

# Synopsis

## “Tropical Atlantic Climate Experiment” - TACE

### Preface

A focused observational and modelling effort is urgently needed in the tropical Atlantic to advance the predictability of climate variability in the surrounding region and to provide a basis for assessment and improvement of coupled models. A “Tropical Atlantic Climate Experiment” (TACE) is proposed to address these issues. TACE is envisioned as a program of enhanced observations and modelling studies in the tropical Atlantic spanning a period of approximately 6 years (2006-2011). The results of TACE are expected to contribute to the final design of a sustained observing system for the tropical Atlantic.

The main focus of TACE is on improving the predictability of the eastern tropical Atlantic and the representation in models of key dynamical processes underlying its behaviour. The eastern equatorial Atlantic is badly represented in coupled and uncoupled climate models and is a source of low prediction skill on seasonal to interannual time scales. Presently, it is also a region of very limited sustained observations. Due to limitations in prospective resources, TACE cannot adequately address the western tropical Atlantic, it cannot address the South Atlantic Convergence Zone and its observational part has an oceanographic focus. To complement the overarching goals of TACE, there will be a need for an additional project or activity in the western tropical Atlantic.

A separate “TACE White Paper” provides a thorough overview of the physical processes affecting climate variability in the tropical Atlantic. In this executive summary, the major scientific thrusts of TACE are outlined and recommendations are made for new and/or continuing observations and modelling studies relevant to TACE. These recommendations represent the culmination of planning efforts that have been carried out between 1999-2005 at several workshops, including the Tropical Atlantic Workshop in de Bilt, Netherlands (June 2004) and a TACE Implementation Workshop in Miami (February 2005). Details of implementation were discussed at these meetings and represent the current consensus on the required observational and modelling components of the program. All documents and reports related to TACE planning can be found at <http://www.clivar.org/organization/atlantic/TACE>.

### 1. Introduction

The ocean has a major influence on tropical Atlantic variability mainly through the influence of tropical Atlantic SST on variations of the Atlantic marine ITCZ complex. The most notable climate impacts involve the variability of rainfall over northeast Brazil and the coastal regions surrounding the Gulf of Guinea, and the fluctuations in rainfall and dustiness in sub-Saharan Africa (Sahel). Many studies indicate a high degree of potential predictability for climate variations in the tropical Atlantic region. However,

progress in tropical Atlantic climate prediction has been slow to come due to insufficient understanding of ocean-atmosphere processes that determine climate variability, lack of adequate data to initialize forecasts, and systematic errors in the models used for prediction.

The center of the Tropical Atlantic (TA) climate system, both in terms of climatic significance and a focal point for annual and interannual variability, is the Atlantic Marine InterTropical Convergence Zone (AMI) complex. This system includes the wind convergence zone, with its convection region and precipitation maximum, the surface low-pressure trough, and the maximum in regional sea surface temperature (SST) distribution. The climatic mean annual cycle is manifested in the coherent variation of the entire complex. The migration of AMI and the changes in its intensity are of particular importance as they are linked with the variation of rainfall over the ocean and the adjacent land regions, with direct impact on the economies of some of the world's most densely populated and poorest countries, which rely heavily on agriculture. The climate of the countries surrounding the TA creates the necessary conditions for debilitating tropical diseases such as dengue, malaria, cholera, and meningitis, which are sensitive to the variability in rainfall, temperature, and humidity. The largest global source of dust lies in subtropical North Africa, which in addition to its immediate impact on humans has considerable influence on the global radiative balance and, via the supply of nutrients, on marine biological production and biogeochemical cycles. Also within this region, tropical storms of hurricane intensity regularly inflict tremendous destruction and loss of life on the northern half of the tropical Atlantic, with impact reaching into the Gulf of Mexico and Atlantic coasts of the USA. Finally, there are indications that the TA sea surface state has an impact on North Atlantic climate through atmospheric teleconnections, influencing storminess in that region.

Understanding TA climate variability and predictability, with the goal of improving its prediction and identifying and quantifying its relationship to various societal impacts, are important research goals recognized by CLIVAR. Concerted international effort is needed to improve the understanding of the regions' climate variability and the mechanisms that underlie its observed behavior. With this in mind, a "Tropical Atlantic Climate Experiment" (TACE) is proposed, whose overarching goal is:

**To advance understanding of coupled ocean-atmosphere processes and improve climate prediction for the Tropical Atlantic region**

Specific goals are:

- a) To advance understanding of the key processes that control SST, interactions with the AMI, and related climate predictability in the tropical Atlantic
- b) To contribute to the design of an enhanced sustained observing system for the tropical Atlantic region

The goals of TACE and the recommendations for further research and observations proposed herein are closely in accord with the findings of the CLIVAR Workshop on

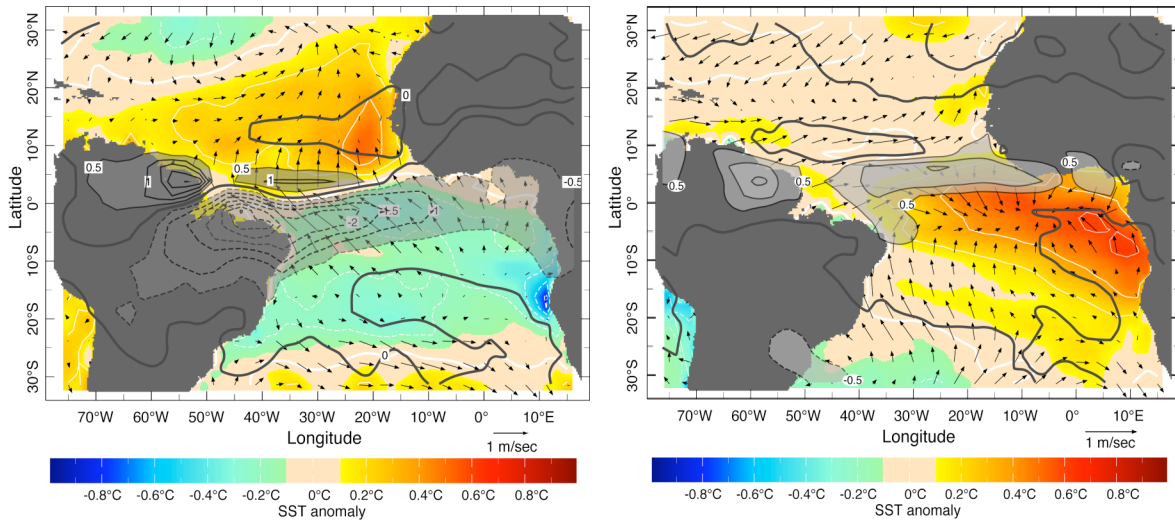
Atlantic Climate Predictability  
([http://www.clivar.org/organization/atlantic/Atl\\_Wshop\\_Proceeds.pdf](http://www.clivar.org/organization/atlantic/Atl_Wshop_Proceeds.pdf)), which provides an excellent summary of the state of prediction in the tropical Atlantic. One of the overarching challenges identified in that workshop requiring immediate action is “*to realize fully the potential of seasonal predictions for the tropical Atlantic region*”.

Many activities in TACE will be in the eastern tropical Atlantic because of the active role of ocean dynamics, in particular advection and upwelling, in controlling SST variations in this region. Furthermore, this is the region where the skill of seasonal forecasts is very low and models have the largest biases. Finally, the ITCZ position in the eastern tropical Atlantic, its strength and the associated precipitation over Western Africa is related to the eastern tropical Atlantic SST. Adequate observations in the western tropical Atlantic are also important since prediction of SST variability in the eastern tropics requires knowledge of the input from equatorial dynamics from the west, and because the supply of thermocline waters to the equator also comes from the west. However, the proposed TACE plan of action will not be inclusive on addressing climate variability and predictability issues of the whole tropical Atlantic. Unfortunately, due to limitations in prospective resources, it cannot adequately address the western tropical Atlantic, a region important for hurricane growth and a region that has teleconnections to the midlatitudes; and it cannot address the South Atlantic Convergence Zone, a key region of interest for climate forecasts over South America. To complement the overarching goals of TACE, there will be a need for an additional project or activity in the western tropical Atlantic. Such a program could sensibly be coordinated with ongoing CLIVAR-Variability of the American Monsoon Systems (VAMOS) and PIRATA activities, and TACE strongly endorses the development of such an activity. TACE needs to be carefully planned in coordination with the existing AMMA program and the French EGEE program which will involve process-related observations in the region during the same time frame as TACE.

## **2. Key aspects of climate variability relevant to TACE**

The identified modes of climate variability in the TA region include the meridional gradient mode, Atlantic Niño, and Benguela Niño. The meridional gradient mode (Fig. 1a) is most pronounced in spring when it is the primary principal component of the SST variability. When matching wet and dry years in the Northeast of Brazil with patterns of SST it is found that drought is associated with an anomalous northward shift of the AMI in conjunction with an anomalous northward gradient of SST. The SST pattern is most pronounced in the northern hemisphere and is accompanied by meridional wind anomalies along the equator heading down the pressure gradient and thus into the warmer hemisphere. Away from the equator anomalous surface winds increase in the cool hemisphere and a decrease in the warm hemisphere. A dipole pattern of diabatic heating is in its positive phase, reflecting enhanced convection, in the warm hemisphere, also associated with anomalous deepening of the mixed layer. Coupled feedbacks involving local ocean mixed layer processes have been suggested to explain the meridional gradient but the role of ocean upwelling and advection in the eastern upwelling domes is not clear at present.

Superimposed on the primarily annual cycle of equatorial SST are anomalies during the boreal summer months that frequently exceed  $1^{\circ}\text{C}$  during the peak month. Warm anomalies are generally maximum in the zone of the boreal summer cold tongue, while cool anomalies tend to have broader temporal and geographic variability. These events, characterized by anomalies of SST and of meridional gradient of pressure and dynamic height in the Gulf of Guinea are referred to as Atlantic Niño (Fig. 1b). The SST anomalies are also correlated with anomalies of the AMI latitudinal position. The observed SST anomalies and heat content anomalies within the mixed layer may also be linked to the sea surface salinity (SSS). During some years, but not all, another region of



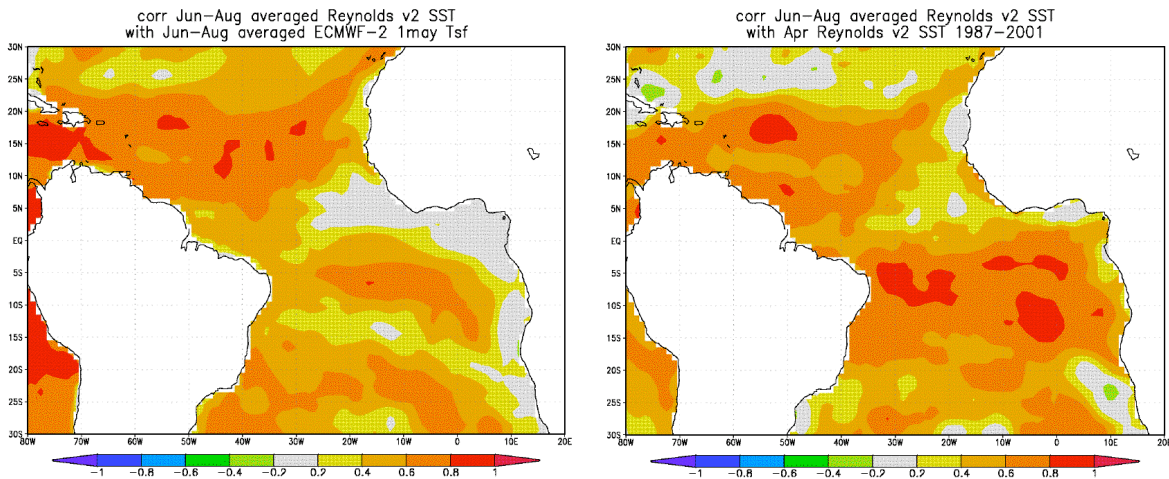
**Figure 1. (a) The “meridional gradient” mode (left panel). First EOF (33%) of the March-April rainfall from GPCP 1979-2001 (contours in mm/day). March-April SST anomaly (colors, in  $^{\circ}\text{C}$  and white contours, every  $0.2^{\circ}$ ) and surface wind anomaly (vector, in m/sec) are determined by regression on the time series of the rainfall EOF. (b) The “Atlantic Niño” mode (right panel). First EOF (23%) of the June-August rainfall from GPCP 1979-2001 (contours in mm/day). June-August SST anomaly (colors, in  $^{\circ}\text{C}$  and white contours, every  $0.2^{\circ}$ ) and surface wind anomaly (vector, in m/sec) are determined by regression on the time series of the rainfall EOF.**

warm anomalies appear along the southwestern coast of Africa as well and is known as the Benguela Niño. Benguela Niños can also occur independently of Atlantic Niños and the degree of linkage between these two phenomena remains a topic of active study. In the equatorial region the skill of dynamical forecast models is very limited, which is due to systematic model errors as well as the lack of data to initialize the models.

All these TAV mechanisms are highly seasonal: there is additional ENSO and NAO forcing in boreal winter; the meridional SST gradient-AMI interaction is strongest in March-May when the equatorial Atlantic is uniformly warm; and the Atlantic Niño mode is most pronounced in the boreal summer coinciding with the season of the cold tongue and the shallow thermocline in the east. Intraseasonal variability associated with tropical instability waves might influence these modes as well, but this interaction is relatively unexplored. On interannual time scales, teleconnections with the extratropics and delayed

oceanic response in the tropics through changes in the Subtropical Cells can be important in shaping TAV. On decadal and longer time scales, the basin-wide Atlantic meridional overturning will likely impact the tropical variability as well, while also anthropogenic influences can have an impact.

Current understanding of TA climate has been hampered by the lack of adequate data and large biases in coupled ocean/atmosphere models. This has led to lack of forecast skill on seasonal and longer time scales. Presently, the forecast skill for eastern equatorial SST in most coupled models is essentially zero even at lead times as short as two months (Fig. 2), and is typically worse than persistence. Most coupled models show large deviations from observed SST in the eastern tropical Atlantic, displacing the cold tongue far to the west and in fact having a warm eastern equatorial regime. While other factors, such as cloud representation, are presumed to contribute to the model deficiencies, more realistic model representation of the important ocean mechanisms in affecting SST is certainly a major requirement for achieving progress.



**Figure 2. Left panel: Prediction skill for SST over the tropical Atlantic from 2-month lead ECMWF forecasts. The eastern tropical Atlantic and Gulf of Guinea show negligible prediction skill, which is typical of current operational forecast capabilities. Right panel: Skill associated with simple persistence.**

The heat budget in the eastern equatorial Atlantic is to a large degree determined by non-local exchanges, i.e. by advection via the large-scale circulation, by equatorial and coastal upwelling and associated mixing processes at the underside of the shallow cold tongue, and by equatorial waves. However, the role of advection by surface and subsurface currents is poorly understood and is a key objective to be addressed in TACE. Also, the role of Subtropical Cells in modulating the mean state of the equatorial thermocline and its variability on longer time scales is of relevance to TACE. While local thermodynamic processes seem to be primarily responsible for setting up the meridional gradient mode, the role of off-equatorial eastward currents and the upwelling along the eastern boundary and in the Guinea and Angola domes is poorly understood.

Predictability studies show that SST anomalies in the eastern equatorial Atlantic are significantly correlated at up to a 3-month lag with subsurface temperature anomalies in the same region, indicating that better SST predictions can be achieved if the dynamics connecting the surface and subsurface layers can be better understood. In turn, an ability to predict eastern equatorial SST's even out to a lead time of 3 months would substantially improve seasonal climate and rainfall forecasts in the region.

*In summary, concerning ocean processes relevant to TA predictability, the role of advection, upwelling, and vertical mixing in the eastern central equatorial and off-equatorial eastern Atlantic, and the role of waveguide influences from the west, are of prime importance to TACE as these processes affect the main patterns of SST variability.*

### **3. TACE Implementation**

To advance predictability of the Tropical Atlantic region and increase understanding of the ocean mechanisms involved, the following implementation objectives are proposed for TACE:

#### **A. Enhance existing observing system to provide the data needed for research and operations**

Observations are needed both for forecasts at seasonal time scales and for understanding the mean TA climate and longer time scale variability. While this distinction is not exclusive, it provides guidance for the parts of the observing system that are a higher priority for real time data delivery.

For seasonal predictions in the TA the most important observations are:

- (i) *in situ* surface and subsurface current, temperature and salinity measurements along the Atlantic equator,
- (ii) surface and subsurface temperature and salinity measurements in the eastern off-equatorial portions of the basin between 20°S to 20°N, including the coastal upwelling regions off NW Africa and SW Africa
- (iii) moored time series observations in the central/eastern equatorial band (~ 5°S to 5°N) to monitor the equatorial wave system and the supply of water masses to the eastern equatorial thermocline and the Angola and Guinea domes,
- (iv) In situ surface measurements of temperature, air temperature, air humidity, radiative fluxes and winds north and south of the equator through the regions of dominant SST variability. Additionally, satellite measurements of SST (including microwave SST), sea surface height, wind stress, cloudiness, precipitation, and ocean colour are needed throughout the TA region.
- (v) atmospheric soundings to study boundary layer and air-sea interaction processes occurring under the varying SST regimes.

For interannual variability and longer time scales necessary observations are (in addition to those mentioned above):

- (i) upper ocean temperature and salinity throughout the tropical Atlantic,

- (ii) surface drifters to monitor the divergence at the equator from upwelling regions to subduction regions,
- (iii) tracer observations to monitor changes in ventilation rates to the equatorial thermocline.

The TACE observational strategy is summarized in Figure 3. The backbone of the current long-term observation system in the tropical Atlantic is the PIRATA mooring array and all efforts should be made to extend this array throughout the TACE observational period. Regular servicing of these moorings needs to be ensured to minimize significant gaps in the data. In addition the ARGO program needs to be enhanced in the central and eastern TA region to increase the coverage of subsurface temperature and salinity measurements, in order to investigate relationships between subsurface heat storage patterns and SST anomalies. Surface drifter coverage needs to be similarly enhanced in the eastern TA to produce better estimates of SST variability and changes in surface circulation and heat advection patterns. Since surface drifters tend to diverge from the upwelling zones in the eastern TA, reliance on profiling floats for SST data is more pressing in these regions. For both profiling floats and surface drifters a meridional resolution of the order of the equatorial deformation radius (~130 km) is desirable rather than the nominal 3°x3° ARGO resolution. Therefore, an approximate doubling of the nominal broad-scale float/drifter density is recommended in this area (Fig.3).

Surface moorings are needed in the center of the northern and southern maxima of the meridional gradient mode and in the eastern boundary regions associated with the Atlantic and Benguela “Niño” modes. Two critical extensions of the PIRATA array are therefore already funded and are planned to be deployed in 2006: (1) extending north along 23°W between the equator and 20° and (2) extending southeastward from the equator along the eastern boundary to ~ 10°S (these are referred to as the PIRATA “Northeast” and “Southeast” extensions, respectively). The Southeast extension is initially just a single mooring as part of a pilot study. A further PIRATA extension to 10° S along the 23° W mooring line is recommended to fill a data void in that region. Additional moorings are needed to measure advection in the equatorial waveguide. Recommended locations are at 35° W, 23° W, 10° W, and 0° E, with extensions north and south of the equator at one or more of these locations to monitor the transport and variability of the Equatorial Undercurrent, the South Equatorial Current, and intraseasonal variability related to Tropical Instability Waves.

Continuation of VOS measurements of upper ocean temperature across the tropical Atlantic to determine heat storage variability is necessary as well as satellite missions to measure the relevant variables. Detailed hydrographic, direct velocity, atmospheric profiling observations, and (less frequently) tracer measurements, should be made along 23°W during PIRATA mooring cruises. Repeated glider sections through key regions of variability may also be feasible using coastal or island bases or by timing their missions with PIRATA servicing cruises. The possibility of including dissolved oxygen sensors on the profiling floats in the eastern TA should be considered to enhance understanding of ventilation and upwelling processes and their variability.

The TACE observations need to be carefully planned in coordination with the AMMA program and the French EGEE program which will involve process-related observations in the region during the same time frame as TACE.

## **B. Improve coupled predictive systems, ocean synthesis, and transfer from science to operations**

The objectives of TACE are directed toward understanding the interaction between the AMI and the upwelling zones in the tropical Atlantic Ocean, to exploit new data to improve forecasts and to reduce systematic model error. To meet these objectives the modeling strategy of TACE aims to:

- 1) Determine oceanic processes important in regulating SST in the tropical Atlantic and associated atmospheric responses
- 2) Identify model biases and their causes using existing and newly available observations and suggest model improvements that lead to improved SST forecasts on seasonal to interannual time scales in the tropical Atlantic
- 3) Provide parameterizations and model improvements to global and regional prediction centers
- 4) Investigate response of tropical Atlantic region to global warming, including teleconnection patterns

SST predictions and climate change projections in the tropical Atlantic region are currently limited by lack of understanding, lack of adequate data, and associated model error in coupled models (e.g. the SST bias in the eastern tropical Atlantic). Different physical processes are important for the SST in the eastern tropical Atlantic. The relevant oceanic processes include upwelling and mixed layer entrainment, vertical mixing in the interior, heat exchange by tropical instability waves, surface and subsurface advection of heat and thermocline displacements induced by tropical waves. In the atmosphere, the shallow and deep convection in the AMI, the stratus clouds and radiation feedbacks, the marine boundary layer processes and possibly dust are relevant. The key parameterizations that affect these processes in models are ocean mixed layer physics, diapycnal mixing, atmospheric convection and stratus cloud parameterizations.

To advance understanding processes that regulate SST, TACE will focus on validation and understanding of:

- a) The mixed layer heat budget in upwelling regions. The simulated mixed layer heat budget will be validated using the meteorological observations on the PIRATA moorings (along 23°W, along the equator and along 10°W) and the surface flux moorings to determine the surface heat fluxes; the surface drifter data and equatorial moorings will be used to determine advection and divergence in the same regions, and oxygen sensors will be used on the 23° W glider section and profiling floats to determine ventilation and upwelling (see A and Figure 3).
- b) The subsurface heat content. Variability in the subsurface heat content will be monitored with the PIRATA moorings and enhanced profiling float coverage in the east. Pathways of subsurface water masses to upwelling locations and properties of the upwelled water will be determined using temperature and



salinity data from ARGO floats, the subsurface PIRATA and equatorial mooring data, and temperature and salinity from gliders. Furthermore, pathways can be derived from tracer sections (see A and Figure 3). This data will be used to validate the ocean models.

TACE has primarily an oceanographic focus, but the representation of stratus and parameterization of atmospheric convection are outstanding problems that will be addressed in cooperation with the AMMA project. The atmospheric sounding data proposed along 23°W will be used for validation and improvement of atmosphere models. Within TACE a systematic investigation on the effect of resolution of ocean models and on the effect of coupling will be performed. This systematic model intercomparison will identify which processes and parameterizations are important for the SST and will attempt to bridge the gap between ocean models used in ocean-only studies (typically eddy resolving) and ocean models used in coupled models. The research requires stand-alone ocean and atmosphere model experiments in a standardized configuration as well as fully coupled experiments. This part of TACE addresses the systematic errors in the coupled models and will lead to improved models for seasonal to interannual prediction as well as for anthropogenic climate change studies.

To improve the seasonal to interannual forecasts, the proposed observations should be used to constrain the model and improve initializations. Predictability studies will be performed to determine what elements of the observing system are crucial for improved forecasts and what key elements may be missing. In particular, TACE will seek to define an optimal observation network in the eastern tropical Atlantic. These activities are expected to improve simulations of eastern tropical Atlantic circulation and SST in the coming years. At the same time, the observational network in the western tropical Atlantic will need to be examined for its adequacy in initializing seasonal forecasts and providing information on equatorial waveguide processes influencing central and eastern tropical Atlantic SST variability.

A TACE data archive will be set up. This will be a web-based interface with links to available observations of the tropical Atlantic region and links to model data. The observations archive will be coordinated and maintained by IFM-GEOMAR, the modelling archive will be coordinated and maintained by KNMI.

Collaboration with global prediction centers and regional prediction centers in Africa and South America (e.g. CPTEC, ACMAD, South African Weather Service) will be an essential ingredient of TACE. New parameterizations and models developed in research models will be provided to the centers. The inclusion of the data observed in TACE in data assimilation schemes for constraining and initializing predictive models is a task of the prediction centers.

Apart from the use of TACE observations to validate and constrain the models, parameterizations developed in relevant process studies (e.g. PUMP and EPIC) will be utilized and tested in the tropical Atlantic, as especially in the cold tongue, similar problems in models arise in the Pacific. Furthermore, close collaboration will be maintained with the AMMA program that includes land processes.

TACE synthesis will be facilitated by targeted workshops where observationalists and modellers meet and discuss their recent work and progress. Initial plans for workshops include:

- Western tropical Atlantic circulation: synthesis of observations and ocean model results
- Pathways into the eastern tropical Atlantic: mean state and changes in ventilation of the tropical Atlantic thermocline.
- Eastern tropical Atlantic mixed layer heat budget: observations and modelling.

A close liaison will be maintained with CLIVAR ocean modelling and coupled modelling working groups on the model improvements to improve simulations of tropical Atlantic climate and, in particular, with the WGSIP (Working Group on Seasonal to Interannual Prediction) and GSOP (Global Synthesis and Observations Panel). Note that TACE focuses on oceanic issues while the lack of predictability in the region is also associated with local and remote atmospheric processes, including problems such as stratus parameterization. TACE will contribute to improving the oceanic side of the predictability problem, but will keep abreast of atmospheric issues that are addressed at other projects within WCRP.

#### **4. Relations with Other Programs**

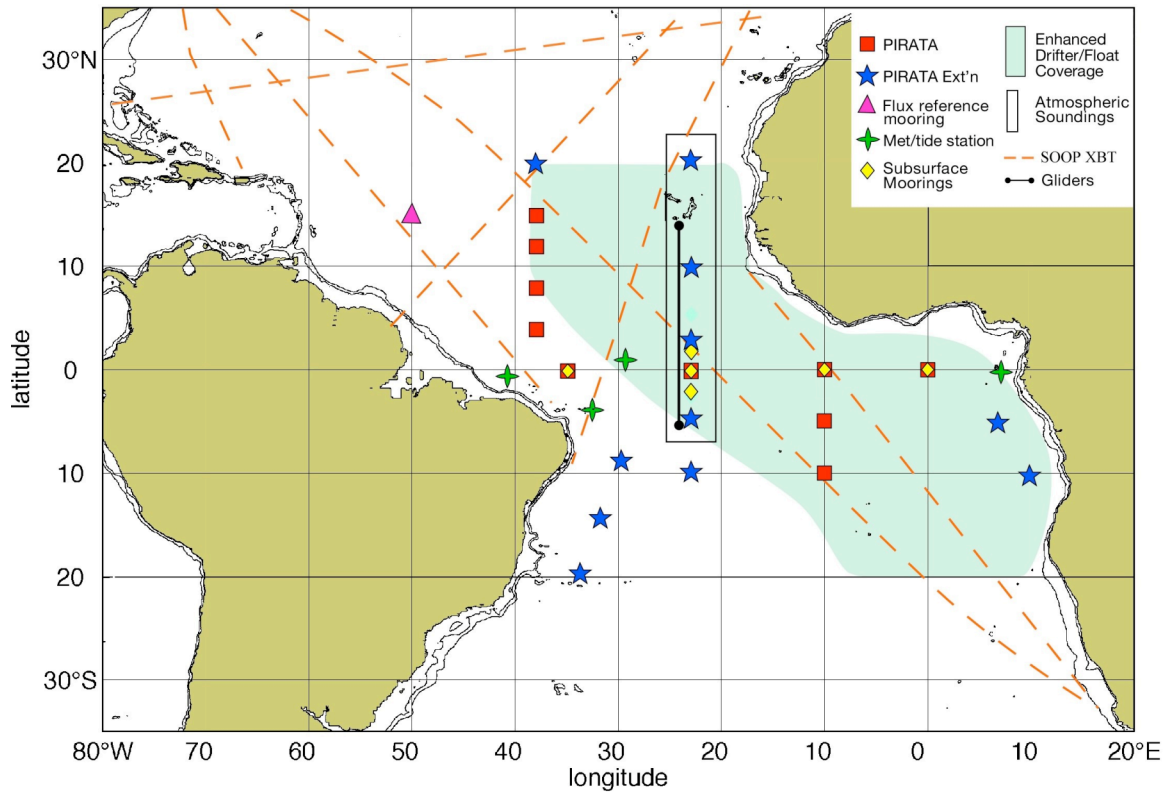
The AMMA, PIRATA, ARGO, EGEE, and TACE programs serve different goals, but operate in the same region of interest. In TACE an enhanced observing system and modelling framework will be set up in the tropical Atlantic Ocean with the goal of advancing understanding and improving predictability of SST. The project will help to define sustained observations needed for predictions and has its core period from 2006-2011. PIRATA is the existing backbone observational network that consists of a mooring array while ARGO is the global profiling float network. These are sustained observations that will operate throughout the CLIVAR period. PIRATA will be reviewed by CLIVAR and OOPC in 2006 and the project will likely continue afterward, although vandalism in the east remains a problem. PIRATA is part of the OCEANsites program and 3 sites will be upgraded to full flux measurement capability (15N, 38W; 0, 23W and 10S,10W) AMMA focuses on the dynamics of the West African Monsoon. It has a large land component, but it has also need for ocean observations. The core period of AMMA is from 2005-2007. EGEE is the French contribution to the ocean component of AMMA and is meant as a process study in the Gulf of Guinea with main field operations from 2005-2007. These projects have different goals and operate over different time frames, but complement each other. Synergistic activities will be developed through workshops and coordination of observations.

In addition to the afore mentioned WCRP and GEOSS activities one focus under the joint IGBP-WCRP SOLAS is regionally adjacent to the TACE study area. An international consortium from largely Germany and the UK are supported to establish an ocean and atmospheric reference site near Mindelo in the Cape Verde Island region. Logistical and scientific synergies are expected.

#### **5. Outlook**

TACE activities are reaching an advanced stage of planning. A first implementation meeting took place on February 3, 2005 in Miami attended by over 50 observationalists, modellers, and representatives from operational groups. Several representatives from Clivar's WGOMD, WGSIP, Variability of the African Climate System Panel (VACS) and Atlantic Implementation Panel (AIP) were present. Planned activities on tropical Atlantic observations and modelling were presented and discussed. As an outcome of the meeting, two TACE working groups will be formed: (i) a TACE/AMMA Implementation panel for ocean observations (prospective co-chairs. P. Brandt and W.E. Johns) and (ii) a TACE modelling and synthesis panel (prospective co-chairs. C. Böning and W. Hazeleger). A tropical Atlantic science meeting has been held in October 2005 in Venice. One of the foci of the latter meeting were TACE activities.

Funding for TACE activities is expected to come from a variety of sources including national funding agencies in the U.S., Europe, South America, and Africa. As became evident at the Miami Workshop, plans or proposals are in place for many of the recommended observational enhancements. For example, the PIRATA Southwest extension has been deployed already in summer of 2005 (Brazil), the Northeast extension is proposed to begin in summer of 2006 (US-NOAA), the 23° W subsurface equatorial moored array will be deployed in summer 2006 (Germany, IFM-GEOMAR), and (at least) one mooring of the PIRATA Southeast extension will be deployed in summer 2006 (S. Africa). Plans for the eastern equatorial subsurface moored array are under development for a proposed deployment in summer 2007 (US-NSF; France-IRD). Other proposals for the remaining enhanced observations and TACE-related modelling activities are anticipated to be developed in 2006 for implementation in the 2006-2011 TACE timeframe.



**Figure 3. TACE Observational Strategy.** The proposed observing system components include (see legend): Continuation of PIRATA moorings; PIRATA extensions along 23 ° W, 10-20° S off Brazil, and 5-10° E off West Africa; equatorial subsurface moorings at 35° W, 23 °W, 10° W, and 0° E; island meteorological and tide gauge stations; enhanced float/drifter coverage in the eastern tropical Atlantic; repeated atmospheric soundings along 23 ° W; ship-of-opportunity XBT lines, and selected glider transects.