP reaches its maximum size around September, with large AWPs being almost three times larger than small ones. Although ENSO's teleconnections are influential on the AWP, about two thirds of the large and small AWP variability appears unrelated to ENSO. The AWP is usually geographically different from the tropical North Atlantic; however, the AWP size is correlated with the tropical North Atlantic SST anomalies. Two groups of the model ensemble runs with and without the AWP are performed and compared. The model results show that the AWP's effect is to weaken the summertime North Atlantic subtropical high, especially at its southwestern edge. The AWP also strengthens the summertime continental low over the North American monsoon region. In response to these pressure changes, the easterly Caribbean low-level jet is weakened. The weakening of the easterly Caribbean low-level jet increases (decreases) moisture convergence to its upstream (downstream), thus increases (suppresses) rainfall in the Caribbean Sea (the far eastern Pacific west of Central America). Our model runs show that the effect of the AWP is to weaken the southerly wind of the Great Plains low-level jet. However, the AWP strengthens the northward moisture transport of the Great Plains low-level jet in the summer because the AWP-induced increase of specific humidity overcomes the weakening of southerly wind, and vice versa in the fall. Finally, the AWP largely reduces the tropospheric vertical wind shear in the main development region that favors hurricane formation and intensification during August-October.

Chunzai Wang, "An overlooked feature of Tropical Climate: Inter-Pacific-Atlantic Variability"

Abstract : Both the tropical Pacific and Atlantic host an equatorial mode of interannual variability called the Pacific El Niño and the Atlantic Niño, respectively. Although the Pacific El Niño does not correlate with the Atlantic Niño, anomalous warming or cooling of the two equatorial oceans can form an inter-Pacific-Atlantic sea surface temperature (SST) gradient variability that induces surface zonal wind anomalies over equatorial South America and over some regions of both ocean basins. The zonal wind anomalies act to bridge the interaction of the two ocean basins, reinforcing the inter-Pacific-Atlantic SST gradient through atmospheric Walker circulations and oceanic dynamics. Thus, a positive feedback seems to exist for climate variability of the tropical Pacific-Atlantic Oceans and atmosphere system, in which the inter-basin SST gradient is coupled to the overlying atmospheric wind. Rainfall responds to the inter-Pacific-Atlantic SST gradient by showing an anti-symmetric configuration between the two equatorial oceans, suggesting that rainfall is sensitive to the equatorial inter-basin SST gradient, regardless of which ocean is anomalously warm or cold.

Ludos-Herve Ayina, "The potential apport of high resolution satellite-derived turbulent fluxes in a numerical simulation of the Tropical Atlantic Ocean".
Abstract : The specific objectives of this study emphasizes estimation of turbulent fluxes over the tropical Atlantic Ocean with high spatial and temporal resolution using satellite radar and radiometer measurements, and to evaluate the ability of the ocean model to correctly simulate the dynamic of the tropical Atlantic Ocean when forced by those satellite turbulent fluxes (wind stress and latent heat fluxes). Consistency of the same surface parameters retrieved from several satellites is assured. The flux fields are compared to in-situ observations (PIRATA) and atmospheric analysis fields over the whole basin and in some specific locations. Three sensitivity simulations forced with satellite and atmospheric analysis fields are performed. The control experiment is forced with the European Centre for Medium-Range Weather Forecasts (ECMWF) fluxes. The solutions of these simulations are compared with data from PIRATA buoys and from sea surface temperatures analysis by Reynolds and Smith in the equatorial Pacific Ocean.

Paulo Nobre, "First year of data from the PIRATA SWE and model results"
Abstract : An analysis of the first year of data from the Southwest Extension moorings at 8ºS, 32ºW; 14ºS, 33ºW; and 19ºS, 34ºW will be presented.

Edmo Campos, "Impact of Atlantic ocean circulation on Tropical Atlantic climate and variability"
Abstract : Numerical experiments with a coupled ocean-atmosphere model (MICOM-SPEEDY) were run to investigate some aspects of the Atlantic circulation and their impact on the Tropical Atlantic. These experiments were conducted by changing the boundary conditions of the OGCM (an implementation of MICOM to the Atlantic). Experiment NOMOC is based on boundary conditions taken from a globally coupled SPEEDY-MICOM run, which has no thermohaline circulation. Experiment NOAGU is a case with no Agulhas leakage. The results are compared with a control run, in which the boundary conditions are taken from the Levitus climatology.

In the NOAGU case, the results after a 30-year run show a decreased temperature distribution in the SE quadrant of the South Atlantic. There are also some changes in the North Atlantic, which could be due to atmospheric teleconnections. There is a greater impact on salinity partly as a result of a shift in the position of the ITCZ. In the NOMOC run, there is a sharp decrease in the meridional heat transport. The surface temperature in the North Atlantic shows a decrease of the order of 10ºC, whereas the upper South and Tropical Atlantic become 1-2ºC warmer and 0.5-1 PSU more saline. These changes in the mean state have a profound impact on SST variability in the tropical Atlantic: The equatorial cold tongue mode disappears and the dominant mode of variability is now located over the Benguela region.

These results suggest that tropical Atlantic climate and variability are sensitive to changes in the MOC and that monitoring of this region is relevant for understanding the dynamics of the MOC.

Rana Fine: summary/report of October's Tropical Atlantic Variability meeting.

Gustavo Goni, "The dynamics of the North Equatorial Countercurrent"
Abstract : Independent estimates of the dynamic height are derived from sea height anomaly fields combined with climatological hydrographic fields and from expendable

bathythermograph (XBT) observations to investigate the spatial and temporal variability of the North Equatorial Countercurrent (NECC). Twenty-two XBT sections from a meridional high density transect that crosses the region are used to investigate the variability of the eastward flowing currents, westward countercurrents and undercurrents based on the slope of the isotherms and on the dynamic height fields that characterize each particular current. The location and geostrophic transport of the NECC derived from the twelve years of sea height anomaly data are compared with the results obtained from the XBT transects. West of 25W-30W, the location of the NECC has annual and semiannual cycles with maximum northerly locations during February-March and September-October. East of this region, the core of the NECC exhibits an annual motion following the migration of the ITCZ. However, the geostrophic transport has an annual component with minimum values during the boreal spring months and higher values during the boreal fall months regardless of the NECC location.

Mathieu Rouault, "First results from the PIRATA Southeast Extension"
Abstract : Initial observations from the Southeast Extension mooring at 6ºS, 8ºE will be presented.

Late afternoon : open discussion about PIRATA scientific goals, links to Tropical Atlantic Climate Experiment (TACE), CLIVAR, AMMA, etc.

Friday, November 3

Rapporteur: J. Trotte

PIRATA Resources Board (PRB) meeting: logistics and operations needed before the next Memorandum of Understanding (MoU), new data sets, new MoU, ship time, financial contributions to PIRATA.

Session 4 - PIRATA-12 report, membership, adopted resolutions and recommendations.
Report of PRB meeting.
Election of a Chair and Vice-Chair.
Date and venue of next PIRATA SSC and PRB meetings.

APPENDIX 1: Comments from CLIVAR AIP on the PIRATA Status and Perspectives Document

1. Introduction

At the PIRATA X (Fortaleza 2004) and PIRATA XI meeting (Toulouse 2005), Brazilian, US and French partners in the PIRATA program expressed their desire to extend the program, but decided that an assessment should take place by CLIVAR and GOOS. Members of the Atlantic Implementation Panel of CLIVAR and the Ocean Observations Panel for Climate of GOOS performed the review based on the document "PIRATA; accomplishments of PIRATA : 1997-2005. Status and Perspectives".

In general CLIVAR strongly supports the PIRATA program. According to CLIVAR it is of the foremost importance to maintain the current mooring array and to strongly support the currently planned extensions. This would enable PIRATA to be firmly established as the main backbone of the tropical Atlantic observing system. The failure to do so would be a disaster for climate science community. The new Northeast, Southwest and Southeast extensions of the mooring array are strongly supported. Concerns rise as well. Some of these are of practical nature, in particular the issue of vessel support and vandalism. To guarantee a sustained observing system these should be addressed. Also, some of the goals of PIRATA are broad and one should be cautious about predicting a quick, large and positive impact of PIRATA data on the results coming out of (seasonal) prediction systems and ocean state estimation. There is a need for an integrated framework in order to see how all the different actions (in situ, modelling, data assimilation, satellite observations, etc) interact constructively with each other. This would be important in terms of setting priorities for new actions to be launched in the future.

CLIVAR would like to commend the participants of this project for their perseverance in the face of numerous adversities to obtain a major improvement in the description of the conditions in the tropical Atlantic region.

On behalf of the CLIVAR Atlantic Implementation Panel,
Wilco Hazeleger

2. General remarks

The *Pilot Research Moored Array in the Tropical Atlantic* (PIRATA) review document is well written and very concisely summarizes the status and accomplishments of the various PIRATA teams.

The goals of the PIRATA project extend from description through understanding to prediction of variability in the coupled ocean-atmosphere system in the Tropical Atlantic, and by implication to improved understanding and predictability in the regions influenced by the tropical Atlantic. These are clearly very broad and challenging goals, particularly given the shortage of technical and research capacity initially available in the region.

PIRATA is largely motivated by the expected societal benefits to be derived from an improved ability to predict ocean conditions and ocean-atmosphere exchanges in this region and the influences on weather and climate – for both the ocean and the atmosphere. Major effects include variability in fisheries, winds, precipitation and air temperatures. There is also a need for improved understanding of the horizontal and vertical ocean circulations in the equatorial band, the associated cross-equator transports of heat and how these might be influenced by local or remote variability.

To address the above challenges, the first step was (and continues to be) to develop an improved description of basic conditions and the variability in these conditions. Thus a major sustained field program in this region was clearly essential. Fulfilling this objective has been complicated by limited financing and the lack of adequate local vessel and technical support, and the situation has been exacerbated by additional challenges including unexpected interruptions in vessel availability and costly vandalism, presumably by some of the people that the project aims to benefit.

The PIRATA project has wisely built on the expertise and technical developments previously established for the TAO array in the equatorial Pacific and it has benefited from additional technical developments during its lifetime. Noteworthy are improved satellite measurements of sea level, SST, rainfall and winds, improved rain and salinity measurements from the ATLAS buoys, and improved information on the larger scale variability in upper ocean conditions supplied by the Argo project. Tide gauge, air pressure, SST and SSS data from São Tomé and new meteorological stations at Fernando de Noronha Island and St. Peter & St. Paul Rocks also contribute to the near-real-time data that is now available and all of this information can now be ingested into operational modelling systems that have developed very significantly since the initiation of PIRATA.

In addition to the rapid-access information mentioned above, a suite of measurements (ADCP, surface temperature and salinity, CTDs, XBTs, meteorological observations etc.) are made during each servicing of the PIRATA observation network and continuous ADCP measurements are available over the upper 130m since late 2001 from a mooring located at 23°W-0°N, coincident with an ATLAS buoy site. All of these observations have greatly increased the baseline information available for the region.

Finally, it is clear that the PIRATA field program has and will continue to form the foundation for some programs and to complement others; noteworthy examples include Argo, AMMA (African Monsoon Multidisciplinary Analyses), TACE (Tropical Atlantic Climate Experiment – endorsed), BCLME (Benguela Current Large Marine Ecosystem), GOOS (Global Ocean Observation System), SOLAS (Surface Ocean – Lower Atmosphere Study), GODAE (Global Ocean Data Assimilation Experiment) and CLIVAR (Climate Variability and Predictability). The importance of this "foundation role" in an area where data coverage is sparse and field programs are particularly challenging to mount should not be underestimated.

3. Achievements

It is clearly demonstrated that the PIRATA array has provided an invaluable amount of data for numerous and varied applications, among which one can cite for instance, analysis of climate variability at seasonal-to-interannual timescales, equatorial dynamics, mixed-layer temperature and salinity budgets, air-sea fluxes, data assimilation, weather and climate forecasts etc … It is of the foremost importance to maintain the current mooring array and to strongly support the currently planned extensions. This would enable PIRATA to be firmly established as the main backbone of the tropical Atlantic observing system. The failure to do so would be a disaster for climate science community. The CLIVAR science community desperately needs long and coherent datasets to study interannual to decadal fluctuations and their interaction with anthropogenic climate change.

It is clear that the basic goal of improved description of oceanic conditions and air-sea exchange (including variability in these conditions) has been achieved by PIRATA and the policy of making observations freely and rapidly available via the internet has gone a long way towards optimizing the use of this information. Capacity building is an additional aspect of the observational program that should not be overlooked, particularly given the well-known inadequacies of observations in the southern hemisphere, and the relatively poor funding in the region. Hopefully, the increased technical and research capacity developed through projects like PIRATA will eventually help reduce the imbalance between observational programs north and south of the equator. Overall, the participants in this project are to be commended for their perseverance in the face of numerous adversities to obtain a major improvement in the description of the conditions in this region.

Given that the field program goals of PIRATA have been (and continue to be) successful, we must ask if the additional information collected is being put to good use. The publications listed in the status and perspectives document make it clear that the data have been used to address numerous descriptive and technical issues, including the provision of improved descriptions of seasonal and interannual variability in ocean conditions and air-sea fluxes and the reliability/uncertainty of the information that has been collected both by the PIRATA array and from satellites. Further, the goal of using budget calculations to help determine the relative roles of surface fluxes and oceanic processes in the determination of surface and upper-ocean variability has been realized to the extent possible. In addition, many other technical issues and descriptive works have been successfully addressed. It is clear that the data collected is of high quality, but it remains somewhat sparse – a fact that is, at least to some extent, being addressed by recent and proposed extensions. However, PIRATA seems to focus on seasonal and interannual time scales. Intraseasonal variability is also of importance in the region. In addition to seasonal outlooks, meteorological agencies in the region (eg the South African Weather Service) are also concerned with extended range forecasts, particularly for agricultural applications.

To justify the transition of PIRATA from a pilot project to a sustained operational observing system providing real-time information for use in weather and climate prediction, definitive evidence of economic value is essential. The demonstration of such value will inevitably require predictive models with useful skill. An important issue is whether or not strong evidence of net economic value will be available by the end of the present consolidation phase. In this regard, the recent and proposed extensions are encouraging since they increase the potential for skillful predictions of events like the Benguela Niño and its effects on local rainfall. This type of predictive work seems essential to justify the transition to a long-term observing system with secure funding commitments, but has not been planned in a coordinated way (the TACE project is a first step toward this goal).

Also important are projects like TACE and AMMA that will make use of PIRATA data and build on the PIRATA backbone to address clearly complementary goals. The resulting prospects for improved understanding of dynamical processes and applications to the development of predictive systems certainly increase the prospects for successful transition to a sustained operational system. In particular, it is clear that to improve forecast capabilities over any/all timescales, observations must be used to improve model initializations and to constrain and/or validate model variability. With the baseline data provided by PIRATA and other programs (including satellite observations, Argo data and meteorological observations) this is now possible and is being put into practice.

A great deal of work has been achieved on validation of existing remote sensing data, in particular satellite SST products, with some very interesting new results (among others the overestimation of the latent heat flux by reanalysis products and the thorough validation of the EUMETSAT OSISAF data products). All these activities are strongly supported by CLIVAR.

This being said, a complete, detailed and coherent assessment of the scientific potential of the PIRATA array is a delicate and complex task. It is not obvious and sometimes impossible to objectively assess the real impact of PIRATA data for some of the objectives, just because the number of years is still limited and/or due to non homogeneity in the observing system (for instance, it may not be realistic to study the impact of assimilating PIRATA data on the quality of seasonal forecasts in the tropical Atlantic region, this would require a much larger dataset -10 years is barely enough - in terms of temporal coverage). In terms of the main goals (stated page 6), it is probably fair to say that the first two have been quite successful while the third one is a little bit behind. The third goal is “to provide a set of data that could be used to develop and improve the predictive models of the ocean-atmosphere system”. This covers both the estimation of the initial ocean state to be used for the prediction and the coupled models used to perform the forecast. These are obviously long-term goals and the role of PIRATA data is certainly important, but many other factors are probably as or even more important. Thus, one should be cautious in predicting a quick, large and positive impact of PIRATA data on the results coming out of the prediction systems. This is likely going to be a very

long and difficult task with an unknown outcome at this time. The last point is the position of PIRATA with regard to other current or planned initiatives. There is a strong need to better define the global picture which encompass all these projects. This suggests the need for an integrated framework to be developed in order to see how all the different actions interact constructively with each other. This would also be important in terms of setting priorities for new actions to be launched in the near future.

4. Recommendations and comments

4.1 General

Based on the fact that high-quality data is being successfully collected and used in both research and operational projects, and the fact that each of these applications shows great promise to grow and complement the other, we recommend that the PIRATA project be continued and transitioned to a long-term system to the extent possible. However, several issues need to be carefully addressed to ensure that the project is cost-effective and hence sustainable. Some specific considerations and concerns include:

1. The most obvious issue that needs to be addressed is vessel support. It is clear from Appendix 8 of the Status and Perspectives document that this issue has been carefully considered and it appears that the status quo may become the option of choice more because of inertia than for good scientific or logistical reasons. We encourage the PIRATA Resources Board to continue to push this issue to find a more permanent and reliable solution. Any such solution should attempt to take into account the need for additional observations, particularly to the south, in addition to the PIRATA program.
2. The ongoing efforts to reduce the losses associated with vandalism must obviously be continued.
3. We support continued efforts to extend the PIRATA array in scientifically justified and cost effective ways. The proposed SW extension off Brazil, the SE extension off Angola and the NE extension along 23°W are each well-justified in the report and warrant support to the extent possible. However, it should be noted that the SE extension is a pilot project supported by BCLME (Angola, Namibia, South Africa) and not by South Africa as the PIRATA document states. The mooring has been deployed near 6S, 8E in June 2006 during an EGEE cruise. Also, Benguela Nino's influences rainfall over western Angola and northwestern Nambia, but there is not much evidence as yet for a broader impact.
4. CLIVAR supports the complete instrumentation of the PIRATA fluxes reference sites. This is crucial if one wants to go further in the understanding of coupled air-sea processes at various time scales.
5. Although one of the main objectives of PIRATA was to monitor the equatorial and meridional modes, it is unclear whether the actual network is optimally calibrated to assess the fluctuations of these modes. Figure 7 shows that there are instances where the simple index derived from PIRATA is not in good agreement with the usual SST dipole index (1999 and 2001). The diagnostic provided to show the lag-relationship between the two modes isn't very clear (figure 9). A more detailed assessment of the capability of the current network to depict the links between the two modes is certainly required. In this regard, the proposed extensions to PIRATA would certainly be very useful. Also, a higher resolution near the equator is required to resolve the waveguide. CLIVARs WGSIP has indicated that a denser network is needed to make progress in seasonal forecasting. Another interesting question is the frequency dependence (and in particular at sub-annual time scale) of this relationship, which can certainly be examined with PIRATA data.
6. In terms of longer plans, it is striking to see that the document focus on the meridional resolution of the equatorial waveguide and the Gulf of Guinea region only while the region of the north Brazil current is not mentioned, contrasting with the strong statement made on page 39. This is a bit surprising as this region has a strong influence on western tropical Atlantic SST anomalies which are very important in terms of tropical-extra tropical teleconnections.

7. Finally, there are obvious questions and concerns about whether or not the full (extended) PIRATA array can be maintained in a long-term program. A careful determination of the most critical elements of the array is clearly needed in case program cuts are required. Such an evaluation should consider the consequences for funding, R&D and operational programs if specific elements of the array are eliminated. This evaluation needs to take into account other data sets (e.g., observations from satellite platforms and Argo) that may help fill the gaps.

4.2 Links with the modelling and synthesis community.

The use of PIRATA data in operational ocean and atmospheric modeling is very encouraging. The development of coupled data-assimilative ocean-atmosphere models is a challenging area of research that needs to be supported if maximum long-term benefits to society are to be achieved. This is particularly true for medium to long range weather forecasting where the evolution of ocean conditions are important and are unlikely to be well-represented by persisted ocean anomalies. CLIVAR encourages more work in this area and particularly:

1. PIRATA data could be used more in terms of validation of existing coupled models. Most coupled models have 0-order biases in their representation of the basic features of the tropical Atlantic climatology. The current PIRATA data could be used to better understand why the coupled models have such large biases in terms of the zonal SST gradient mean state (it is indeed a coupled problem and has to be analyzed as such). The use of PIRATA fluxes to validate coupled climate models in terms of the SST-heatflux (both radiative and turbulent components) feedback is strongly encouraged even though one has to devise a clever way to compare in situ data with model gridded data. This is essential as it will provide an indication of the persistence of the SST anomalies which is likely to play an important role in terms of potential predictability. It is useless (in terms of improving predictability) to have the best array of moorings as well as the best data assimilation system if the initial state ocean (sub-)surface anomalies are unrealistically washed away by the coupled models used in climate forecasts. It is encouraged that the PIRATA community liaises well with WGOMD and WGSIP panels of CLIVAR and WCRP to improve this.
2. Tuning of high resolution ocean models through their representation of the EUC (Clipper and MOM simulations) as well as process studies such as the role of TIWs upon the transport of the EUC, the behaviour of the EUC in the Gulf of Guinea. This is clearly a very important topic as it has very important consequences in terms of a better understanding of the equatorial dynamics in the Atlantic and improvement of ocean physical parameterizations. These types of studies should be strongly encouraged in the future (for instance the importance of the diurnal cycle on the representation of coupled processes and the links with the vertical resolution needed in ocean models). Again, liaising with the modelling panels is encouraged.
3. Ocean state estimation: much more work is needed to really prove the positive impact of PIRATA data upon the ocean state estimation. Comparison of simulations with and without PIRATA data assimilation has to be performed with independent data and for longer periods. Reasons for the not-so-large improvement when using PIRATA data should be better understood although it seems probable that it partly lies in the data assimilation technique that is currently used in the MERCATOR prototype (it is hoped that MERCATOR will slowly evolve towards variational techniques which have proved to outperform OI schemes in the tropical Pacific).

4.3 Links with other programs

Supplementing the backbone PIRATA observations with additional research projects such as TACE and AMMA is also encouraged. Strong links exist between PIRATA and the Atlantic Implementation Panel of CLIVAR. Similar interaction with the Working Group on Seasonal and Interannual

Prediction (CLIVAR-WGSIP) and Working Group on Ocean Model Development (WGOMD) is encouraged. These types of R&D projects are essential to maximize the benefit from the investments made in the PIRATA program. In addition, PIRATA is relevant to the biogeochemical cycles and ecosystems research communities (e.g. impact on low oxygen zones and fisheries). Specific comments:

1. The links seem obvious but are not sufficiently detailed in the document. In particular, the scientific links with AMMA are considered as obvious, however this is not the case since AMMA is mostly concerned with the hydrological cycle over the continents. The same could be said with regard to TACE.
2. More generally, there is a need to better define the roadmap to optimally link on one hand very detailed process studies and the observations network, and on the other hand the more global and integrated climate picture.

APPENDIX 2: Comments from OOPC on the PIRATA Status and Perspectives Document

Review of the PIRATA report
Accomplishments of PIRATA: 1997-2005, Status and Perspectives
By a subgroup of the Ocean Observations Panel for Climate (OOPC): D. E. Harrison, F. Schott, R. Weller
October 2006

Summary: The PIRATA array and related observations taken during mooring exchange/refit and ancillary cruises have allowed a multitude of studies leading to a much better understanding of Tropical Atlantic Variability (TAV), and have made possible the initiation of ocean forecasting for the region. Prior to the multi-national establishment of the PIRATA network and related regular cruises, observations of the Tropical Atlantic were much sparser than for the Tropical Pacific. OOPC fully endorses the concept of sustained observations of TAV, including continuation of the network and of the southwestern and planned eastern extensions. However sustained observing of the region should be undertaken with an integrated observing system in which surface moorings are used where they are the most effective technology, and other technologies are used where they offer advantages. OOPC thus recommends that annual meetings of the TAV community be established which include PIRATA, and that development of a plan for of an integrated observing system for the tropical Atlantic be a priority for the TAV community.

1. PIRATA status 2006

OOPC compliments PIRATA for its accomplishments under challenging conditions. The existence of PIRATA and of its associated exchange cruises has resulted in a seasonal and interannual coverage of the tropical Atlantic that was impossible before, except for brief periods during international experiments like the GARP programs GATE and FGGE. An important result of PIRATA is that it has spawned significant enthusiasm and progress among adjacent nations, and in particular Brazil. PIRATA observations are important for operational oceanography and climate forecasting in the tropical Atlantic. Much has been learned in the analysis of PIRATA data. Doubts on the mean zonal circulation on the equator were resolved using PIRATA moored data, and revealed the existence of two westward intermediate currents (EICs) underneath the Equatorial Undercurrent (EUC), separated by an eastward flow in between. As was accomplished in the Pacific earlier using TAO exchange cruises (e.g. Johnson et al., 2002; Sloyan et al., 2003), PIRATA ship sections have recently allowed us to better quantify the transports of the eastward equatorial and off-equatorial undercurrents (Schott et al., 2003; Brandt et al., 2006; Fischer et al., 2006). Furthermore, the existence of PIRATA has allowed process studies (for example, a study on mixing in the eastern cold-tongue lead by M. Dengler of IFM-GEOMAR) that are essential in improving models, and has certainly helped triggering planning activities for internationally-coordinated equatorial (TACE) or near-equatorial (AMI, AMMA) studies. A multi-year study of the eastern equatorial regime has also been proposed to the German Deutsche Forschungsgemeinschaft (DFG), which also benefits from the momentum and perseverance of PIRATA.

2. Recommendations

Importance of moored or profiling subsurface observations at intraseasonal timescales
Recent observations in the central tropical Atlantic (Brandt et al., 2006) have emphasized the need for subsurface coverage of intraseasonal variability at time scales shorter than a month. Their spatial structures and dynamics are not yet sufficiently well understood, and their surface signatures are not satisfactorily resolved by satellite observations. This requires subsurface moored ADCP or rotor current measurements with a best data quality standard. Mooring survivability would be greatly

increased if subsurface floatation is used, for example with a top float near the 100m level carrying an upward (high-resolution) and a downward (longranger) ADCP. Whether this task can also be carried out by gliders in the future needs to be investigated.

The need for eastern tropical Atlantic and cold tongue studies
Coupled models have significant difficulty in reproducing tropical Atlantic stratification and SST (e.g., IPCC-AR3 and CLIVAR/TACE reports), with the cold spot essentially appearing in the central basin and too-warm eastern tropics. Improved parameterization of the shallow eastern mixed layers is therefore important. Since advection is important in the tropical belt and eastern upwelling regimes (Foltz et al., 2003), moored current observations are essential in the region, including documentation of the poleward propagation of coastal-trapped waves (CTWs). The proposed southeastern extension (SEE) focuses on the Benguela Niños with moorings at 6-8° S; and the proposed northeastern extension (NEE) on the ITCZ migration, i.e. on issues of interest for AMMA/AMI, with planned moorings along 23° W in a region important for climate anomalies and hurricane generation. Therefore the OOPC strongly endorses both extensions and the associated research foci.

Southwest Extension
After international review, Brazil has started a program with three moored stations off its northeastern coast, between 8-19° S . In this region, surface buoys are much less prone to vandalism and meteorological observations are useful for forecasts in Brazil. Recent observations have shown that there is large intraseasonal variability in the region, and from altimetry and high-resolution model analyses (Ph.D. study K. v. Schuckmann, IFM-GEOMAR), a relation to the interior basin has been suggested. Therefore, moored observations in the zonal inflow regime will be helpful for understanding the ocean response and boundary interaction.

The PIRATA mooring concept
At the start of PIRATA, there was a general interest in and preoccupation with the “SST Dipole Mode”, leading to the two NW and SE off-equatorial mooring lines that run through the presumed dipole maxima. Good coverage of the equatorial belt and boundary interaction regions (PIRATA extensions) by moored stations is of continued highest importance, as observations and model studies have shown a large contribution of advection and diffusion to the heat and salt balance on the equator, and for the propagating boundary signals. At the NW and SE off-equatorial stations, advection plays a less important role. Given the availability of other types of observations of stratification and water mass variability (Argo float profiles in particular) a reassessment of how much of an off-equatorial moored station coverage will be needed in the future should take place. Furthermore there were high hopes in obtaining much more realistic model simulations through data assimilation. However, it is fair to say that at the present stage of evolution of ocean data assimilation systems, it is unclear how well sparse data points from a dozen or so widely distributed moored stations actually influence model simulations.

Use of surface moorings
The biggest problem PIRATA has faced is vandalism of surface moorings, which has resulted in significant losses, data gaps and data quality deterioration. There should be a discussion of why the use of surface moorings is essential at each of the present locations, in particular in the east, where vandalism is higher, given the technical advances in autonomous observations since the beginnings of PIRATA. Many of the use examples cited in the review document could be addressed by other sampling means: for example (Figures 7&9) – satellite SST can also produce the dipole index. More generally, the possibility of gliders deployed as virtual moorings should be explored, as they may be able to produce the same benefit with a far reduced risk of vandalism. Certainly the surface met and flux data have high value. However, some questions should be addressed by the TAV community: Does daily-averaged data of coarse vertical resolution from the ocean justify the quality challenges posed by vandalism to surface moorings? What is the density of moorings needed to get the surface meteorology and fluxes? Are these independent observations or are they too coarse to have any coherence?

Development of an Integrated Observing System for TAV
It is suggested that the TAV community work with the PIRATA community and the tropical Atlantic operational oceanography community to design an observing system that makes best use of all available technologies. It is suggested that OSSEs be carried out in which the importance of individual stations and sampling strategies for recovering the energetically important parts of the variability are investigated, by subsampling and reconstructing output fields of high-resolution models, such as those available from the 1/12 degree FLAME or HYCOM models. This strategy was successfully applied for investigating sampling strategies in the tropical-subtropical Indian Ocean with its strong intraseasonal variability (Vecchi et al., 2006). It is also recommended that model simulations with ocean data assimilation be tested by using different subsets of PIRATA location data.

3. Vessel support

Ship time is one of the limiting factors for successfully continuing PIRATA into the future. Through OSSEs and interaction with the meteorological/assimilation community it should be determined which surface stations with met observations are considered essential. Subsurface moorings could be deployed for one year at a time with little risk of vandalism, but there would be technical challenges in obtaining the data in real time. These systems should be tested before any transition. The impact of delayed mode access to some observations should also be weighed against the probability of ultimately more complete data sets made possible by less vandalism-prone observational techniques.

4. Technical mooring issues

This section has a number of specific questions from OOPC based on the PIRATA review document.

1) There needs to be more information provided about calibration, quality control, quality assurance, and accuracies of the sensors, instrument systems, and resulting data. There is no discussion of calibration procedures (factory or lab calibrations how often?), of how sensors degrade with time in the field (certainly the salinity and meteorological sensors do or can), of problems with ADCP data due to fish (in the TAO array they have gone to separate subsurface moorings to get ADCP data as the fish return could not be beat so how does PIRATA do QC on the ADCP data?). On page 28 the report mentions the “bad quality of the buoy data” – what does this mean, certainly the buoys cannot measure SST and make a temperature measurement at some depth below the hull which is never mentioned – so how much bias arises due to this? Page 45 talks about dust deposits-how do these affect the met sensors, especially the radiometers? Several discussions about the use of the buoy data talk about using the buoy data as a truth to identify biases and then points to differences; yet, none of this discussion has much impact as one does not know how accurate the buoy data are and thus cannot judge if any of the differences are valid and/or significant. For an operational continuation of PIRATA in the future, there must be

- a thorough and careful statement of practices and procedures for QC/QA and calibration,
- justification based on field comparison with other data of the in situ accuracies,
- a discussion of the observational challenges (bioufouling of salinity, degradation of met sensors, fish swimming in the ADCP sampling field).

There is a reference in the text to a TAO website, but it does not carry sufficient information. It is the procedures and practices used in PIRATA that must be documented, and the accuracies and uncertainties are too important not to be discussed in some depth in this report. Page 26 uses the phrase “high quality buoy observations” but there is no substantiation of what this means. On page 40 there is a discussion of differences between the buoys and models of 0.4 °C in SST, 0.6 °C for air temp, 1.3 m/s for wind speed—are these significant? Which is correct? Certainly in low winds buoy air and sea temperatures can have at least this much error.

2) Following the above, what is the procedure for updating the real-time data with corrections based on post-deployment calibrations? How are users alerted to these corrections? A table of sampling rates is needed.

3) The document needs more detailed description of the sampling and cruises. How often are the cruises ("…at least once a year …", page 7)? What observations are made on the land-based meteorological stations (page 15)? A further explanation of the statement on page 51 is needed, that work is being done to get higher sampling rate data sent via satellite with the result that PIRATA data sets would be "more useful and even indispensable for more skillful predictions."

4) The utility of the telemetered data to meet some of the goals is unclear. The telemetered data is daily-averaged (top of page 15), so how does this get used to check or initialize models? The vertical spacing of the temperature sensors is coarse; is the resulting accuracy in the mixed layer depth determination good enough? What are the error bars on Figure 25 – the mixed layer salinity balance? How was the vertical sampling strategy chosen? – Argo floats give much more vertical resolution – to get a mixed layer salinity balance, would not that be a better approach?