

**PIRATA-9  
and  
CLIVAR/OOPC/IAI WORKSHOP  
ON THE SOUTH ATLANTIC CLIMATE OBSERVING SYSTEM  
(SACOS)**

FEBRUARY 3 – 8, 2003 - Angra dos Reis - Brazil



# Outline

- The PIRATA 9
- The SACOS Workshop
- The PIRATA Western Extension



## PIRATA-9 Final discussions & recommendations

- 1) Cruises: – 2002 / 2003 Brazil and France maintain commitment.
- 2) Data Return:
  - Statistics still too low data return;
  - Vandalism again and again; Technical failures was a problem in 2001-2003
  - *to continue with Java (0N-10W) and Soul (0N-0E) sites up to 2005 (end of the Consolidation phase);*

***Task: investigate alternative technologies that could decrease vandalism. PMEL is already working in the issue and will continue doing so.***

- 3) Training: Need for speed the training of personal for maintenance of mooring.

***Task: CPTEC should lead the actions to select and get appropriate funding to send Brazilian technician/engineers to PMEL for training.***

## **PIRATA-9 Final discussions & recommendations (continued)**

4) Recommendation to comply with the following planning:

- Tide gauge at SPSP Rock
- Tide gauge at Atol das Rocas
- Meteorological Buoy at 0N-44W

***Task: this issue has not yet been solved; a particular effort must be done by PIRATA-BR Committee***

5) Suggestion for the implementation of a PIRATA Data Analysis Workshop in 2004 with support of sponsoring organizations.

***Task: INPE/CPTEC and IOUSP should organize the event in Brazil***

6 – A more close relationship with Operational Agencies, users of PIRATA data; an effort should be done to have their participation in next meetings.

***Task: this is to be done by the Chairman of the SCC***

7 – PIRATA could benefit from the EU “Framework Program VI”, where substantial funds are likely to be assigned operational oceanography initiatives to developing nations that are partners to European countries.

***Task: J. Trotte will be the contact to verify the real possibility of this opportunity in PIRATA***

## **PIRATA-9 Final discussions & recommendations (continued)**

8) Action should be done to stimulate the publication of papers using PIRATA data set.

9) Extensions:

- NEE in stand-by
- SEE and SWE were presented and drafts of White Documents were handed during the plenary session.

**(A guideline document was prepared by the SSC: all proposals for extensions to the original back-bone array should be evaluated according to these guide lines.)**

10) The new compositions of the SSC was presented

- **Paulo Nobre** replaces **Ilana Wainer**
- **Edmo Campos** replaces **Antonio D. Moura**

11) PIRATA-10 meeting scheduled tentatively to be hosted by University of Maryland in 2004, or in Cape Town (South Africa); decision will be taken latter .

## PIRATA PRB recommendations

- i) **Long-term ship requirements: Established a special Working Group to “define the needs for ocean observations in the Tropical and South Atlantic, options for meeting those needs, and associated ship requirements.”**
- Evaluate the NOR-50 prospectus and other possible solutions.
  - Consider PIRATA and other international programs for operational oceanography
  - SACOS Workshop will provide significant foundation for defining requirements.
  - The working group is a committee of approximately one-year term for the purpose of delivering a special report to the PIRATA institutions.
  - Recommendations for PIRATA institutions, but other interested institutions/countries will be invited to review and comment.

## **ii) Near-term ship requirements.**

- DHN has scheduled ship support for the next two years in the west with ANTARES as primary and AMORIM DO VALLE as contingency.
- IRD has obtained French Navy support for the east.
- New Naval oceanographic vessel – BEAUTEMPS-BEAUPRE – maiden voyage in 2003

## **iii) Accelerated field technician training for Brazil to maintain in-country expertise similar to France and USA.**

- Two engineer/technicians -- probably INPE plus University of Sao Paulo, will be invited by PMEL for lab training and experience aboard TAO ship.

## **iv) The PRB encourages the SSC to consider alternate technologies to replace ATLAS in high vandalism locations.**

## **RECENT RESULTS:**

- **Cruise to service Brazilian buoys carried in July/Aug 2003**
- **Brazil has created a National Scientific Committee and a Logistic Subcommittee, with representants from the following institutions:**

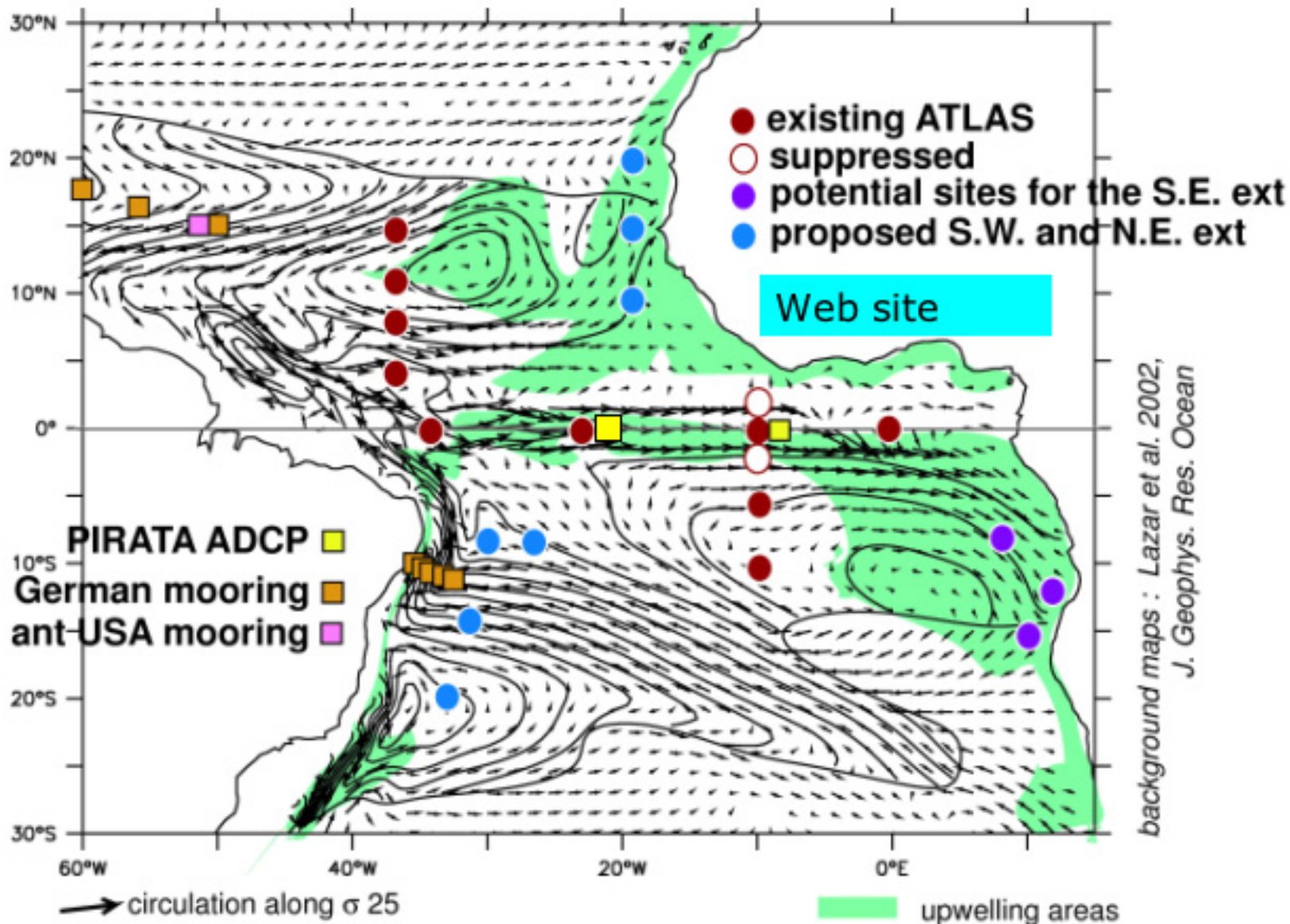
Brazilian Navy (DHN)

INPE

University of S. Paulo

FUNCEME

# Status of the PIRATA array

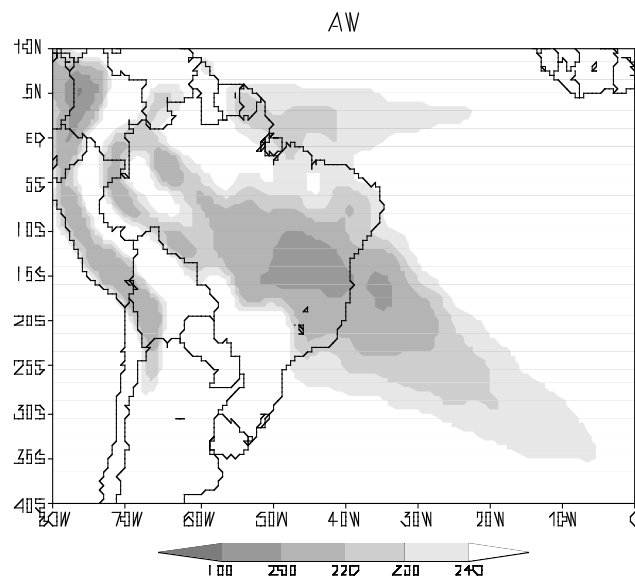
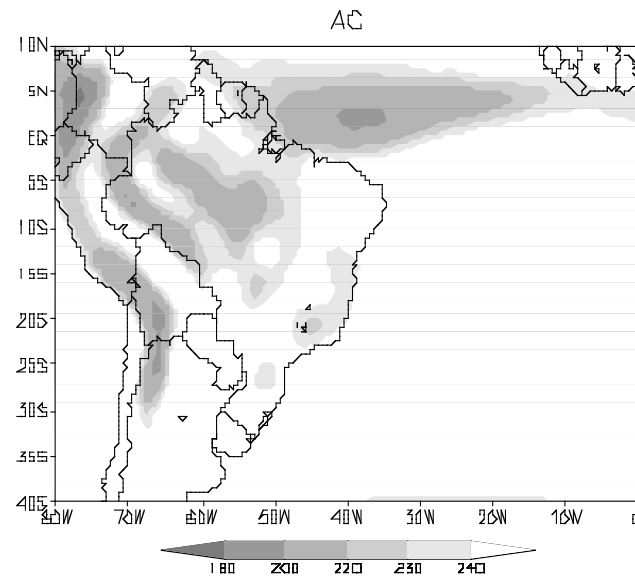
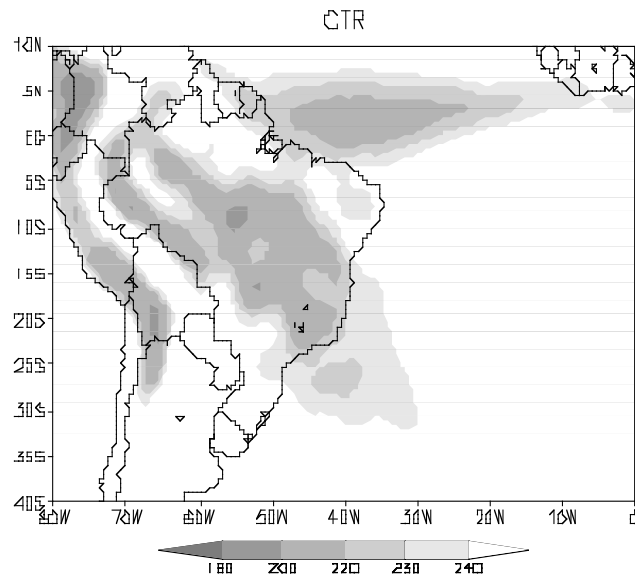


# **The PIRATA Western Extension**

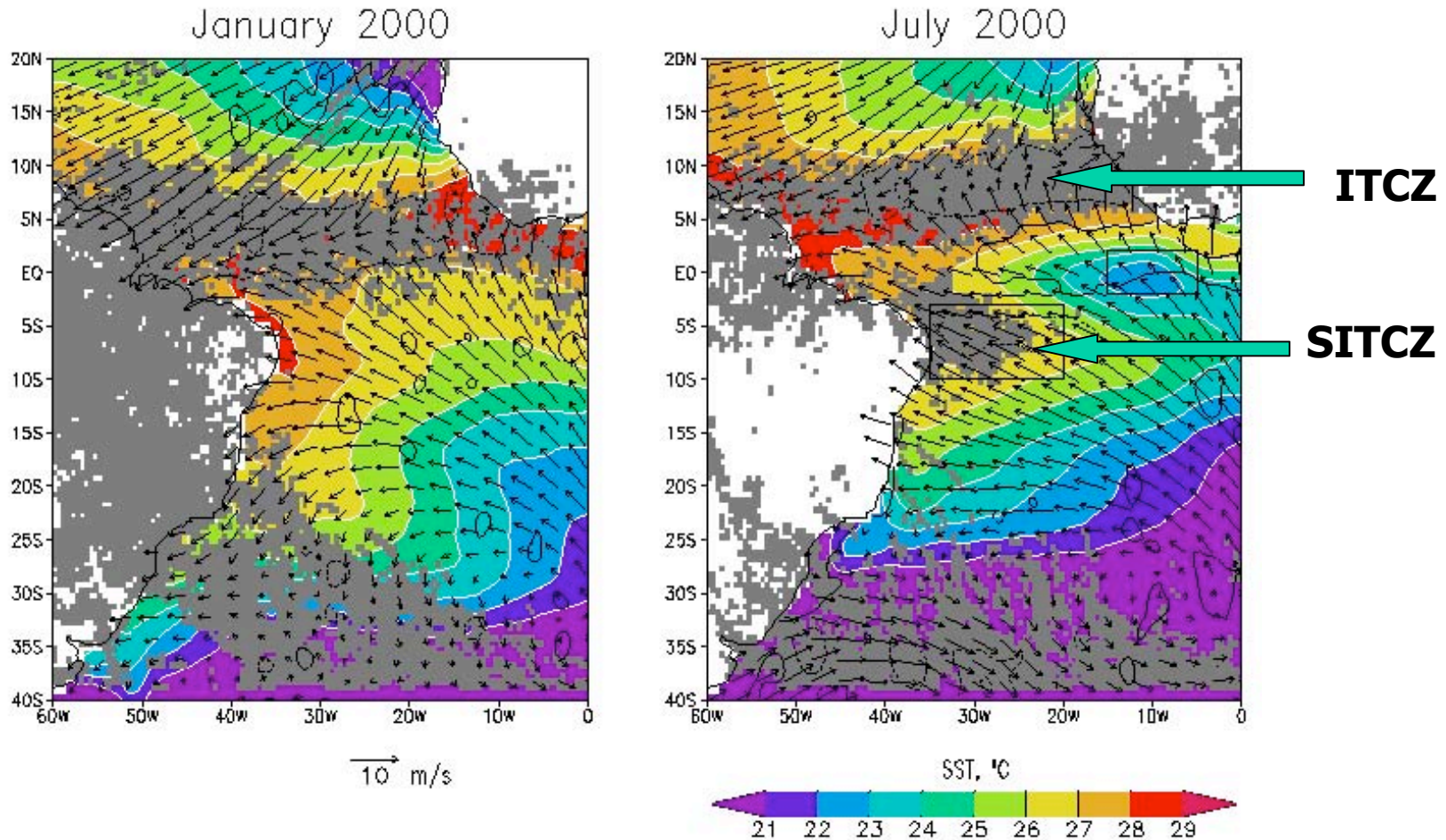
- **In addition to the basin wide modes of SST variability which are the guiding rationale behind the PIRATA backbone, there are regional aspects of SST variability that could further the PIRATA array both in scope and in understanding its guiding scientific questions.**
- **The PIRATA science meeting, in Miami, in May 1999, pointed out the necessity of expanding the original array for better understand and predict the complex ocean-atmosphere interactions in the southwestern Tropical Atlantic.**
- **A particular focus would be the interactions associated with the formation and development of the South Atlantic Convergence Zone (SACZ) over the SW Atlantic.**
- **More recently, both observational and theoretical evidence has suggested that other phenomena also affect climate variations over the SW tropical Atlantic, such as the Southern Inter Tropical Convergence Zone (SITCZ) discussed in a recent paper by Grodsky and Carton (2002).**

# The PIRATA Western Extension

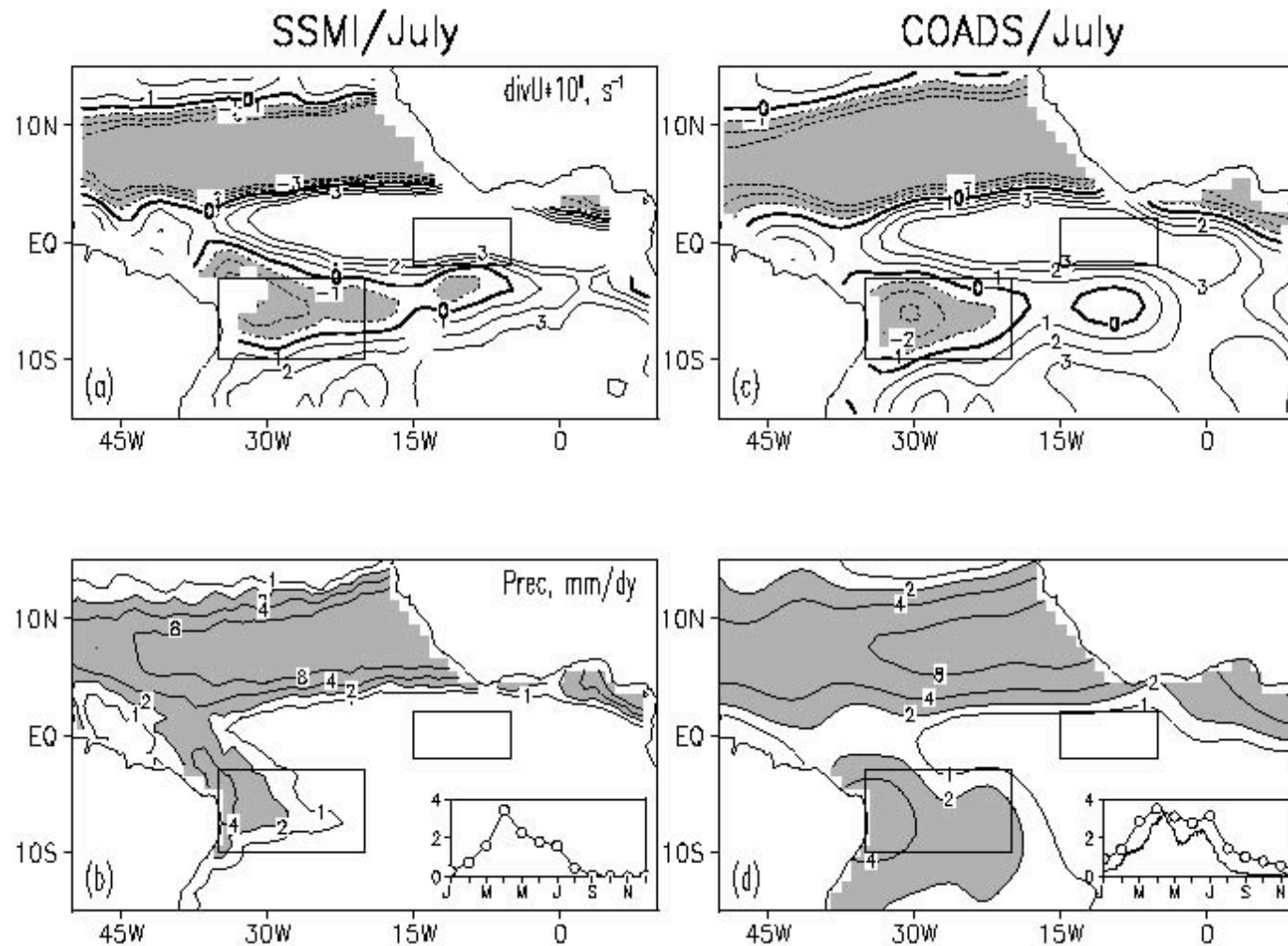
- **At the same time, there are both observational and numerical modeling evidence suggesting that atmospheric variability over the SW tropical Atlantic also influences the SST variability locally, thus forming a coupled system with multiple feedback processes.**
- **While the SACZ represents a notable phenomenon impacting SE Brazil climate during Austral Summer (DJF), the SITCZ is linked with rainfall variations over the eastern coast of Nordeste during Austral winter (JJA).**
- **In both cases, however, tropical Atlantic SSTs is likely to play an important role in the processes modulating rainfall over South America. Thus, a better understanding of the processes modulating SST variability over the SW tropical Atlantic may lead to increased predictive potential of SST regionally, with its downstream cascade of benefits toward regional climate prediction and its social impacts.**



Outgoing Longwave Radiation (W/m<sup>2</sup>) for (a) Control, (b) cold and (c) warm SSTA boundary condition used over the SW tropical Atlantic AGCM experiments (from Chaves and Nobre, 2003)

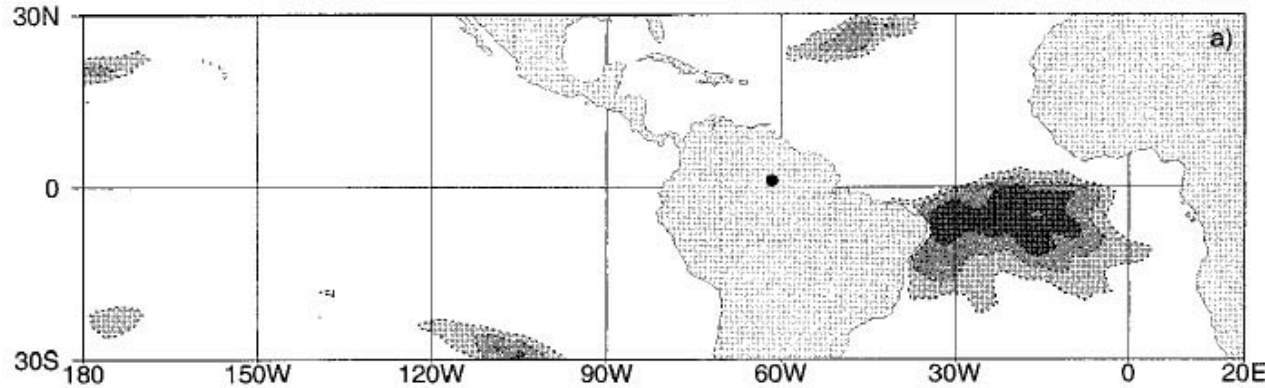


**January and July 2000 SST (color shades), surface wind (arrows) and cloudiness (shaded in grey), depicting the formation of the SITCZ (right panel). Source: Grodsky and Carton, 2002)**

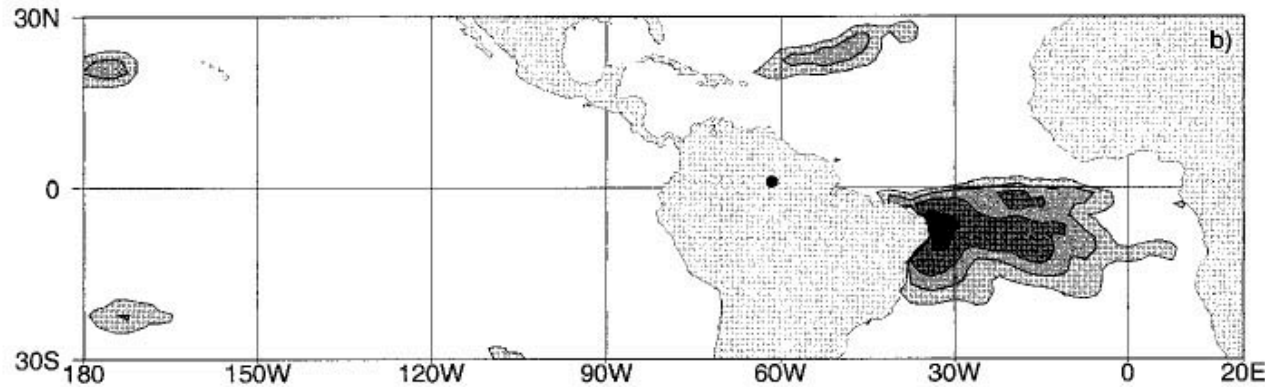


**July near surface wind divergence and precipitation from SSMI and COADS. The boxes show the SITCZ and the cold tongue index regions. The inlays present climatological rainfall averaged over the SITCZ area. The COADS panel shows also the TRMM rainfall. Source: Grodsky and Carton, 2002)**

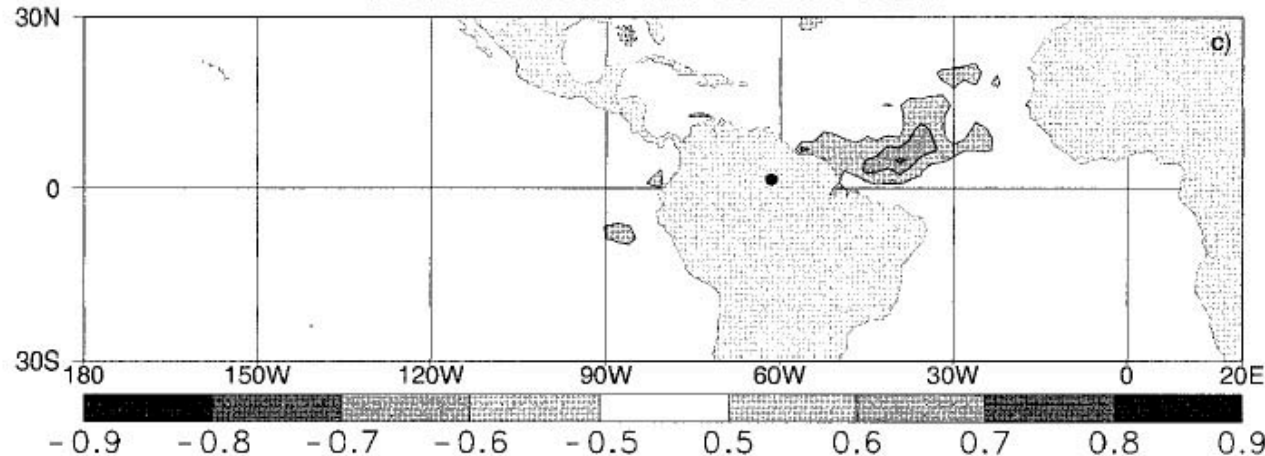
Northern Mean vs FEB-APR SST



Northern Start vs FEB-APR SST



Northern Rate vs FEB-APR SST

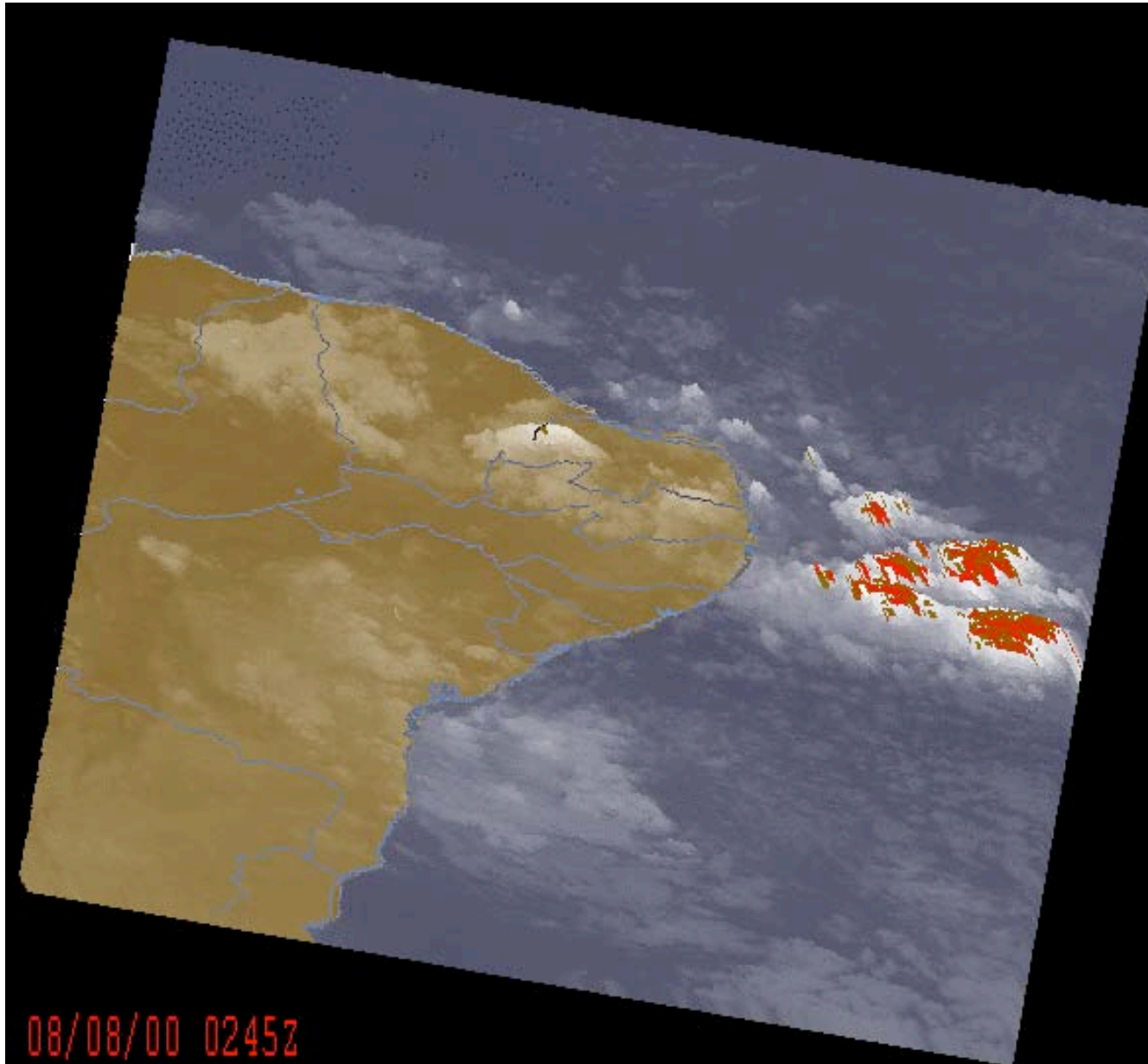


Correlation between AMJ SST and rainfall in northern Amazon (average of 12 stations from 18S to 38N, 638 to 608W; center indicated by dot);

**(a)** mean rainfall;

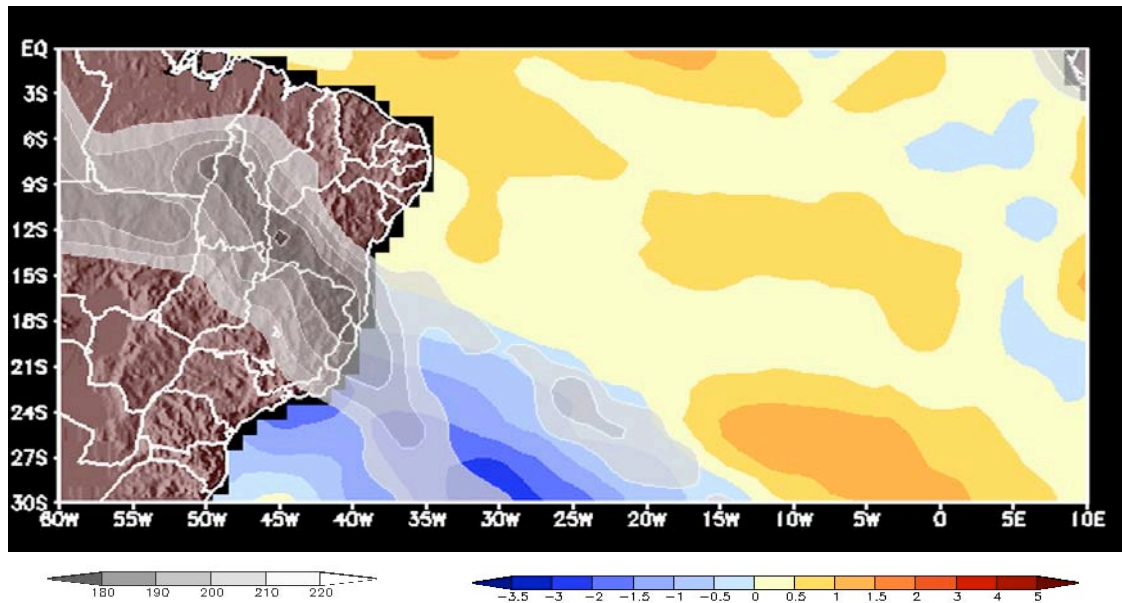
**(b)** northern rainy season starting date; and

**(c)** northern rain rate calculated from start through 30 Apr. Dotted contours indicate negative correlations. (Source: Liebmann and Marengo, 2001).

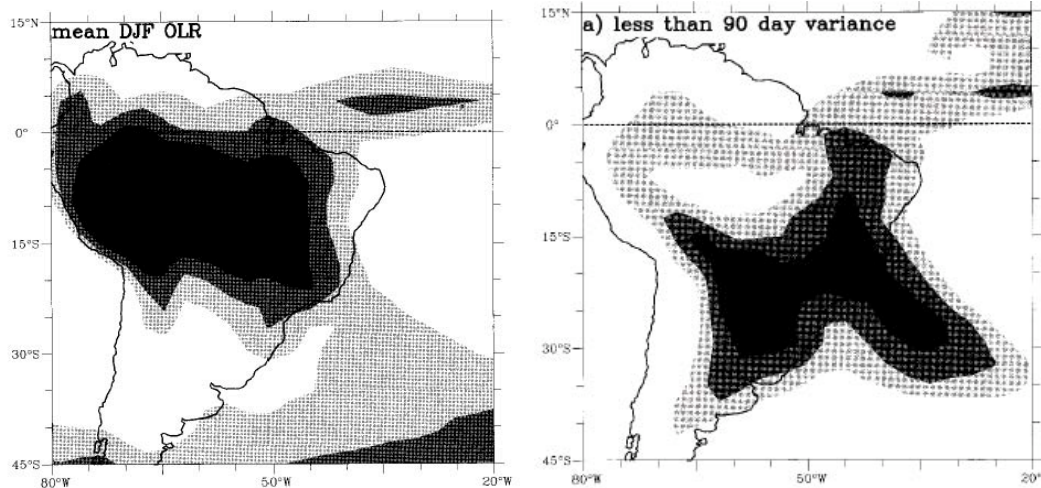


**Infrared GOES satellite image displaying a case of an easterly wave reaching the eastern coast of Nordeste.**

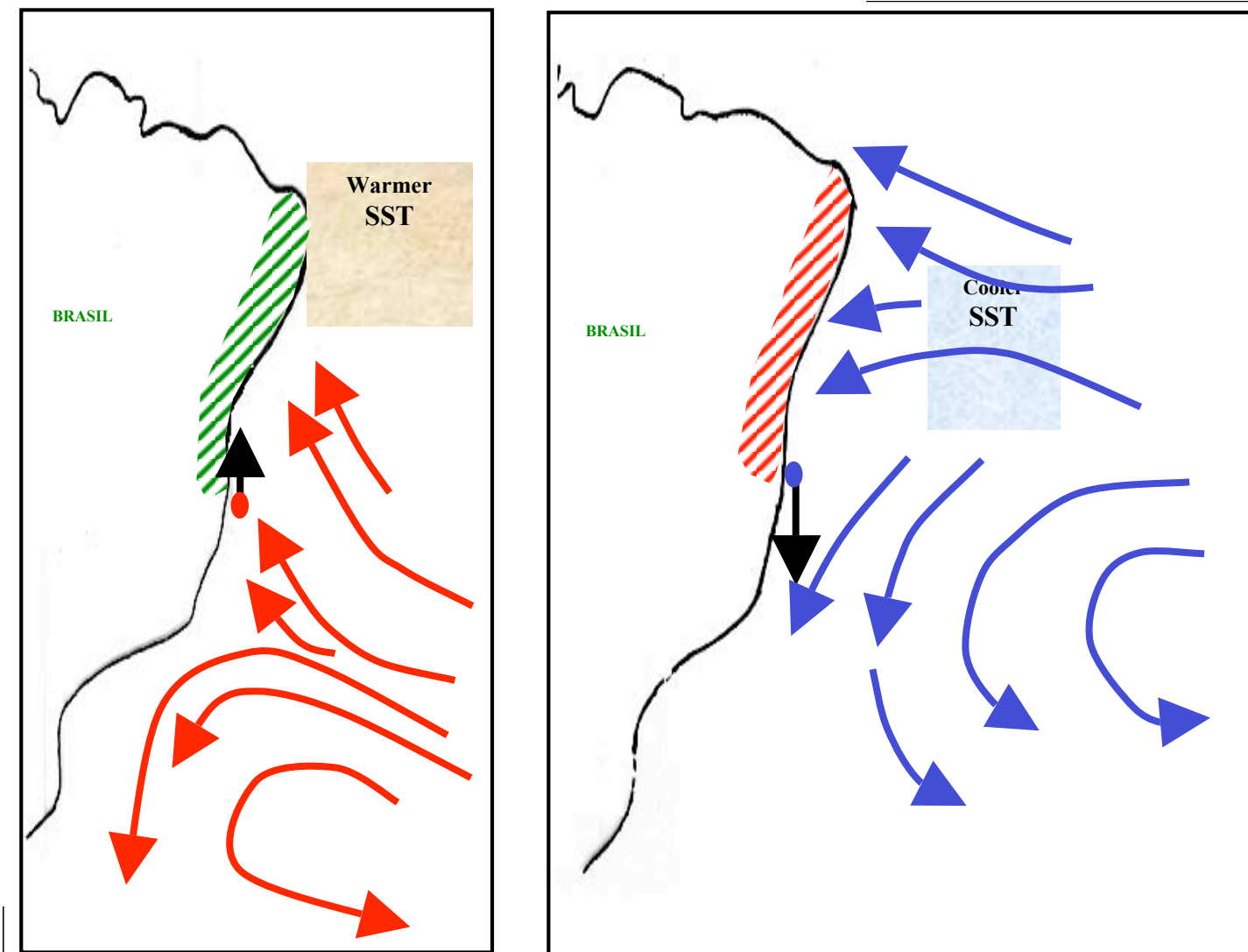
**Shaded in red are the tops of deep convective cumulus clouds. Courtesy of Mr. M. Bottino, CPTEC.**



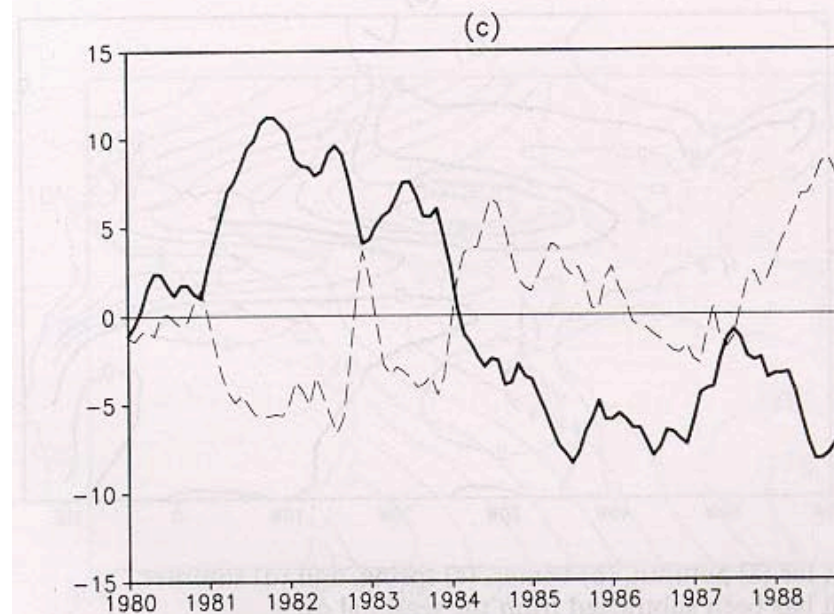
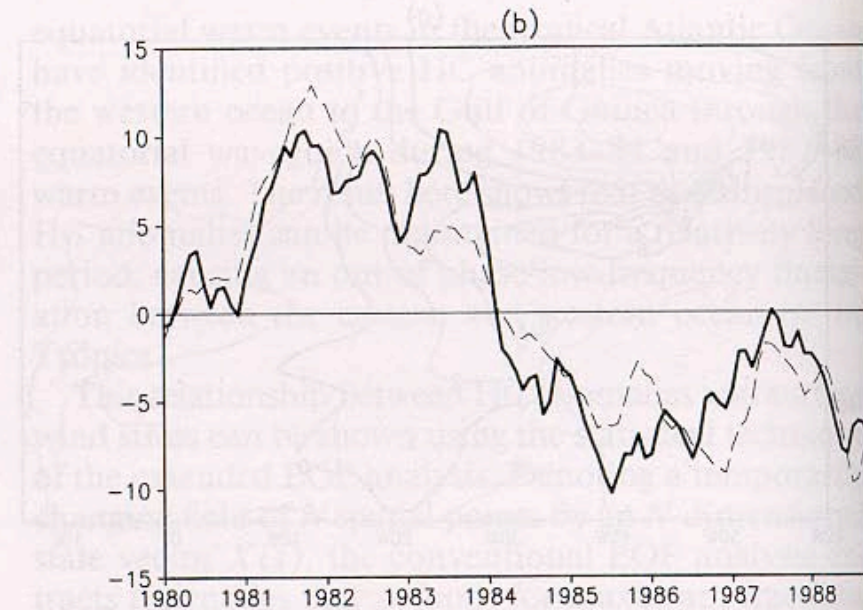
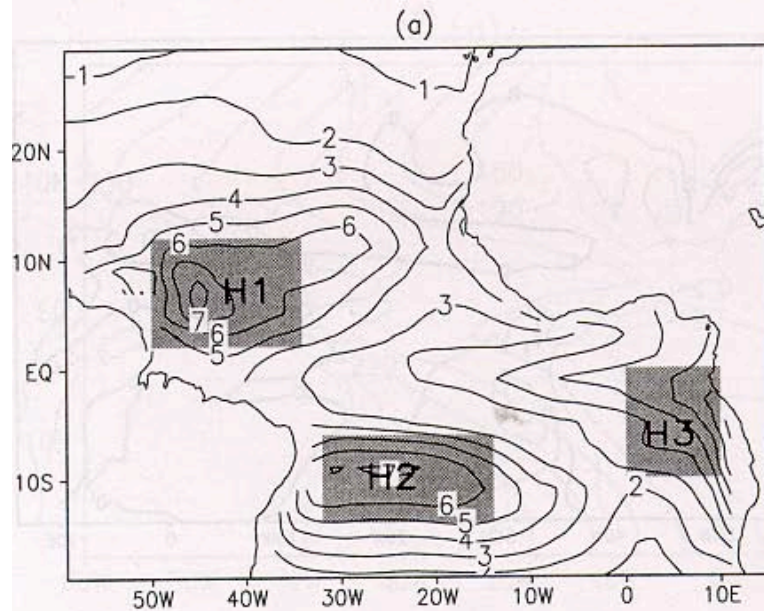
(a) Observed anomalous SST (shades in blue and yellow) and the SACZ over Brazil and the adjacent SW Atlantic (shades of grey). (Source: Courtesy of Mr. M. Sanches, CPTEC/INPE)



(b) Mean position of the SACZ during DJF (left panel) and high pass filtered OLR data (right panel), from Liebmann et al. (1999).



Schematic relationships between JJA rainfall over the eastern Nordeste and surface winds (arrows) and SST (indicated by the rectangles in the panels) for wetter than normal conditions (left) and dryer than normal conditions (right) over eastern Nordeste (Adapted from Rao and Lima, 1993)








(a) Standard deviation of the simulated monthly heat content anomalies in 1980-88 with contour interval  $10^{**4} \text{ J/cm}^{**2}$ . The shaded areas are regions where the indices H1, H2, and H3 are defined. Time series of the simulated indices in 1980-88 in

(b) with the solid curve for H1 and the dashed curve for H2, and (c) with solid curve for  $(H1+H2)/2$  and the dashed curve for H3. The unit is  $10^{**4} \text{ J/cm}^{**2}$ . Source: Huang and Carton (1995).

# The SACOS Workshop



## **Structure of the Workshop:**

-  **The Workshop was structured around a series of discussion and review presentations, interspersed with discussion-sessions to develop cross-cutting ideas and consensus.**
-  **The main presentations were based on short review papers, prepared by a group of invited authors.**
-  **Poster Sessions at the end of the first day and in the first part of the morning of the second were organized for allowing contributed presentations.**
-  **The remaining of the second day was dedicated to the working groups, which were asked to conduct their discussions according to a previously accorded guideline.**
-  **In the morning of the third day there was a plenary session, with the leaders of the four working groups presenting the results of their discussions. These presentations were followed by general discussions.**

## ***The White Papers:***

***Review of South Atlantic intraseasonal to interdecadal variability.***  
(C.Vera, W. Hazeleger, I. Wainer, J. Servain)

***The South Atlantic role on the global thermohaline circulation***  
(A.Piola, A. Gordon, E. Campos)

***Interocean Exchanges*** (W. de Ruijter, S. Cunningham, A. Gordon, J. Lutjeharms, R. Matano and A. R. Piola)

***South Atlantic links and impacts to regional and global climate*** (A. Grimm, A. Robertson, Chris Reason)

***The South Atlantic Observing System*** (S. Garzoli, M. Johnson, A. Piola, C. Provost)

***The Mesoscale Circulation of the South Atlantic Ocean: Does it Matters to Climate?*** (R. Matano, B. Barnier, E. Campos, A. Coward, J. McLean, E. Palma, T.Penduff, M.Schouten, A-M. Treguier, I. Wainer and D. Webb)

***The role of the South Atlantic in the variability of the ITCZ*** (Y. Kushnir, A. Lazar, M. Barreiro, P. Rizzoli)

**Some important points discussed during the  
Presentations**

# Water Masses

- Water masses formed and modified within the South Atlantic, combined with water derived from the Indian Ocean, contribute to the northward return flow required to compensate NADW outflow to the Southern Ocean
- Variations in the composition of the return flow lead to large changes in the South Atlantic meridional heat flux
- Major water mass transformations by sea-air interaction occur at the Brazil Malvinas Confluence and along the South Atlantic Current
- Interior water mass modifications most likely occur in regions of high eddy energy in the southwest Argentine Basin and in the Cape Basin.
- Variability of water mass characteristics, which may result from changes in the share between Atlantic and Indian Ocean water, or from variations in the sea-air momentum, heat and mass fluxes, impact on NADW production and outflow. Though direct a observation of this process is not yet available.

# Water Masses

- Intrusions of warm equatorial water in the tropical South East Atlantic Ocean off Angola and Namibia are linked with above average rainfall along the coast of those countries and sometimes with inland areas of southern Africa.
- During the 1984, 1986, 1995 and 2001 warm events, above average rainfall occurred near the sea surface temperature anomalies and extended inland from the coast to an extent that appeared to depend on the intensity of the regional moisture convergence and atmospheric circulation anomalies.
- In 1982 1992 and 1997 SST and rainfall were below normal in coastal Angola
- The significance of the warm events occurring during the February to April period is that this is the time when SST reaches its maximum in the annual cycle (up to 28°C off northern Angola) and this favours more intense local evaporation and convection and a greater impact on late austral summer rainfall.
- Better understanding of these events and their relationship with regional rainfall is important for seasonal forecasting.

## TH Tropical Atlantic ITCZ

- The TA ITCZ is highly sensitive to changes in SST gradients, (meridional direction, boreal spring). New evidence implies that the SA plays a role in shaping these gradients through surface ocean atmosphere interactions and subsurface, oceanic pathways.
- In the atmosphere, a phenomenon akin to the NAO appears to be acting in the SA in which extratropical wintertime variability imprints its signature in the SST field, which through its persistence, preconditions the coupled system for a positive feedback interaction in the deep tropics three seasons later.
- On a much slower time scale, the SA STC carry (thermocline) anomalous temperature and salinity signals to affect the properties of upwelling water in the tropical regions off western Africa and the equatorial cold tongue.
- These processes are set to affect the variability of the AMI on interannual to decadal time scales and should be considered in addition to the more familiar effects of the NAO and ENSO.

## Questions related to the ITCZ

The study of SA influences on the ITCZ is in its early stages and more work needs to be done to understand and quantify the processes described above:

- Is the atmospheric effect predictable?
- Can the precursors be identified in a robust manner to allow a long-lead prediction?
- How does this phenomenon interact with other external influences on the ITCZ? How does it interact with the apparently large austral summer variability?
  
- What is the role of the STCs in the low-frequency variability of SST in the upwelling regions?
- Can this be quantified in the presence of the direct and highly variable surface interaction?
- What long-term observations should be collected and where to resolve this issue and assess its predictability.

There is planning for the observing system of the SA, it is important to coordinate it with existing efforts in the TA to achieve maximum benefit with addressing the causes of ITCZ variability.

## The Working Groups:

**WKG1:** *Links between the upper South Atlantic, the deeper ocean and the other basins.* Chair: **A. Piola**

**WKG2:** *The South Atlantic links and impacts to regional and global climate*  
Chair: **A. Grimm**

**WKG3:** *Modeling the Coupled Ocean/Atmosphere System.*

Chair: **R. Matano**

**WKG4:** *South Atlantic Observing System and Operational Forecast System.*  
Chair: **S. Garzoli**

## Working Group Tasks:

- Review what the main science issues are;
- Define Hypothesis and why they are relevant;
- Recommend actions to be taken to prove/disprove the hypothesis.

# Summary of the working group reports

## Working Group 1

This group was mainly motivated by the fact that, in spite of meridional heat flux in the ocean being a key element of the climate System, in the South Atlantic the meridional heat flux is uncertain.

The present estimates vary between  $-0.6$  and  $+0.65$  PW. This uncertainty lead the group to base the discussions on the following scientific issues:

- What is the meridional heat flux through the South Atlantic?
- What factors determine and can induce variability in the meridional heat flux?

## Working Group 2:

The strategy of this working group was based on the definition of a set of general questions, followed by some more specific ones. These general questions were:

- What are the gaps in our understanding of the annual cycle?
- What are the leading modes of ocean-atmosphere variability in the South Atlantic? To what extent are they predictable?
- What are the physical mechanisms associated with the climate variability on intraseasonal, interannual and interdecadal timescales in the South Atlantic? What are the relative roles of remote versus local processes?
- What are the most important impacts, regionally and globally, of South Atlantic climate modes?

The scientific issues discussed by working group 2 were (1) the uncertainty in data, (2) the SST variability and (3) the South Atlantic modes of variability and their related impacts

## Working Group 3.

This working group divided their discussions in two main time-domains: Seasonal to Decadal and Decadal to Centennial.

According to their recommendations, in order to *understand and predict* South Atlantic climate variability in seasonal to decadal time scales, it seems fundamental to first study the annual cycle of the system, especially in the Atlantic, where Atmosphere-Ocean-Land coupled models are failing.

In decadal to centennial time scales, they identified two important issues related to the impact of the South Atlantic on the Meridional Overturning Circulation (MOC):

- Water masses transformations (air-sea interactions and interior diapycnal mixing) occurring in the SA are important to the MOC and its variability because they affect the characteristics of the upper limb of the MOC.
- Heat and Salt fluxes from external basins impact the MOC (warm and cold paths)

## **Working Group 4**

**The discussions in WG 4 started with the formulation of hypotheses on the role of the South Atlantic in climate that should be tested experimentally.**

**This was followed by a discussion on what types of observations are needed to test these hypotheses, which was done in the framework of the already existing sustained observations and existing international programs.**

**Finally, recommendations on sustained observations were made.**

## **Recommentadions:**

**Here we summarize the most relevant recommendations from the Working Groups and from the plenary discussions that followed the working group presentations.**

## **Hypothesis 1:**

The export of cold NADW to other ocean basins and import of relatively warm thermocline and intermediate waters in the upper layers determine meridional heat flux in the South Atlantic. Consequently the heat flux through the South Atlantic is equatorward.

## **Recommendation:**

*To better understand the global ocean thermohaline circulation and its impact on climate it is necessary to reduce the heat flux uncertainty in the South Atlantic.*

## Hypothesis 2:

The decadal signal observed in SST in the subtropical gyre of the South Atlantic Ocean is due to variability in the coupled air-sea mode between the SST field of the South Atlantic subtropical gyre and the wind stress curl.

### *Recommendation:*

*To verify this hypothesis it is necessary to monitor the variability in the gyre.*

### **Hypothesis 3:**

SST variability in the southeastern (southwestern) South Atlantic has direct impact on precipitation in Africa (South America).

### **Recommendation:**

*We need to measure the heat storage in the upper water column and the air-sea fluxes*

## **Needed Actions:**

To verify the main hypotheses, a set of actions is listed in the WG reports. In their general aspects, these actions are:

- **To develop studies, based on analyses of historical data, numerical modeling and observations, with the purpose of generating a better estimate of the meridional heat flux in the South Atlantic.**
- **The carry out observational diagnostic studies and numerical simulations to better understand the land-air-sea interactions in different regions of the South Atlantic basin;**
- **To design and implement a sustained monitoring system for the South Atlantic, which could be maintained in by South Atlantic countries in cooperation with North American and European counterparts.**

**Thank you!**

