Prediction and Research Moored Array in the Tropical Atlantic

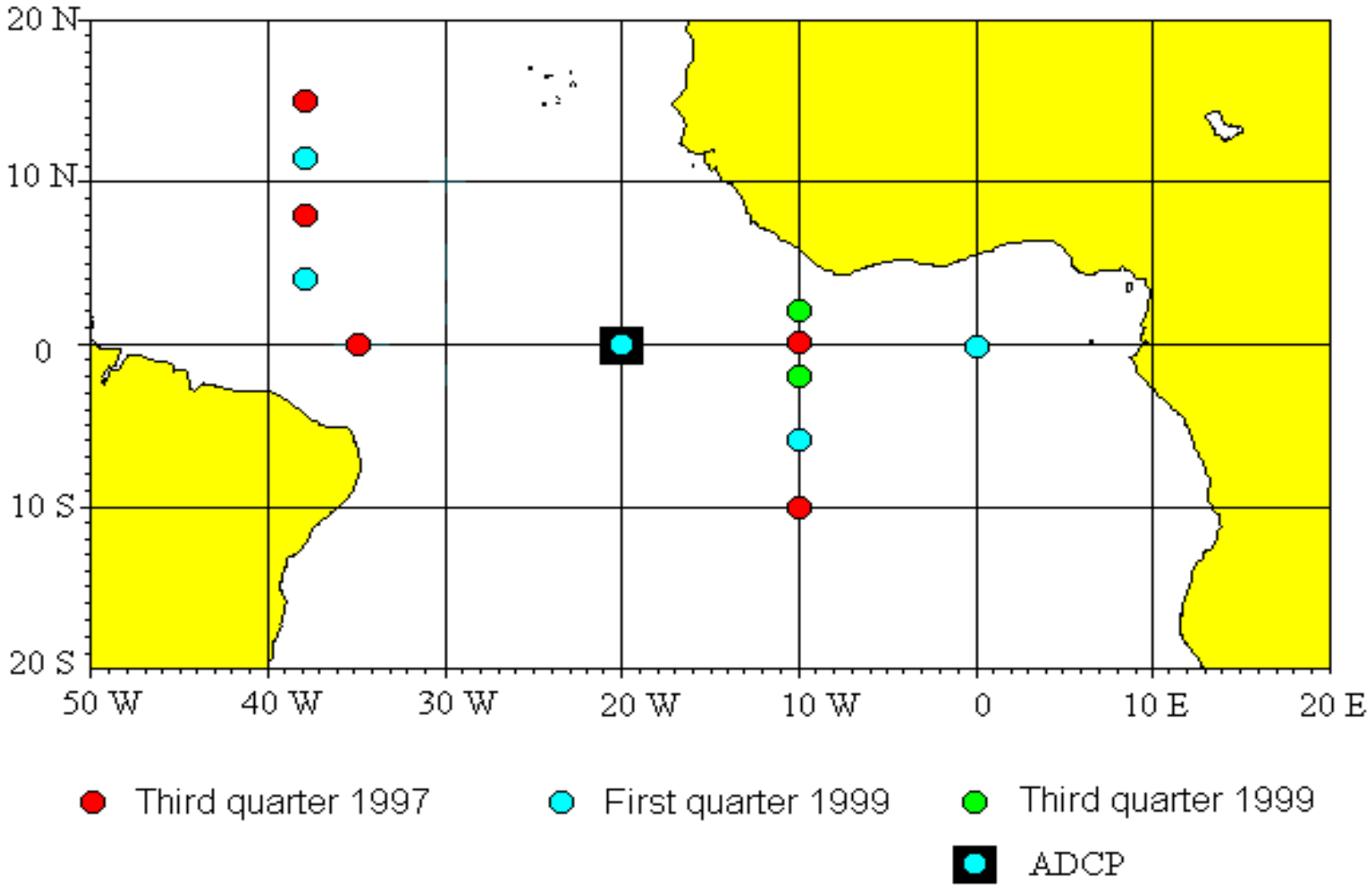
The PIRATA PROJECT 1997-2017

INTERNATIONAL COOPERATION

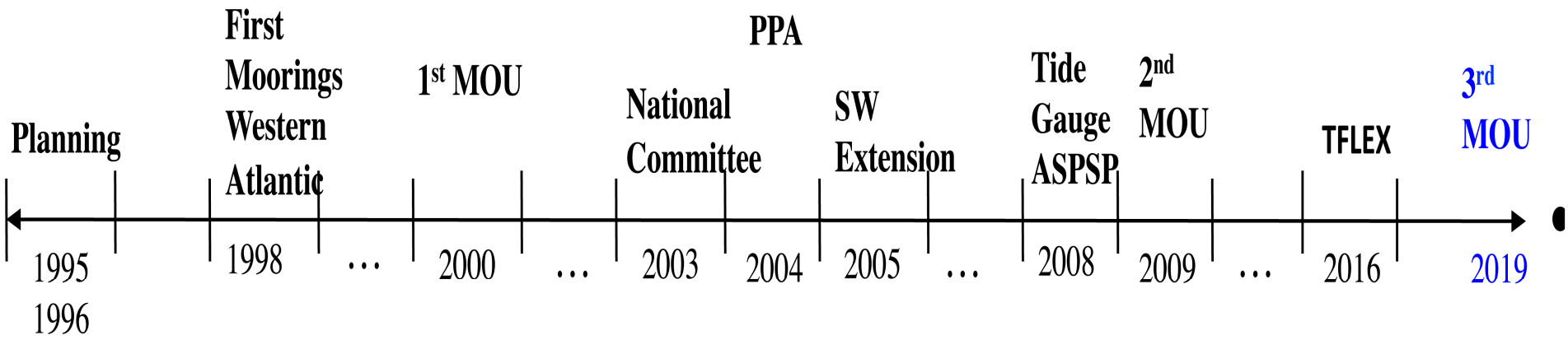
BRAZIL – FRANCE - USA

Paulo Nobre
INPE/CPTEC
OMARSAT-2017, IEAPM, 4 OCTOBER 2017

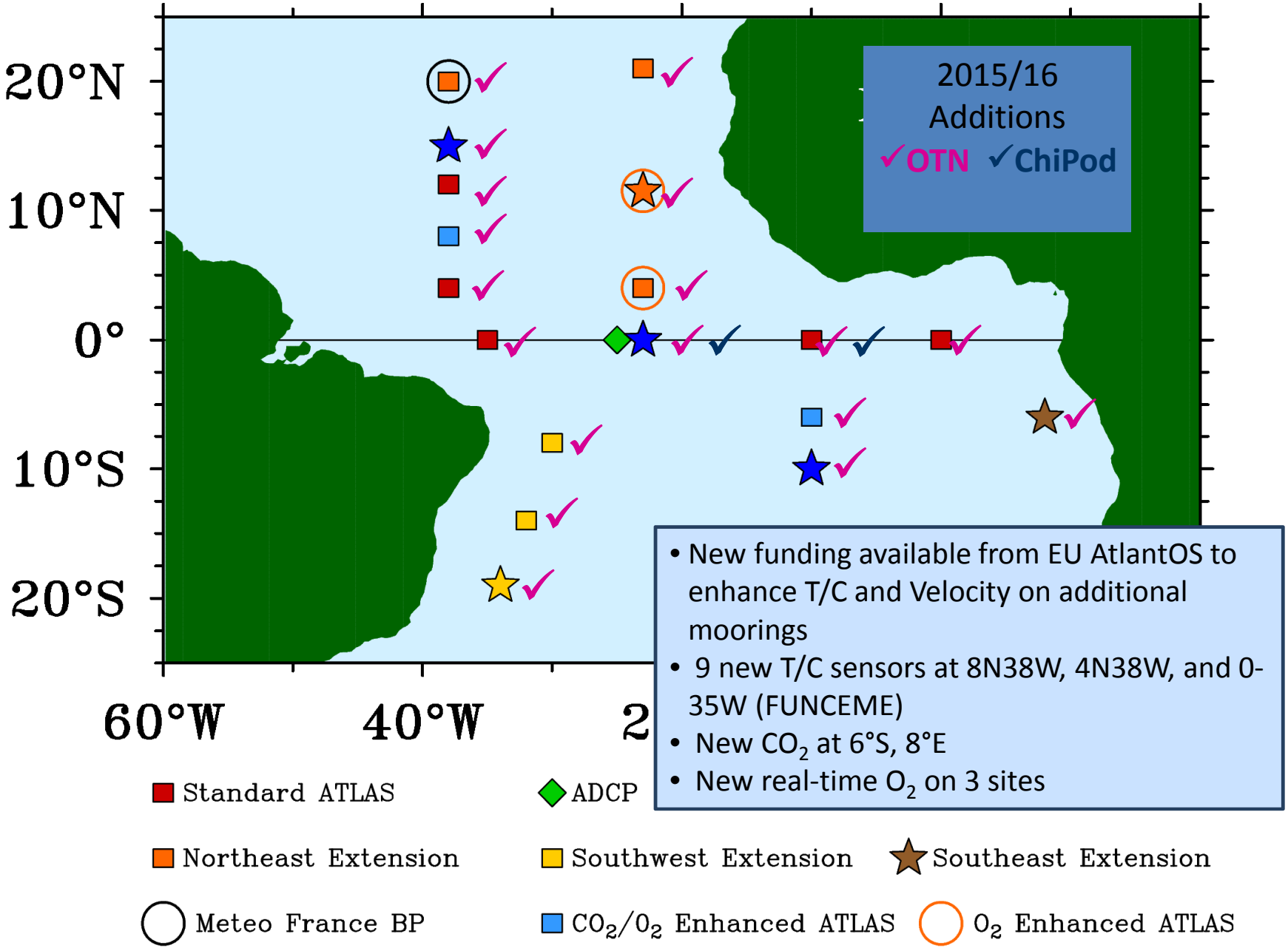
PIRATA Backbone, in 1999



PIRATA Timeline



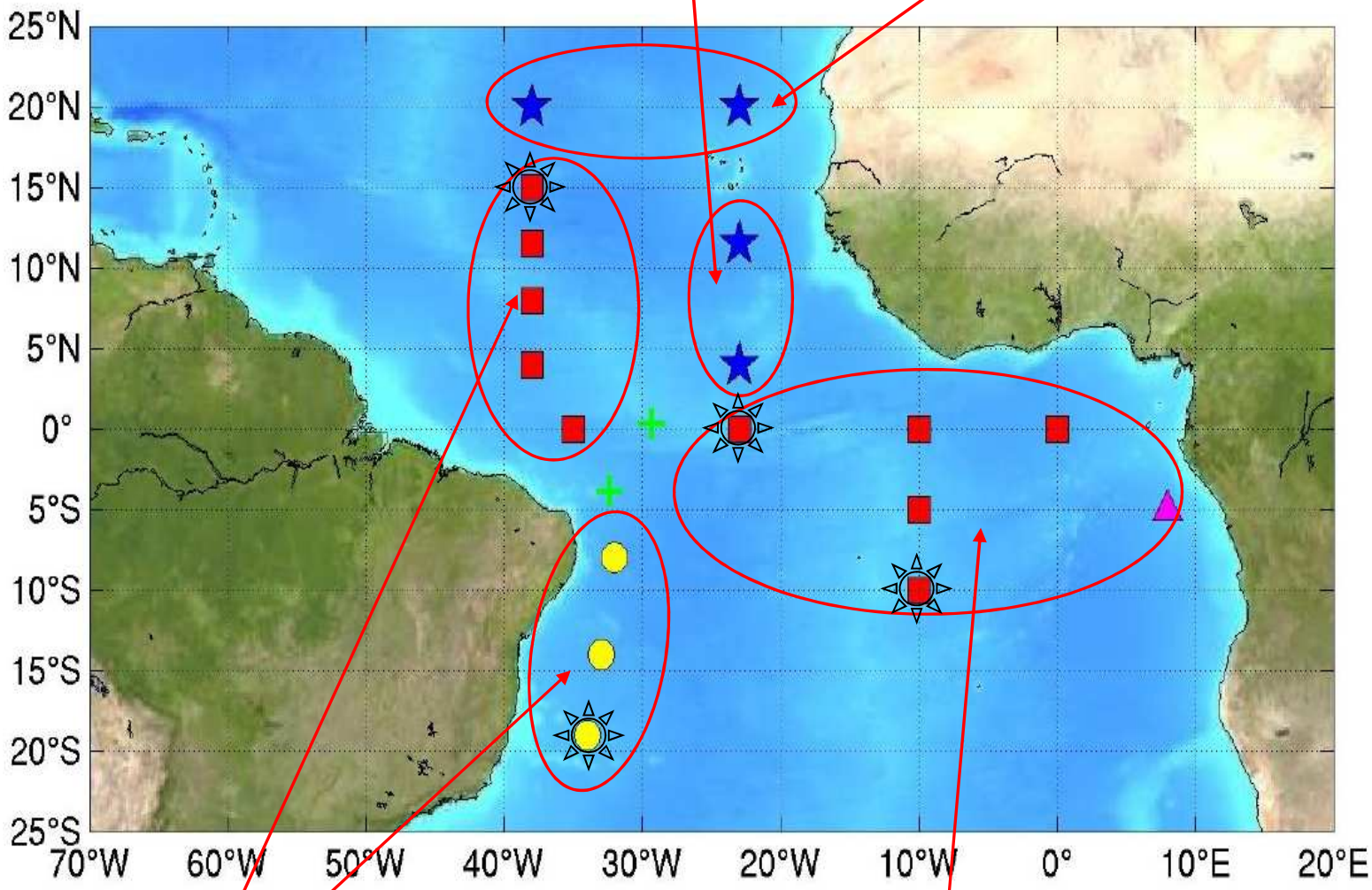
PIRATA



Courtesy: McPhaden, PMEL (2016)

PIRATA network status:

Maintained by USA *: 4 Atlas buoys : 2 deployed in 2006, at 4N & 11N/23W, 2 at 20N/23W & 38W deployed in 2007*



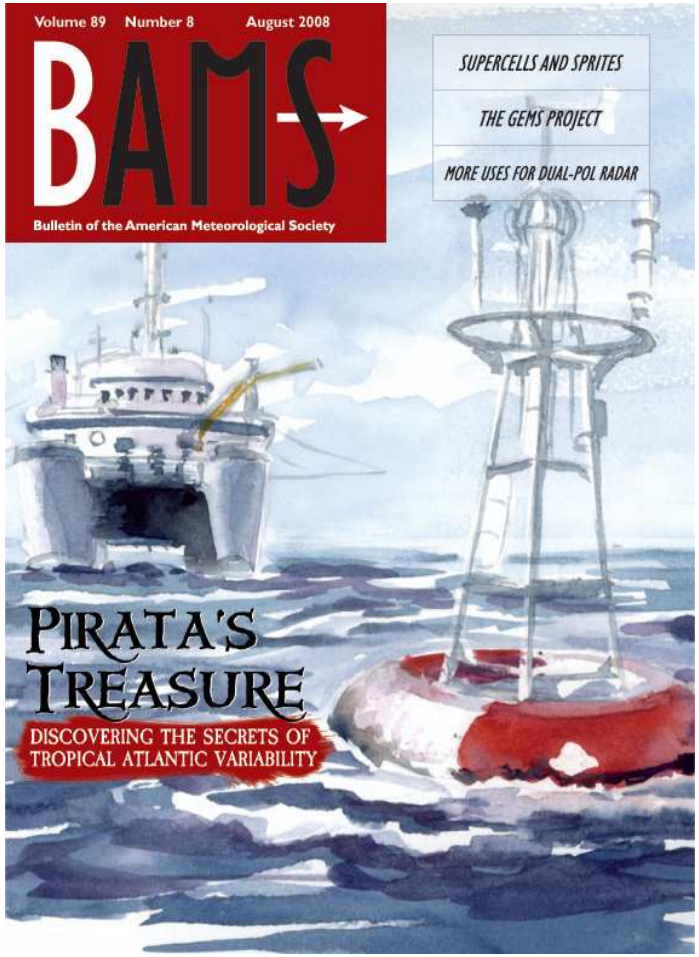
Maintained by Brazil: *8 Atlas buoys*

Maintained by France *: 6 Atlas buoys*
+ At 23° W-Equator : surface ADCP mooring since 2001

Ocean Sites reference flux (swr, lwr, rh, air T, SLP).

PIRATA BAMS paper (Aug. 2008) & new acronym:

Prediction and Research Moored Array in the Tropical Atlantic



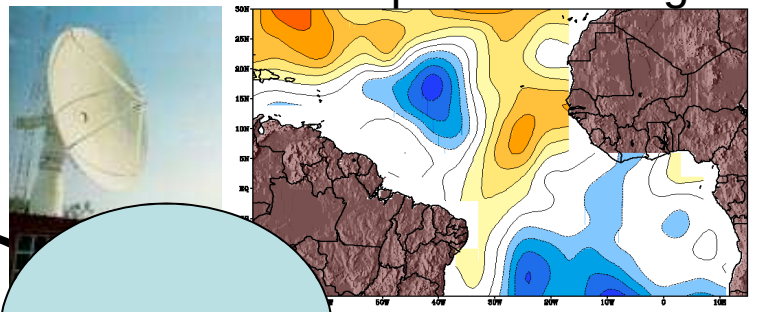
The PIRATA Program: History, Accomplishments, and Future Directions

Bernard Bourlès, Rick Lumpkin, Michael J. McPhaden, Fabrice Hernandez, Paulo Nobre, Edmo Campos, Lisan Yu, Serge Planton, Antonio J. Busalacchi, Antonio D. Moura, Jacques Servain, and Janice Trotte

PIRATA BRAZIL INSTITUTIONS

Marine Operations

Satellite and Coupled Modeling



CPTEC/INPE

DHN

INPE

Weather Forecasting

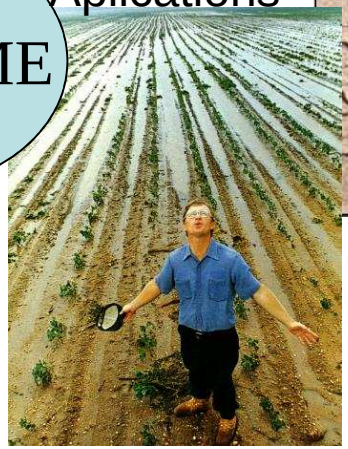
INMET

FUNCEME

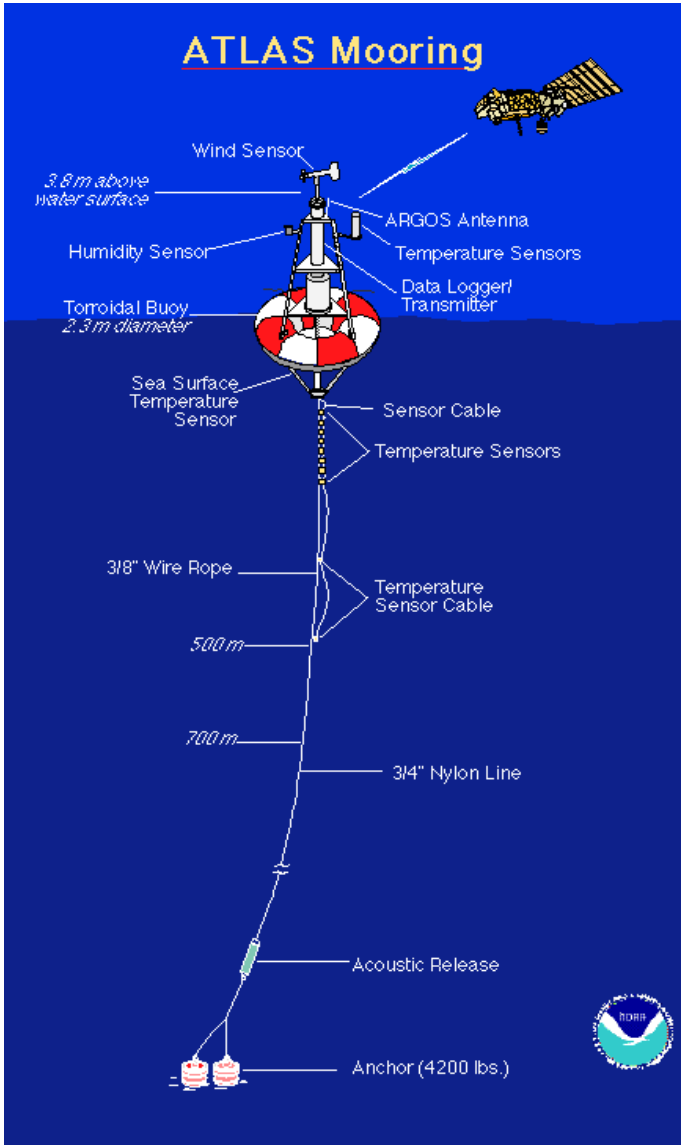
Aplications

IOUSP
UFPE

Education &
Trainning



NOAA/PMEL's ATLAS Mooring



DHN's PIRATA Ocean Fleet

NOc. ANTARES

1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2008, 2009, 2011, 2012, 2014, 2016,

NPqHo Vital de Oliveira

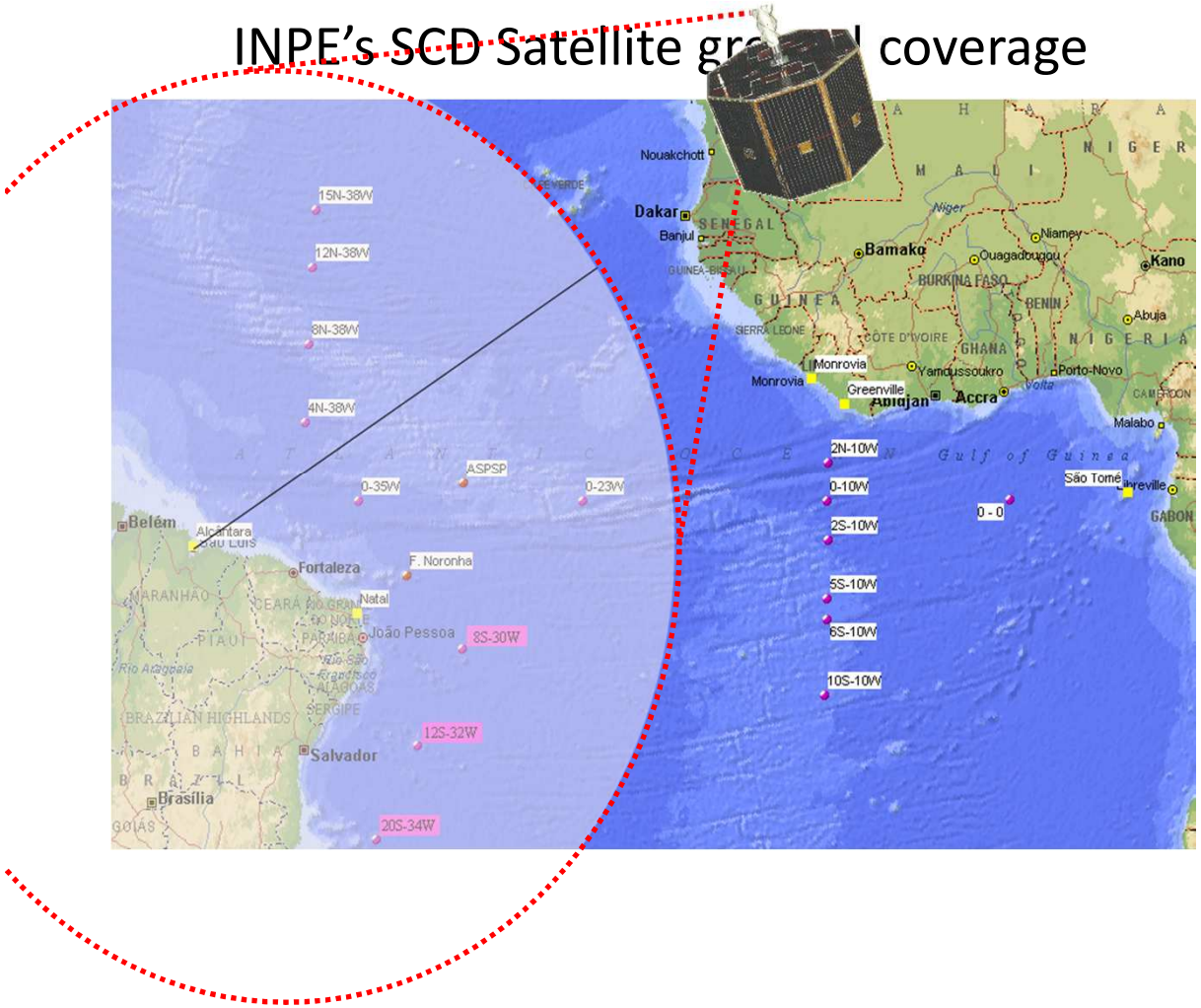
2015, 2017-2018

Amorim do Valle

2002, 2005

PIRATA Moored Buoys Array
INPE's SCD data collection

INPE's SCD Satellite gr[illegible] coverage

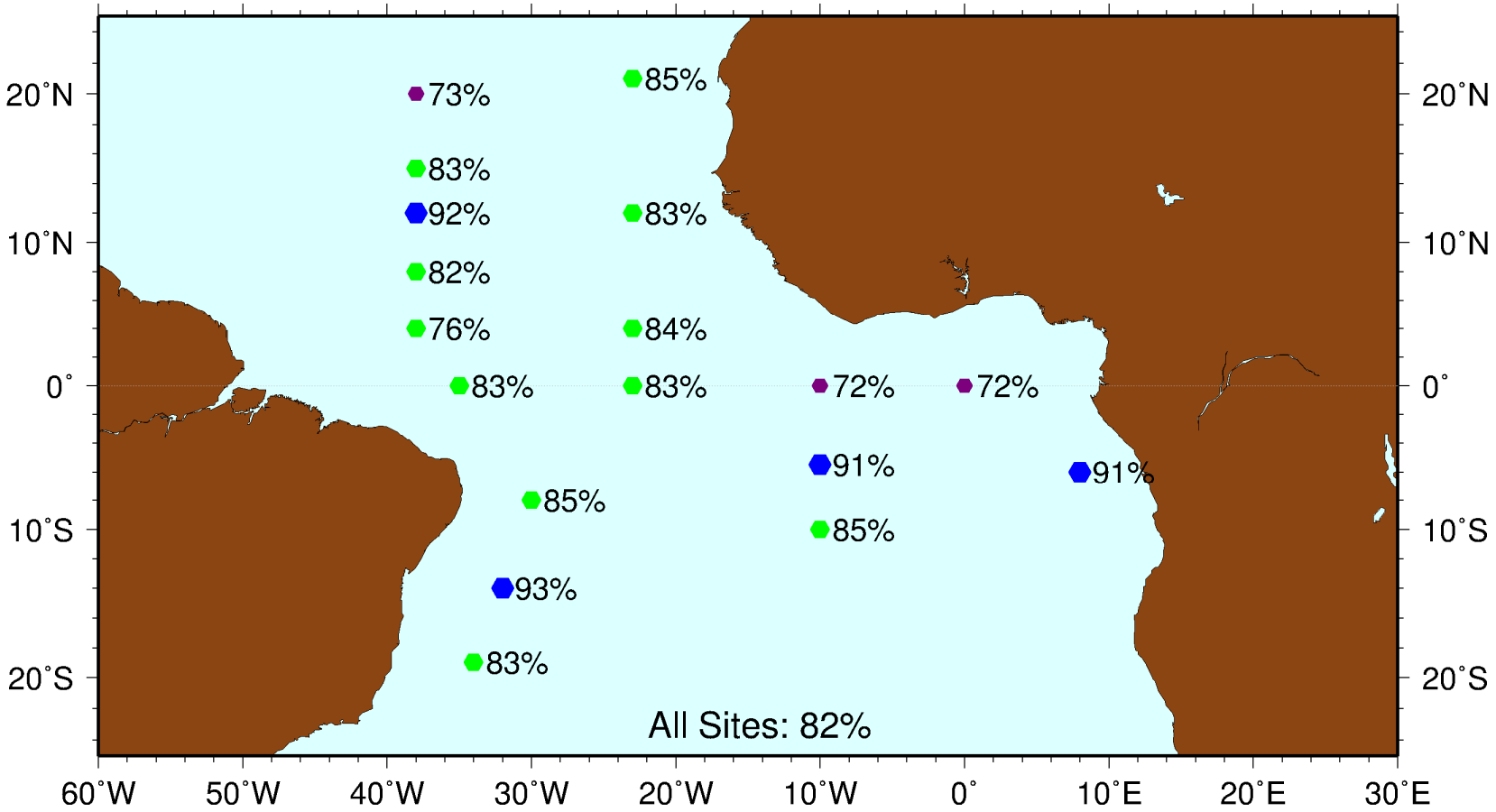


Cuiaba Antenna

Ground Control Room, SJC

PIRATA Mooring Data Return

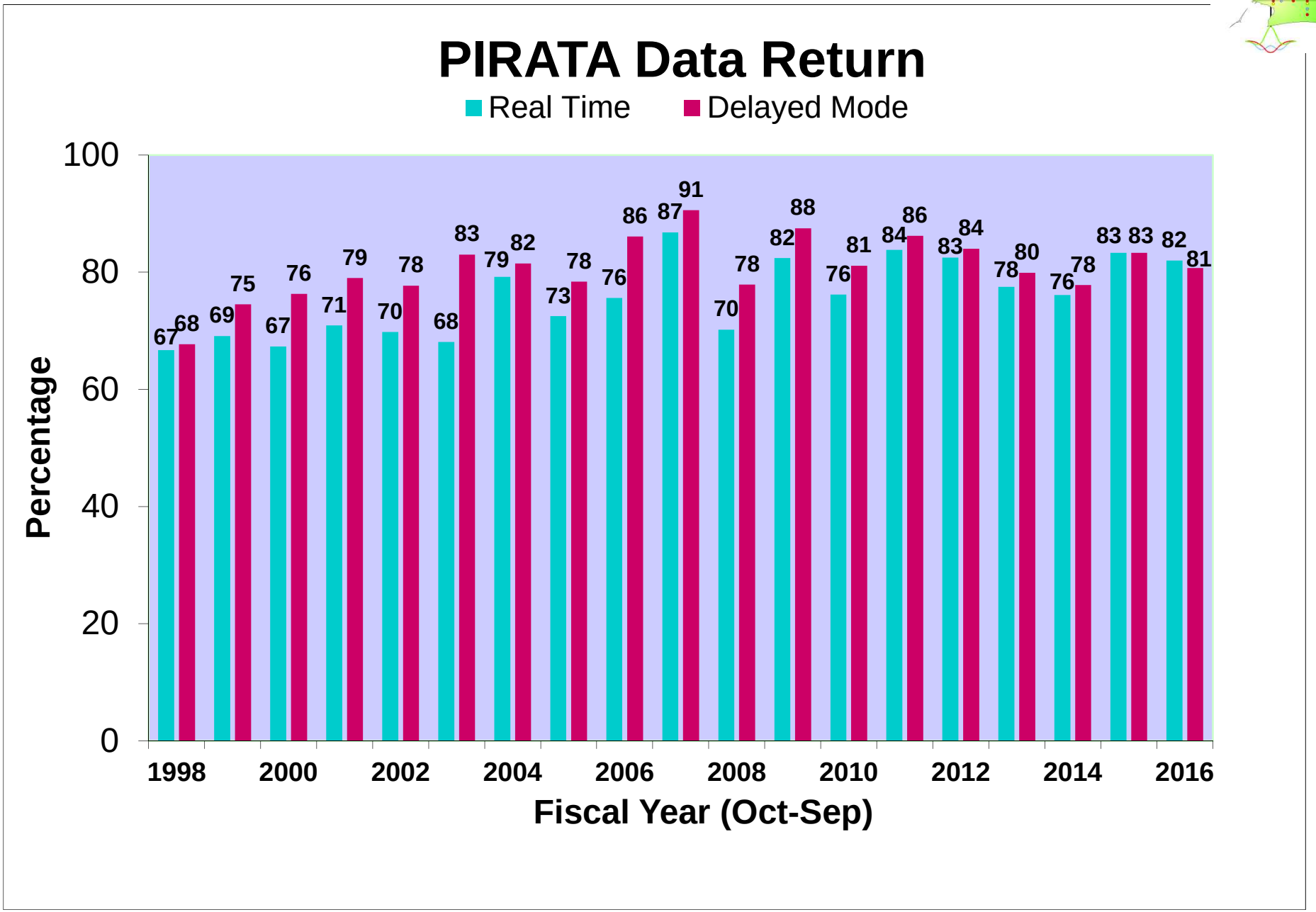
1997 - 2016



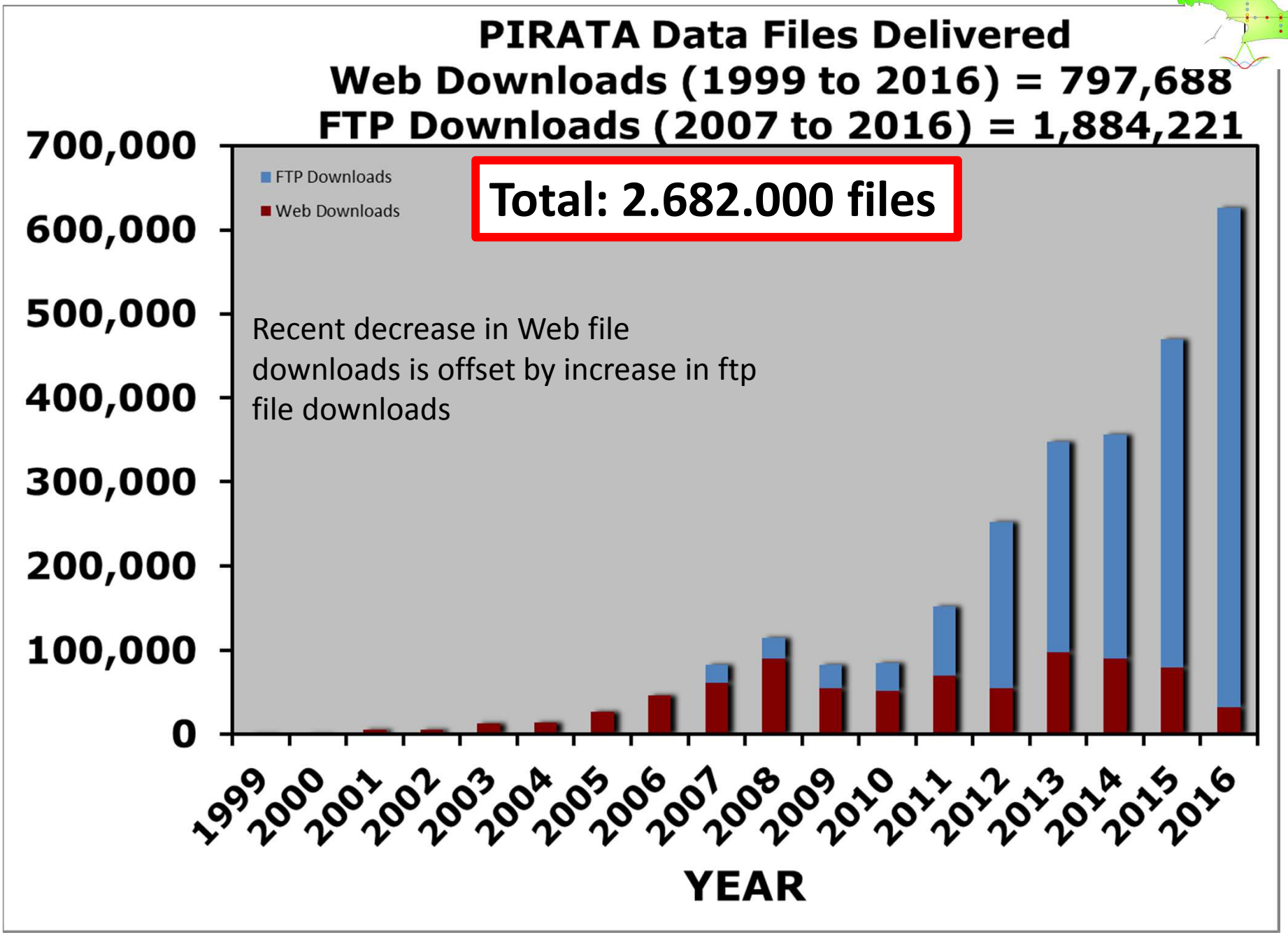
All Sensors

0% - 50% 50% - 75% 75% - 90% 90% - 100%

Courtesy: McPhaden, PMEL (2016)



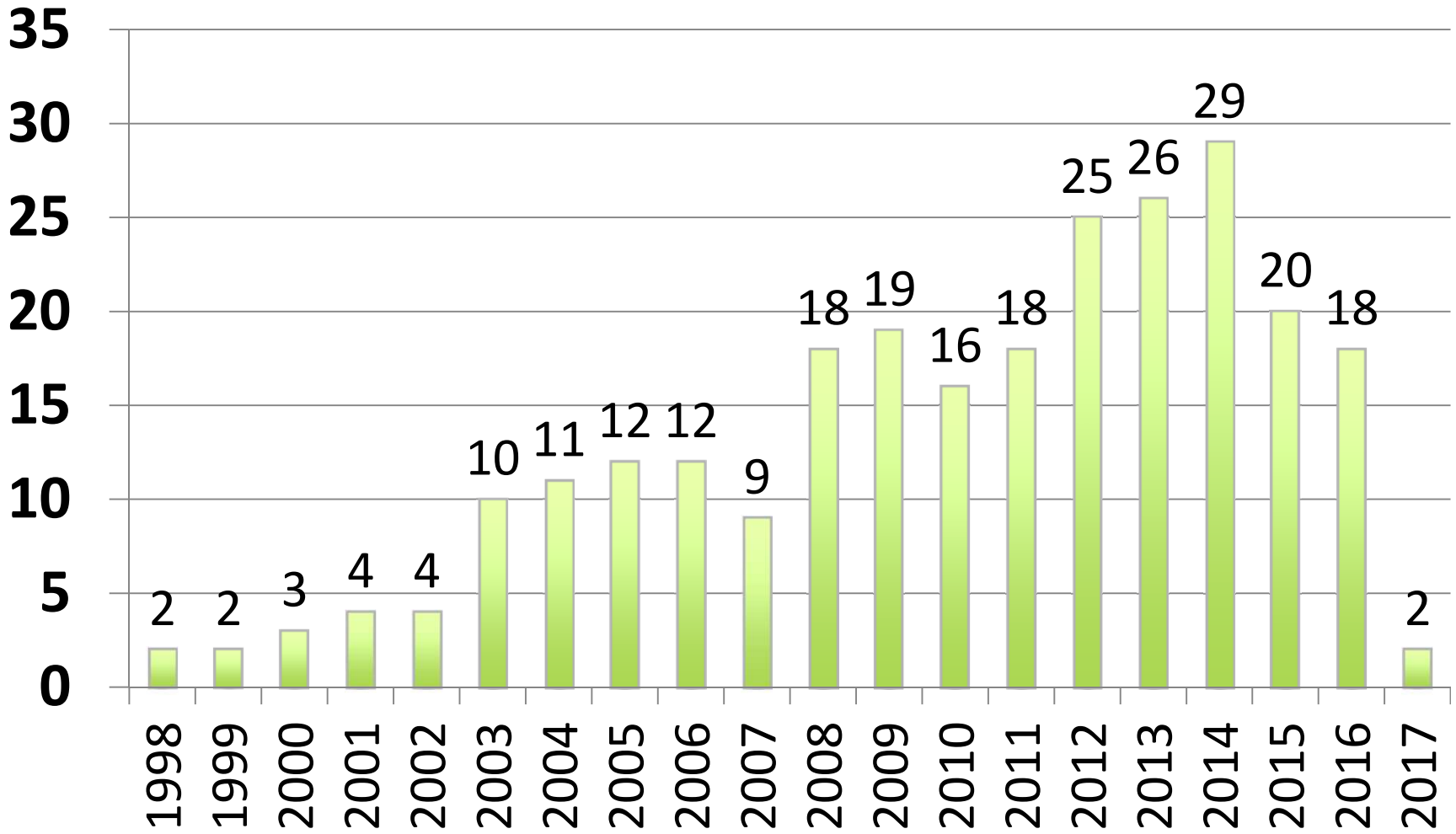
Courtesy: McPhaden, PMEL (2016)



Courtesy: McPhaden, PMEL (2016)

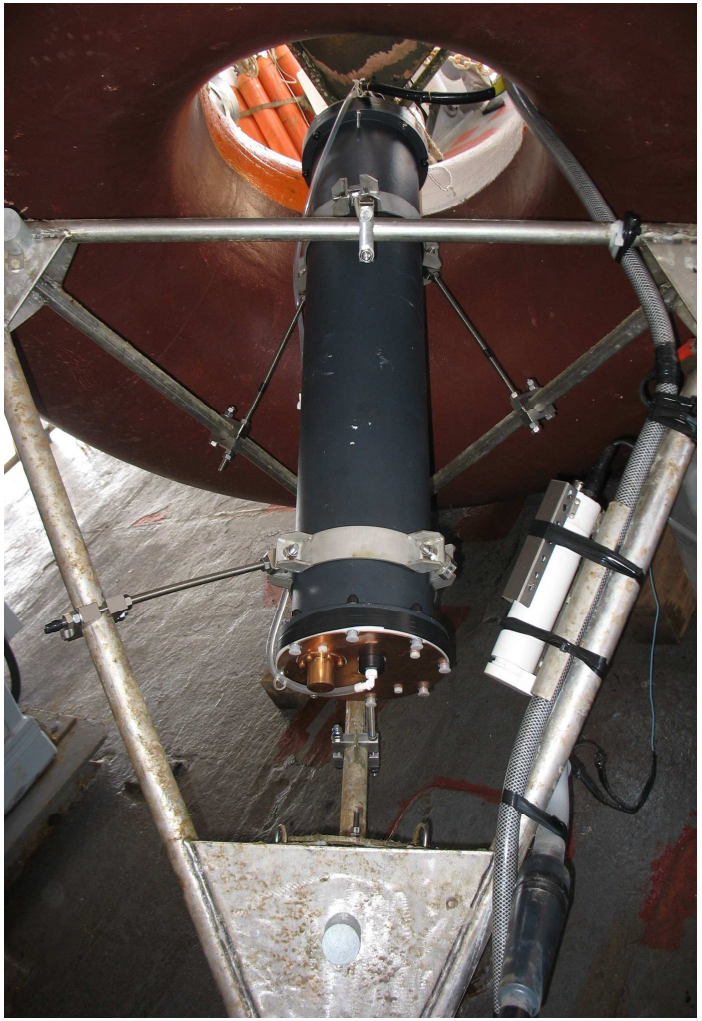
PIRATA Peer Reviewed Journal Articles

Total: 260



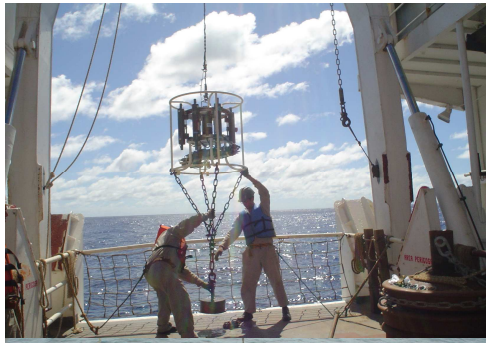
Data Courtesy: Lumpkin, AOML (2017)

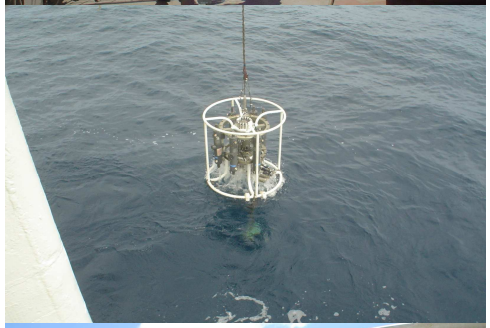
pCO2 sensor @ PIRATA 8N 38W



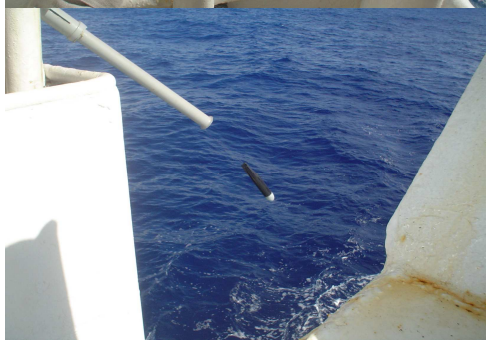
PIRATA Brazil Hidrography

CTD



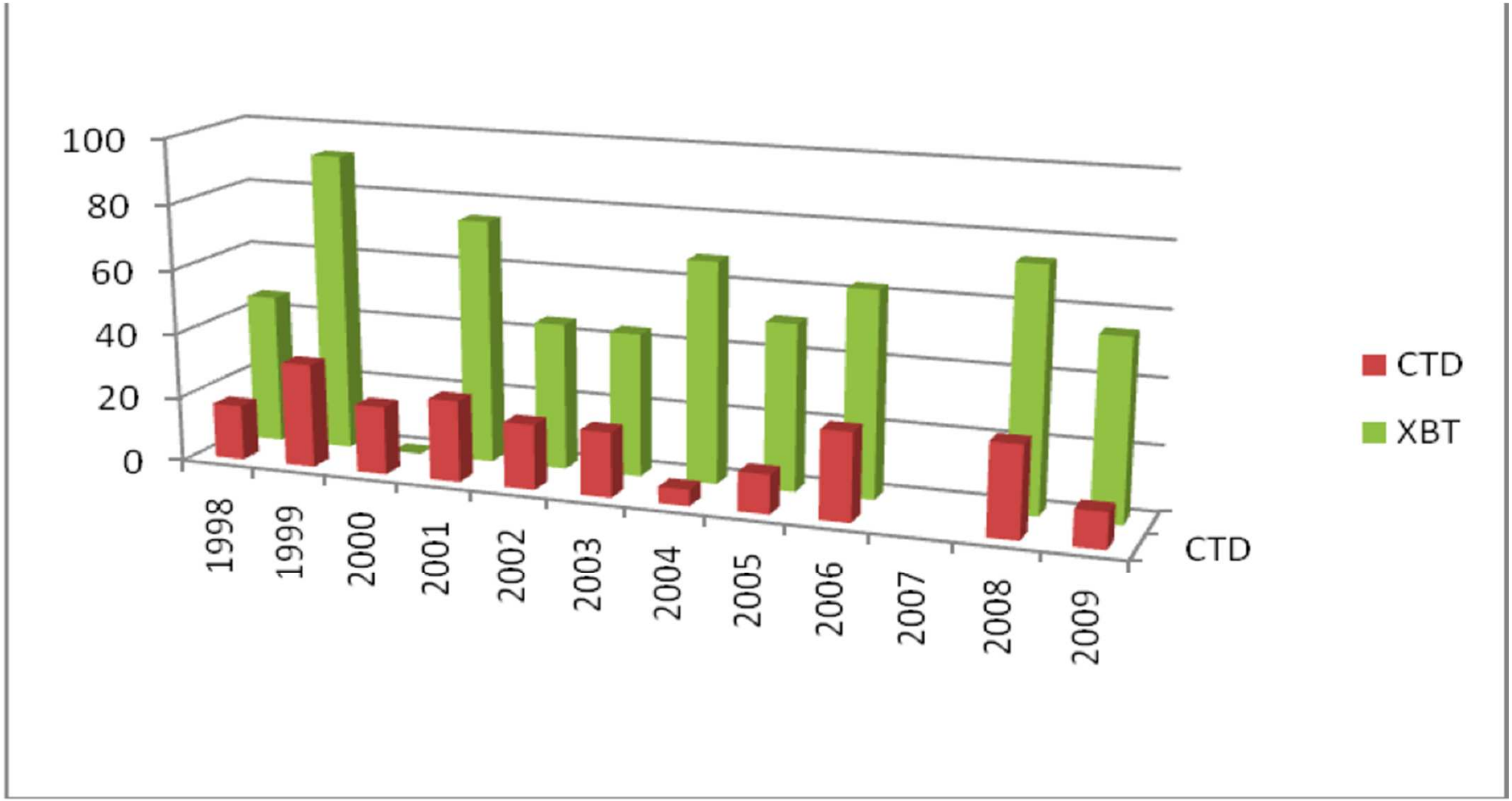


XBT



Radiosonde

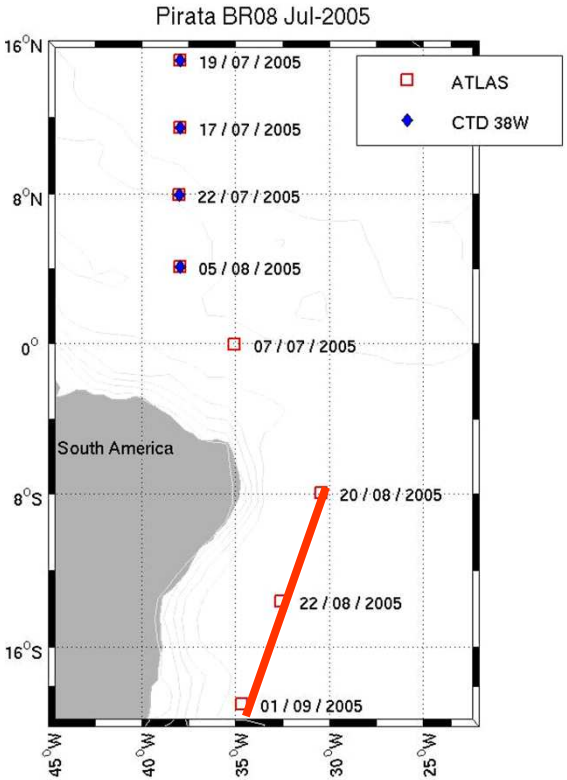
CTD & XBT auxiliary data collected during PIRATA BR cruises

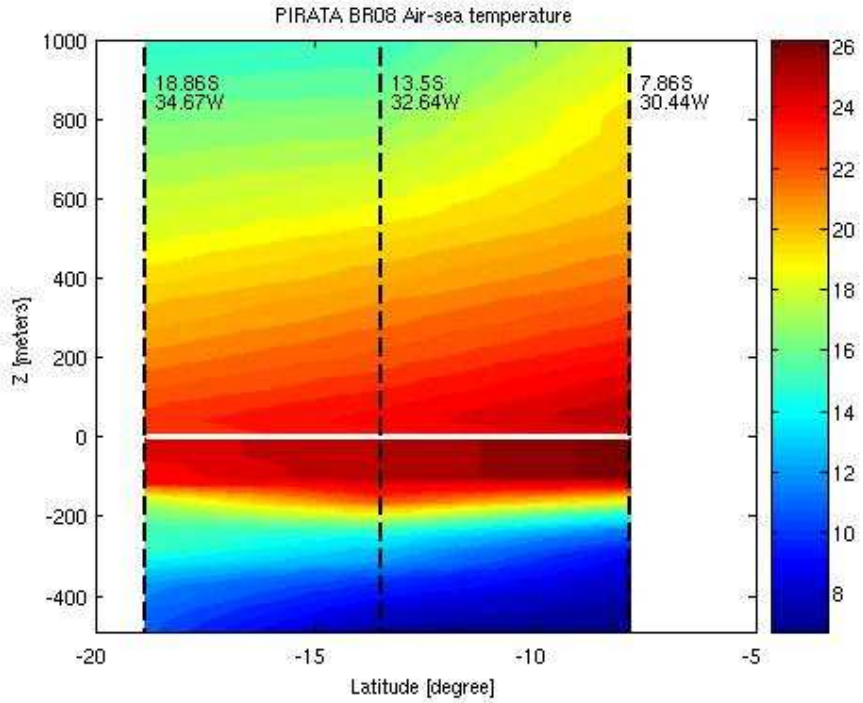


Courtesy: P. Arlino, INPE/CPTEC/LIM (2011)

Simultaneous ocean-atmos temperature profiling

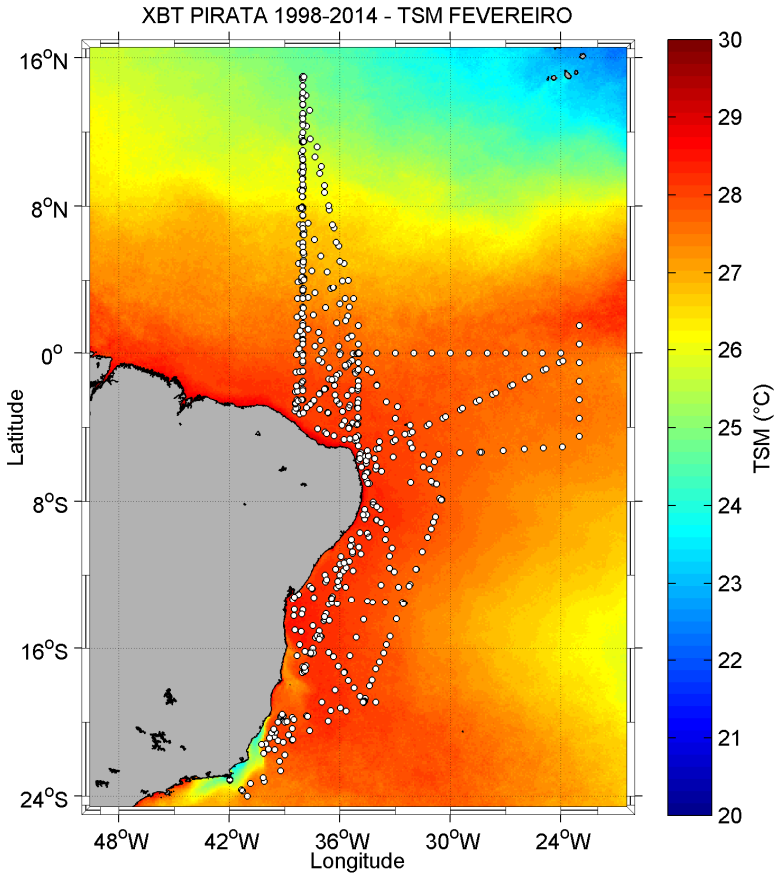
PIRATA SWE (2005-2016)

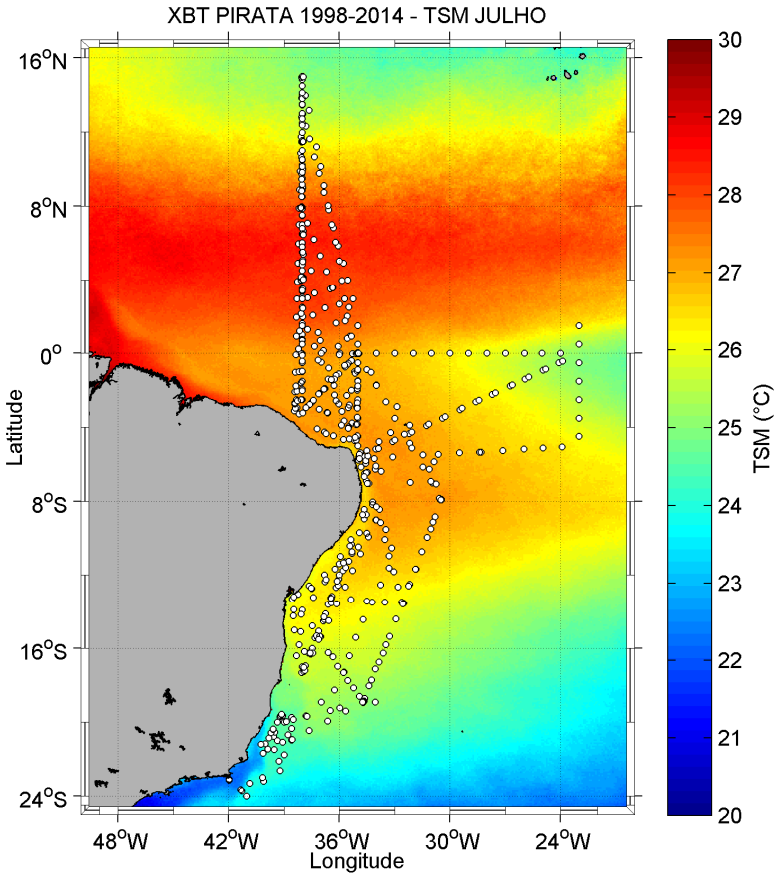




Courtesy: D. Urbano (2008)

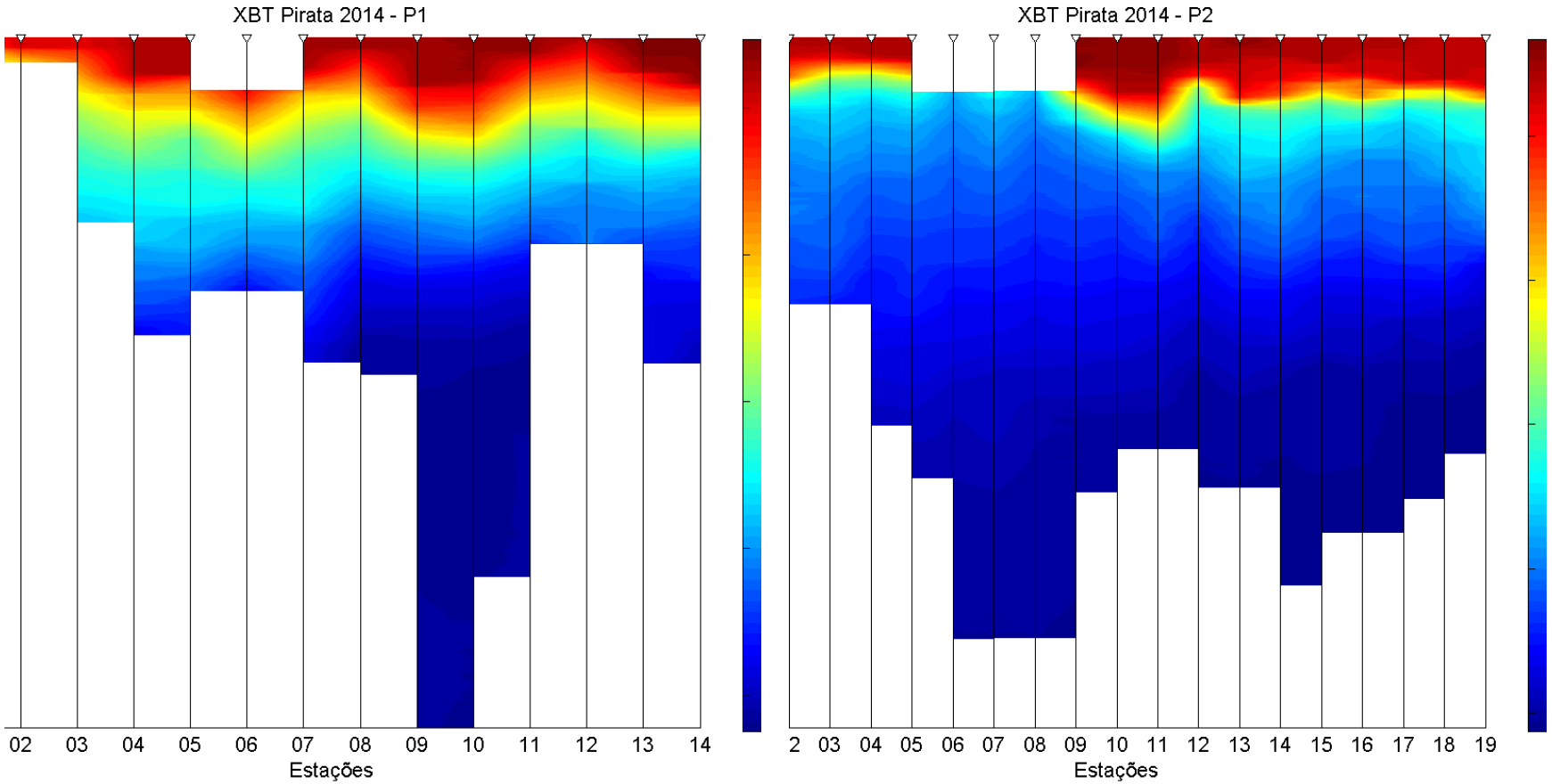
PIRATA BR Cruises 1998-2014 & Climo SST





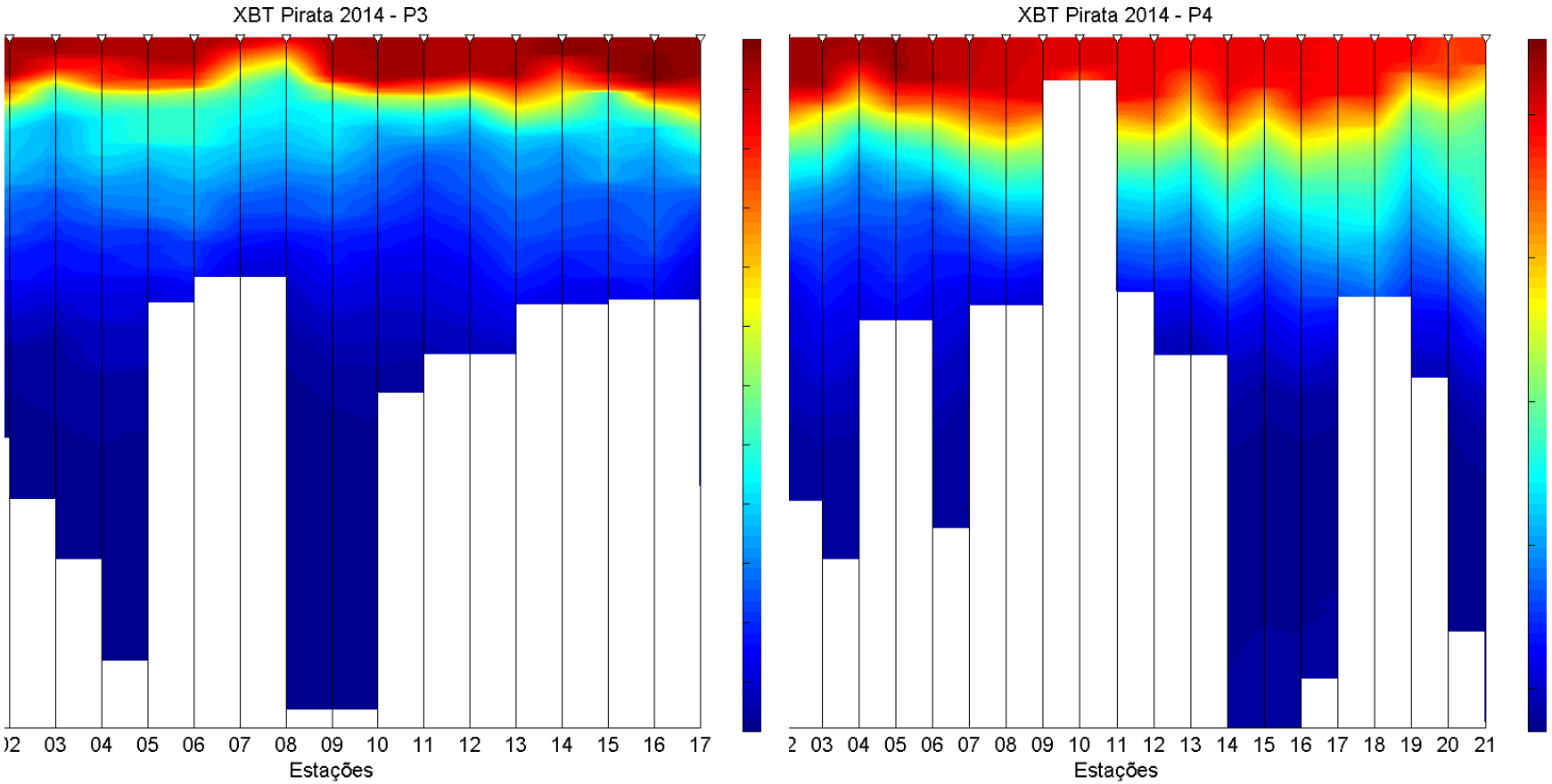
Courtesy: R. Buss and team, INPE/SM (2017)

PIRATA-BR XV 2014 XBTs



Courtesy: R. Buss and team, INPE/SM (2017)

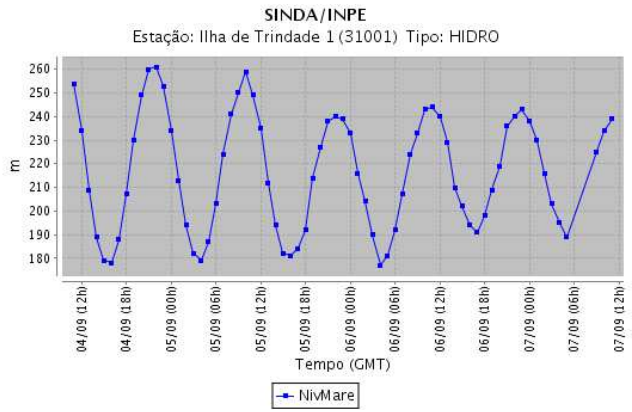
PIRATA-BR XV 2014 XBTs



Courtesy: R. Buss and team, INPE/SM (2017)

Tropical Atlantic Brazilian Islands
(Tide Gauge Network)

Fernando De Noronha
2011 03



H40 NOc. ANTARES

7 Scientists capacity
ADCP, A-Frame, (CTD)/UCTD/pCO2,
radiosondes, SFC Meteorology,
Year of construction: **1983**

H39 – NPqHo Vital de Oliveira

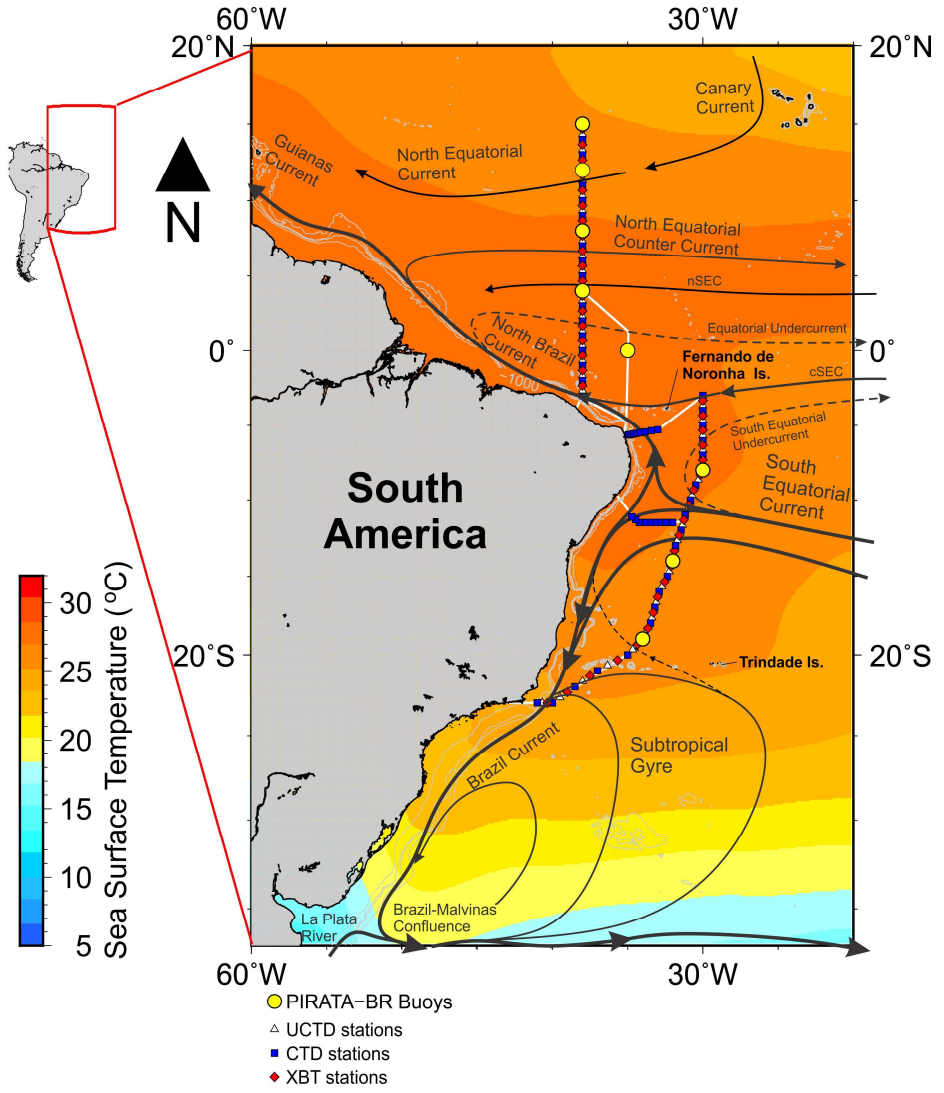
30 Scientists capacity
2 ADCP, A-Frame, CTD/UCTD/pCO2,
radiosondes/SFC Meteorology,
ROV,
2 Lateral Winches
Year of construction: **2015**

PIRATA-BR XVII – NPqHo Vital de Oliveira:

"Western Tropical Atlantic Experiment"

Principal Investigators

1) INPE – Paulo Nobre
2) INPE – Ronald Buss
3) UFPE – Moacyr Araujo
4) UFBA – Vanessa Hatje
5) UFBA – Gisele Rocha
6) UERJ – Leticia Cotrim
7) UFF – Ana Albuquerque
8) UFC – Antonio Geraldo
9) FURG – Felipe Niencheski
10) CHM – Marcio Borges

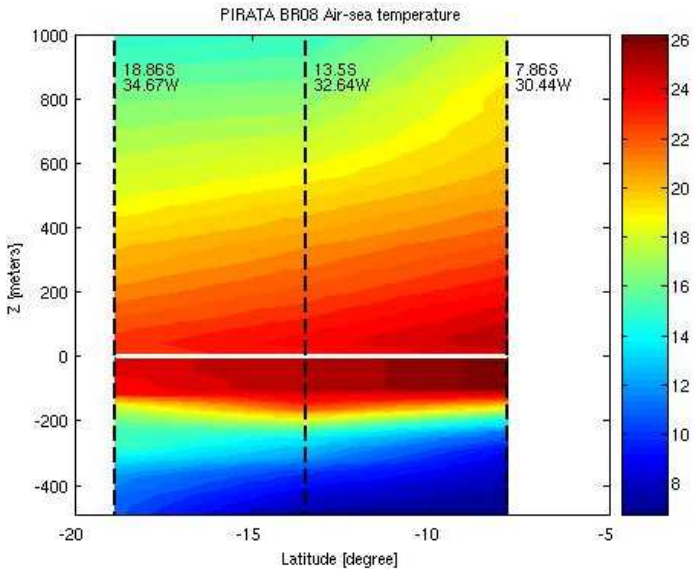


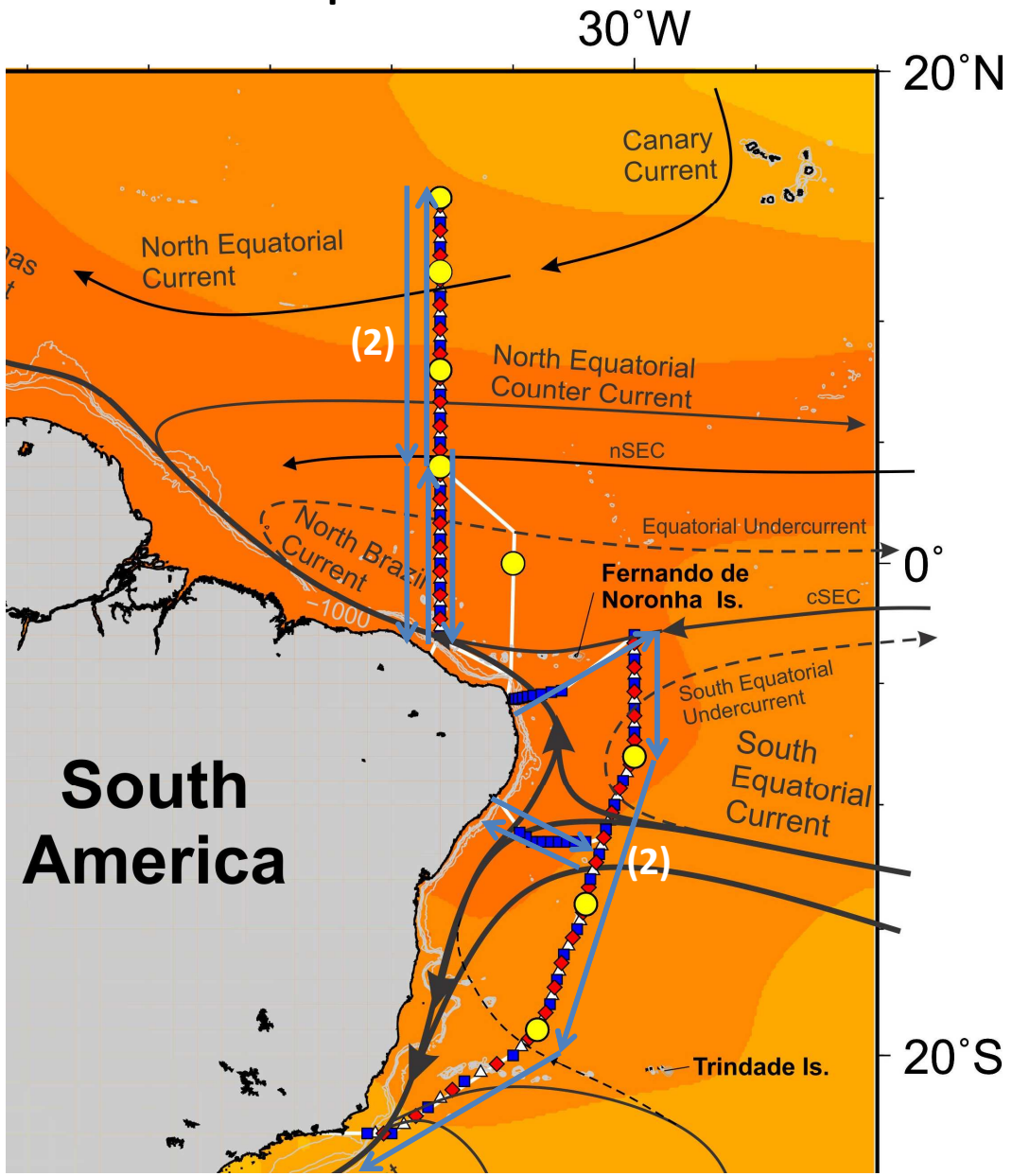
PIRATA-BR XVII – NPqHo Vital de Oliveira:

"Western Tropical Atlantic Experiment"

Upper Ocean-Atmosphere
Repeated Sampling Strategy:

180 T-S profiles
9,000 Km underway: currents, pCO2, atmospheric particles deposition marine microbiology;
Micrometeorology turbulent fluxes;
66 radiosondings





PIRATA-BR XVII – NPqHo Vital de Oliveira:

"Western Tropical Atlantic Experiment"

FULL DEPTH OCEAN SAMPLING

60 stations down to 10m of the ocean floor

Currents

Temperature

Salinity

Oxigen

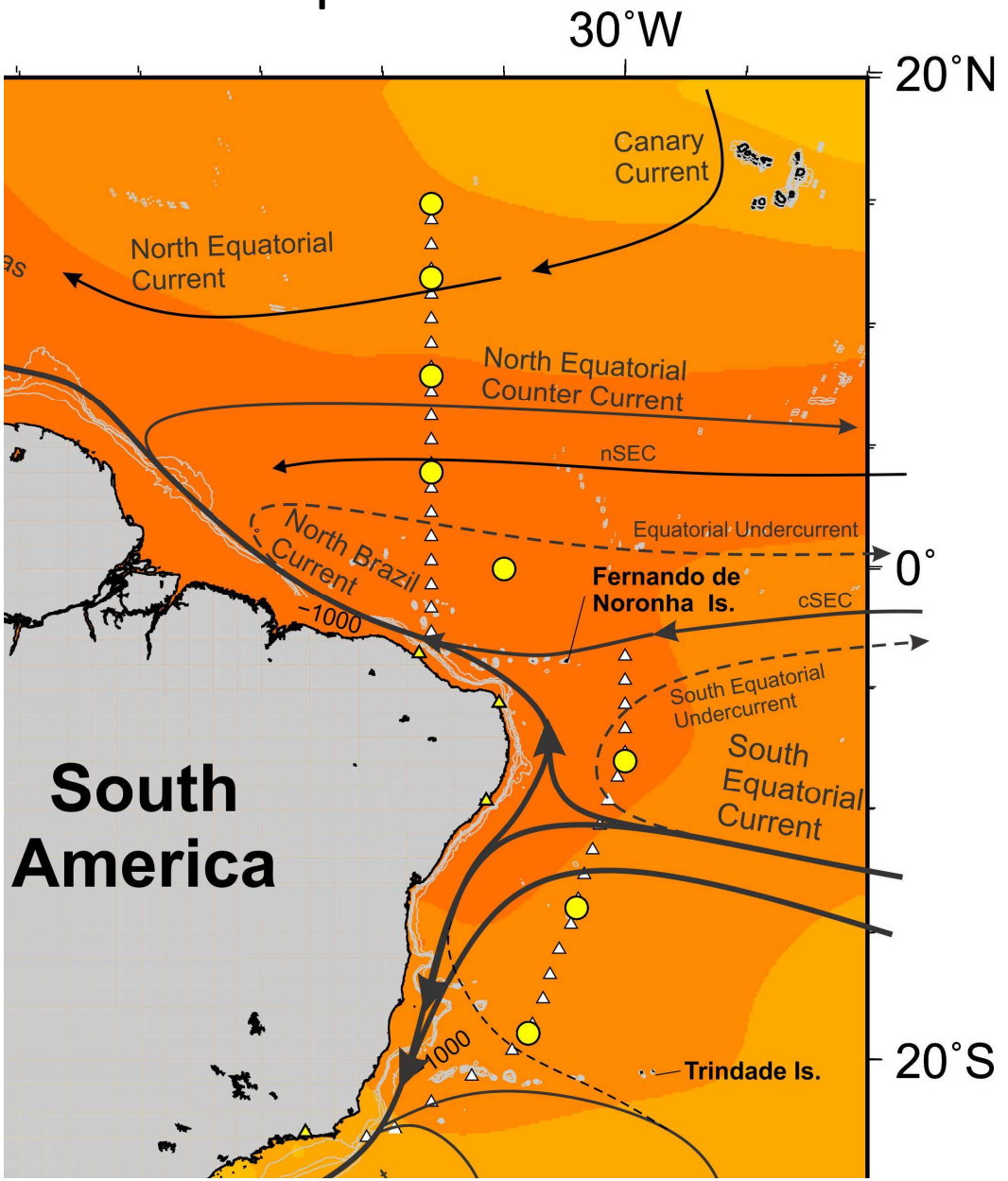
CO2

Marine Biology

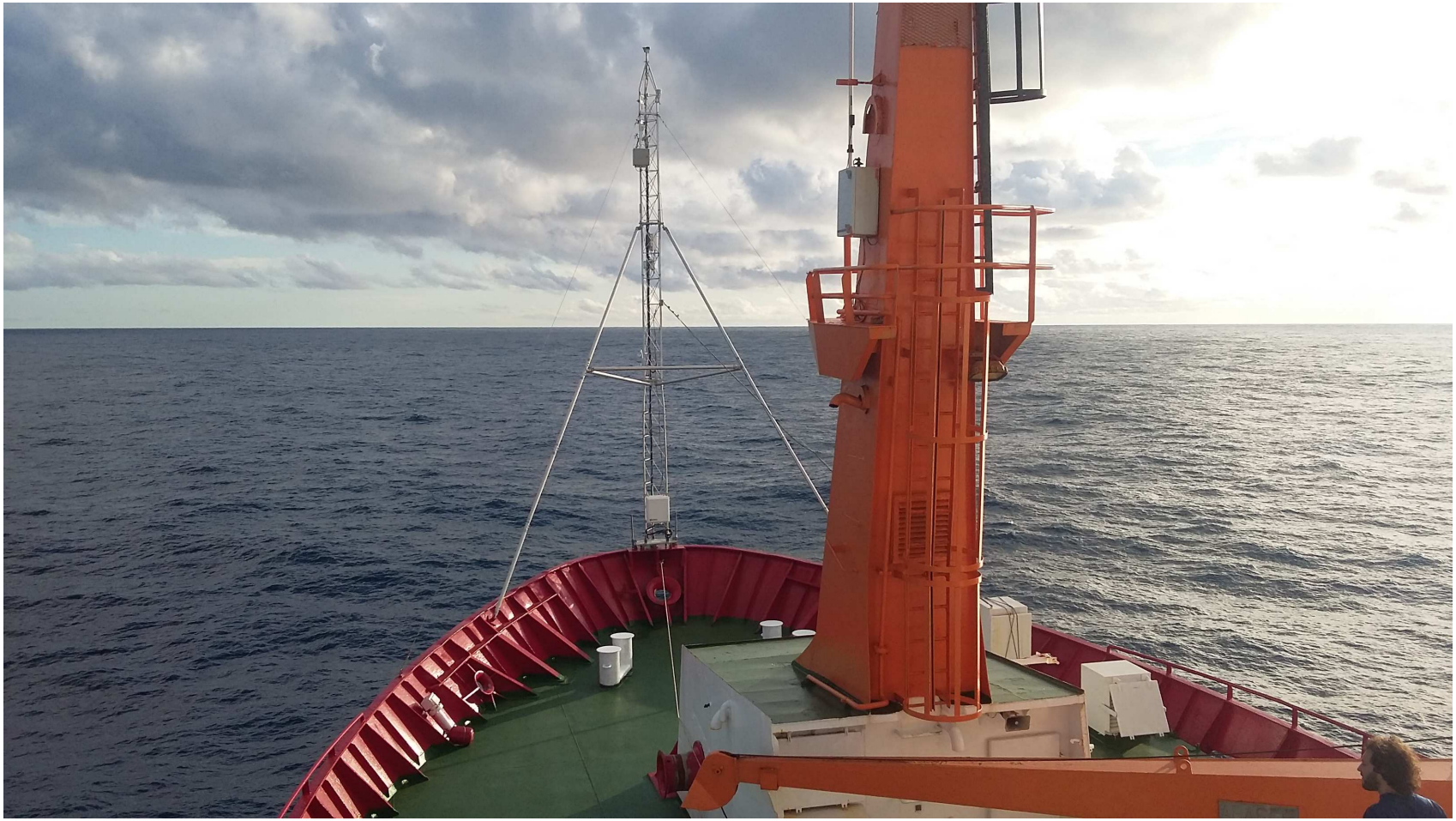
Terras Raras

Bottom mixing layer

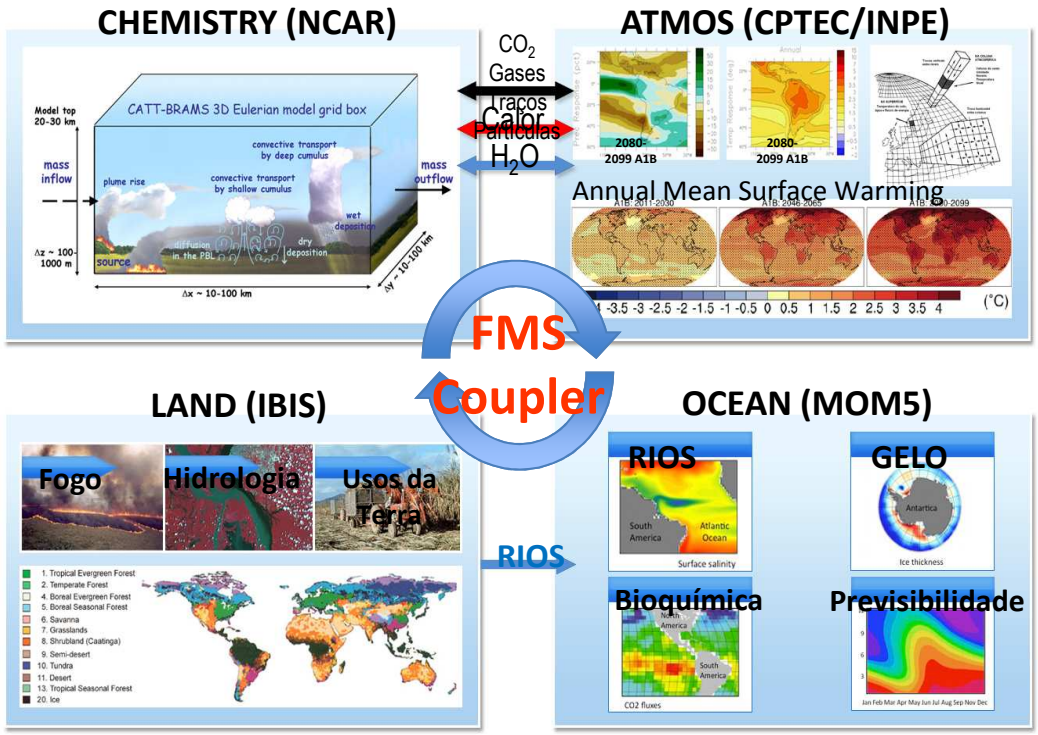
…

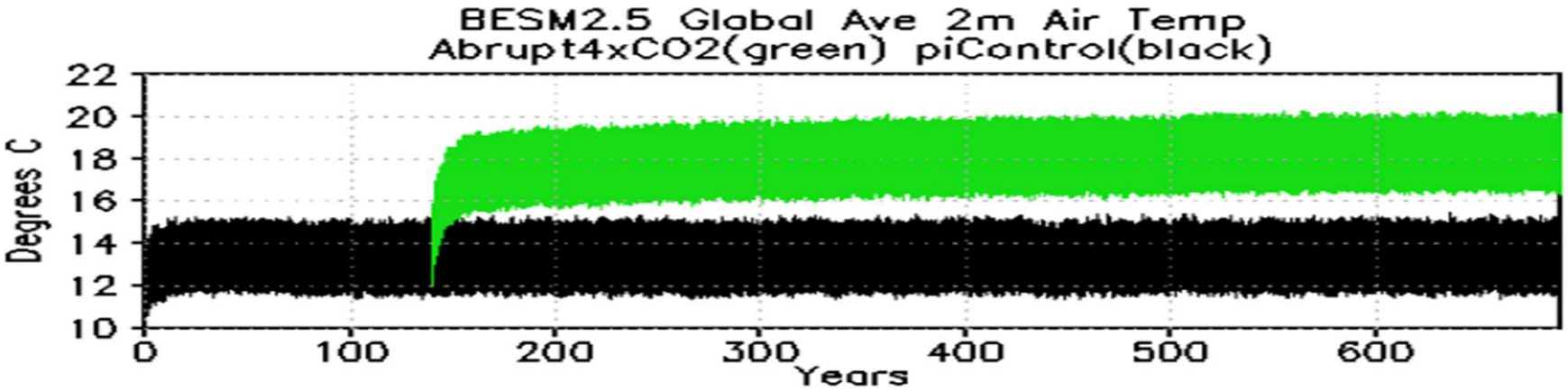


Micrometeorology Tower to measure turbulent fluxes at the air-sea interface

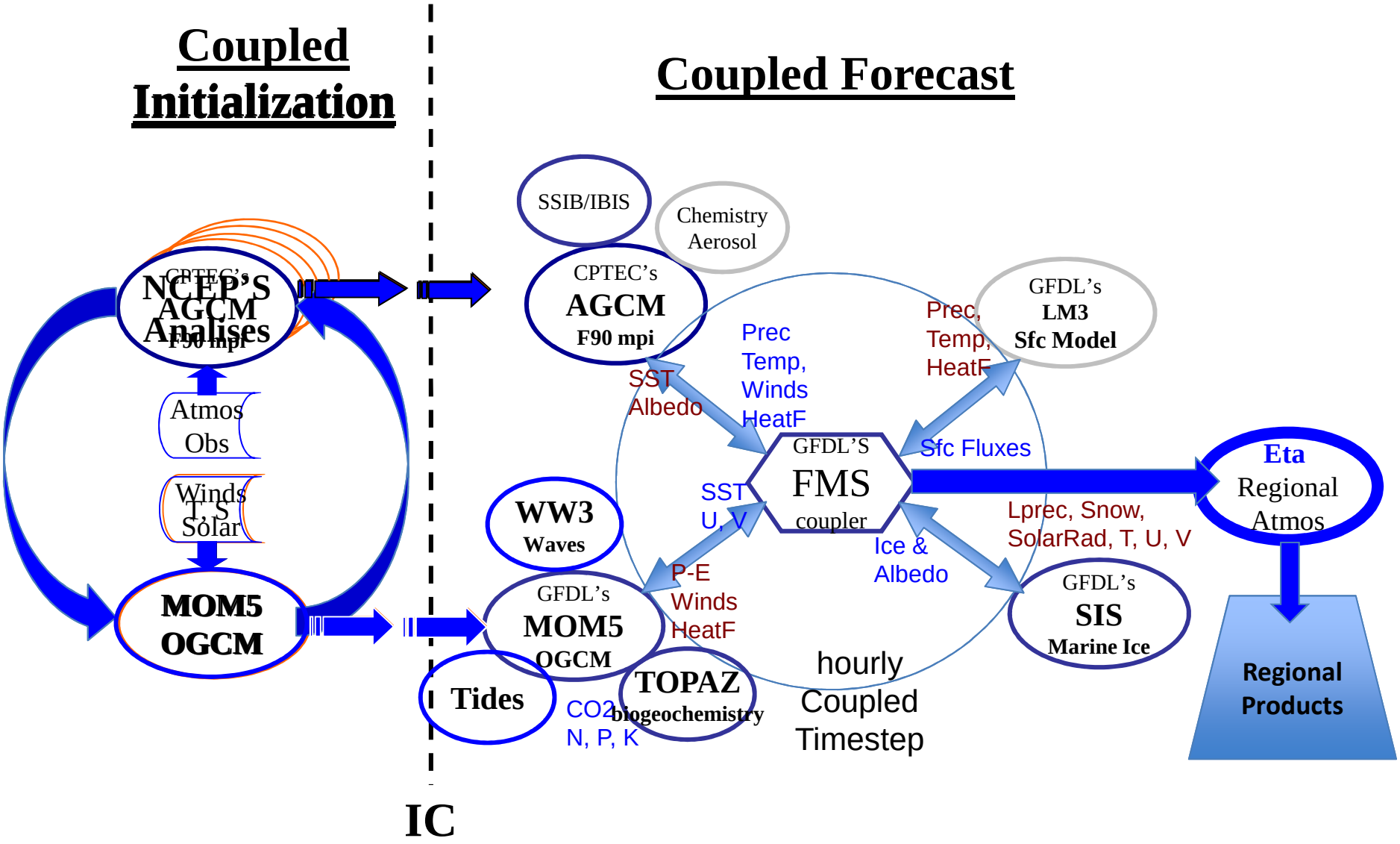


BRAZILIAN EARTH SYSTEM MODEL – BESM

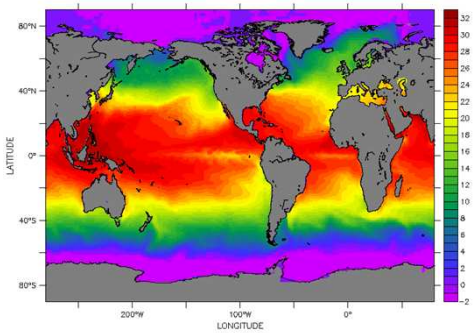




BESM
Climate Forecast System



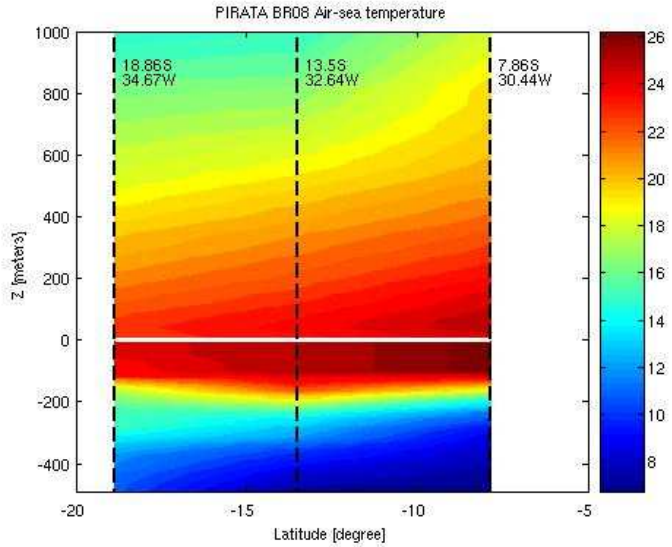
FRE: Tool set developed by NOAA/GFDL for the automation of Earth System Model compilation-execution-plotting-validation of model results; implemented for the Brazilian Earth System Model (BESM) at INPE/CPTEC supercomputer CRAY EX6.

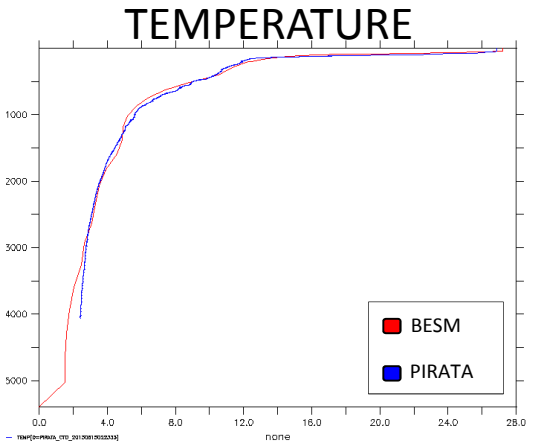


The whole process in three commands:

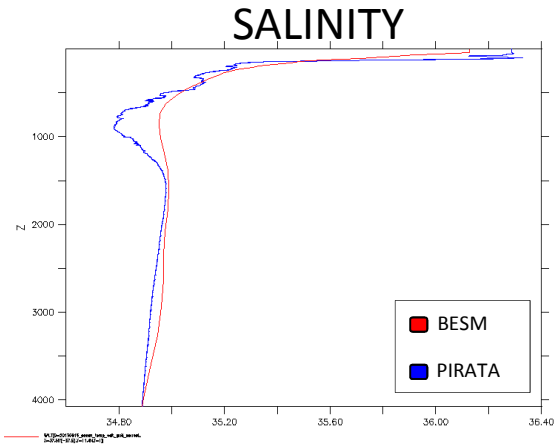
- **FREmake**
- **FRErun**
- **FREvalidity**

Allow scientists and students to do numerical simulations with BESM at INPE's supercomputer, both locally and remotely with extreme easiness and flexibility of use.





Temperature BESM vs PIRATA

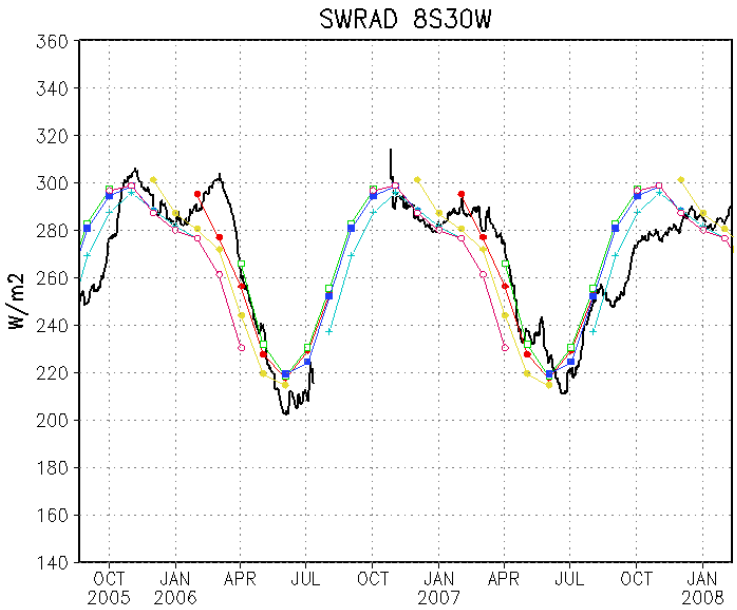


Salinity BESM vs PIRATA

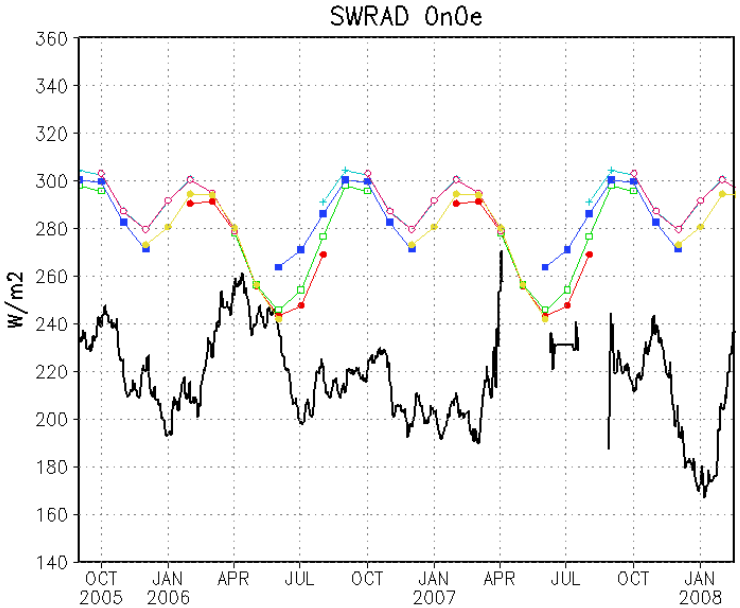
Condições para o dia 15 de junho de 2013, na posição lat:11.487, lon -37.996

BESM simulated & PIRATA observed SW Radiation

8S 30W

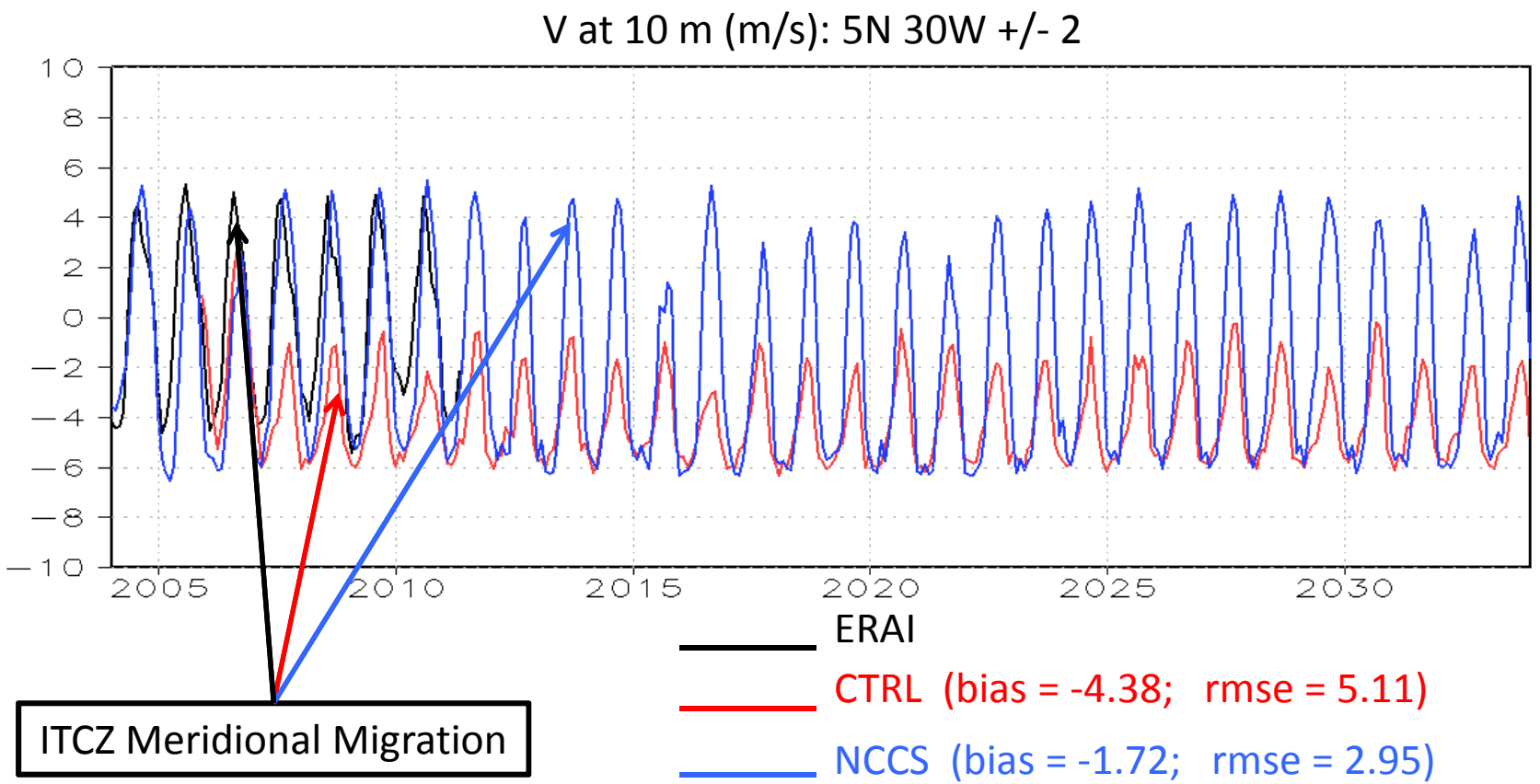


0N 0E



Courtesy: P. Nobre (2008)

BESM Atlantic ITCZ simulations

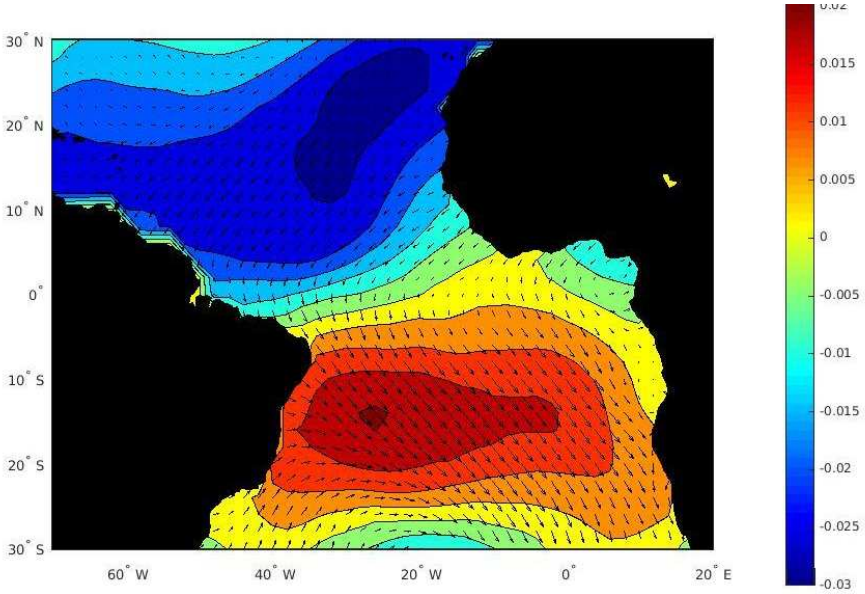


Bottino and Nobre (2017), Submitted

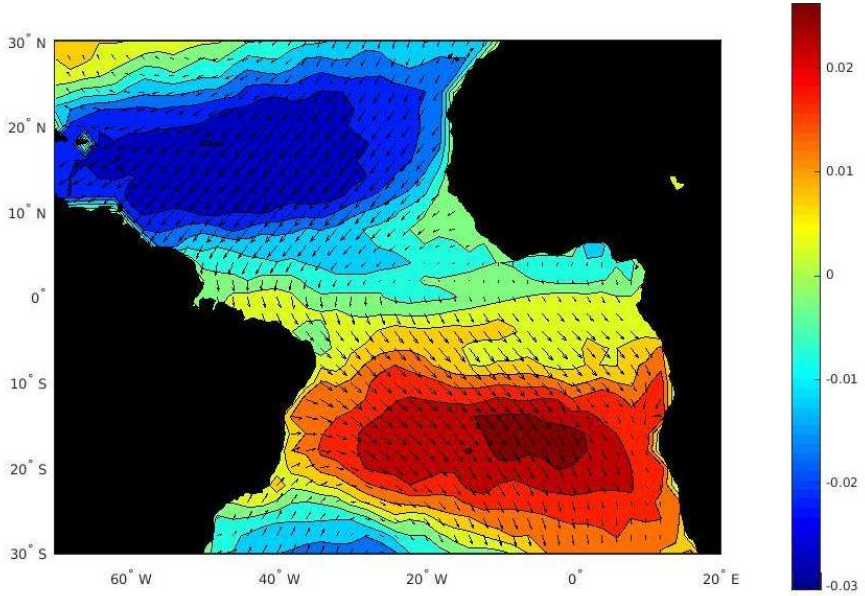
Atlantic Meridional Mode

SST, Taux, Tauy Joint EOF1

ERSSTv4 (9.3%)



BESM2.5 historical run (11.4%)



S. Veiga et al (2017) in preparation

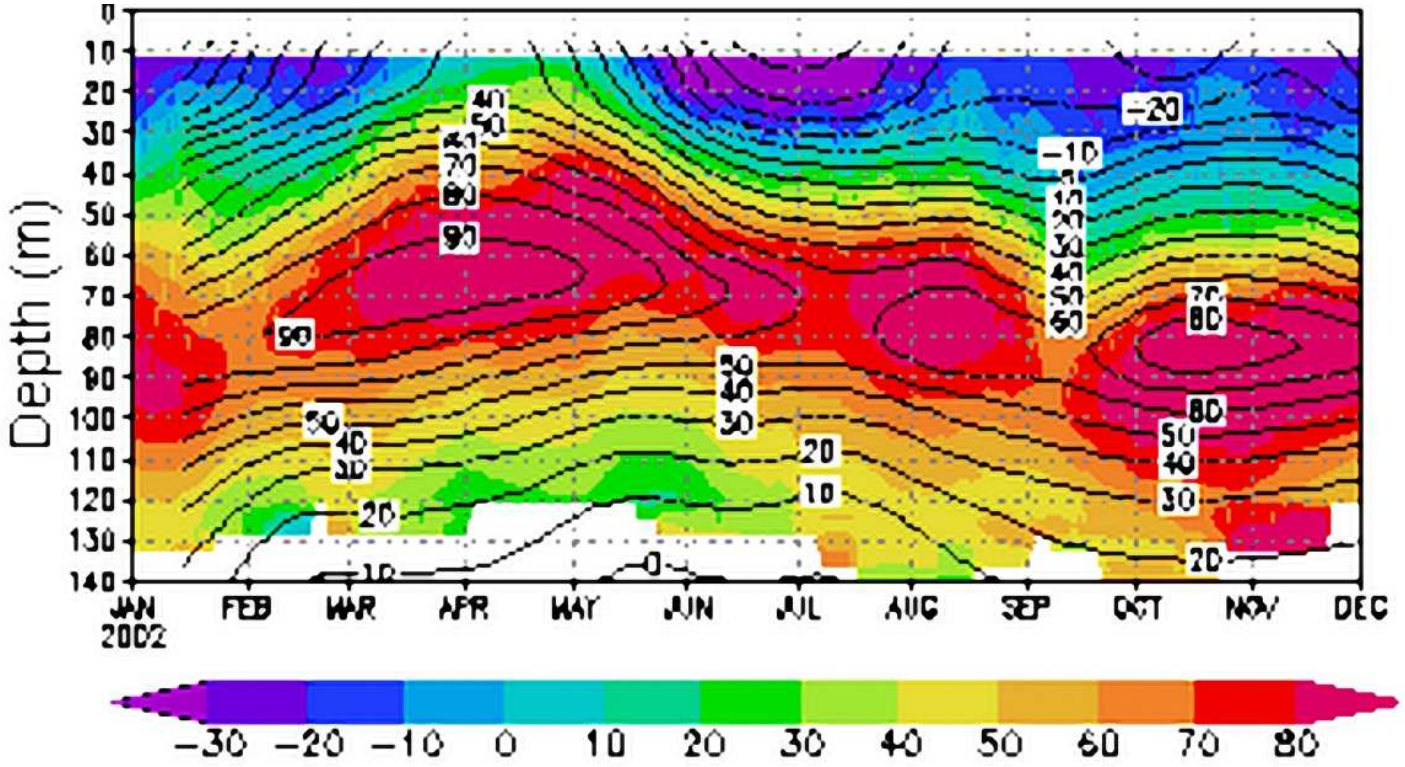
GEOPHYSICAL RESEARCH LETTERS, VOL. 32, L10617, doi:10.1029/2004GL022206, 2005

The Atlantic Equatorial Undercurrent: PIRATA observations and simulations with GFDL Modular Ocean Model at CPTEC

Emanuel Giarolla, Paulo Nobre, Marta Malagutti, and Luciano Ponzi Pezzi

Centro de Previsão de Tempo e Estudios Climaticos, Instituto Nacional de Pesquisas Espaciais, Sao José dos Campos, Brazil

Received 10 December 2004; revised 25 March 2005; accepted 29 March 2005; published 28 May 2005.



Giarola et al. (2005)

Ocean Dynamics (2015) 65:831–843
DOI 10.1007/s10236-015-0836-8

Equatorial Atlantic Ocean dynamics in a coupled ocean–atmosphere model simulation

Emanuel Giarolla[1] · Leo San Pedro Siqueira[2] · Marcus Jorge Bottino[3] · Marta Malagutti[2] · Vinicius Buscioli Capistrano[2] · Paulo Nobre[2]

Received: 28 July 2014 / Accepted: 1 April 2015 / Published online: 19 April 2015

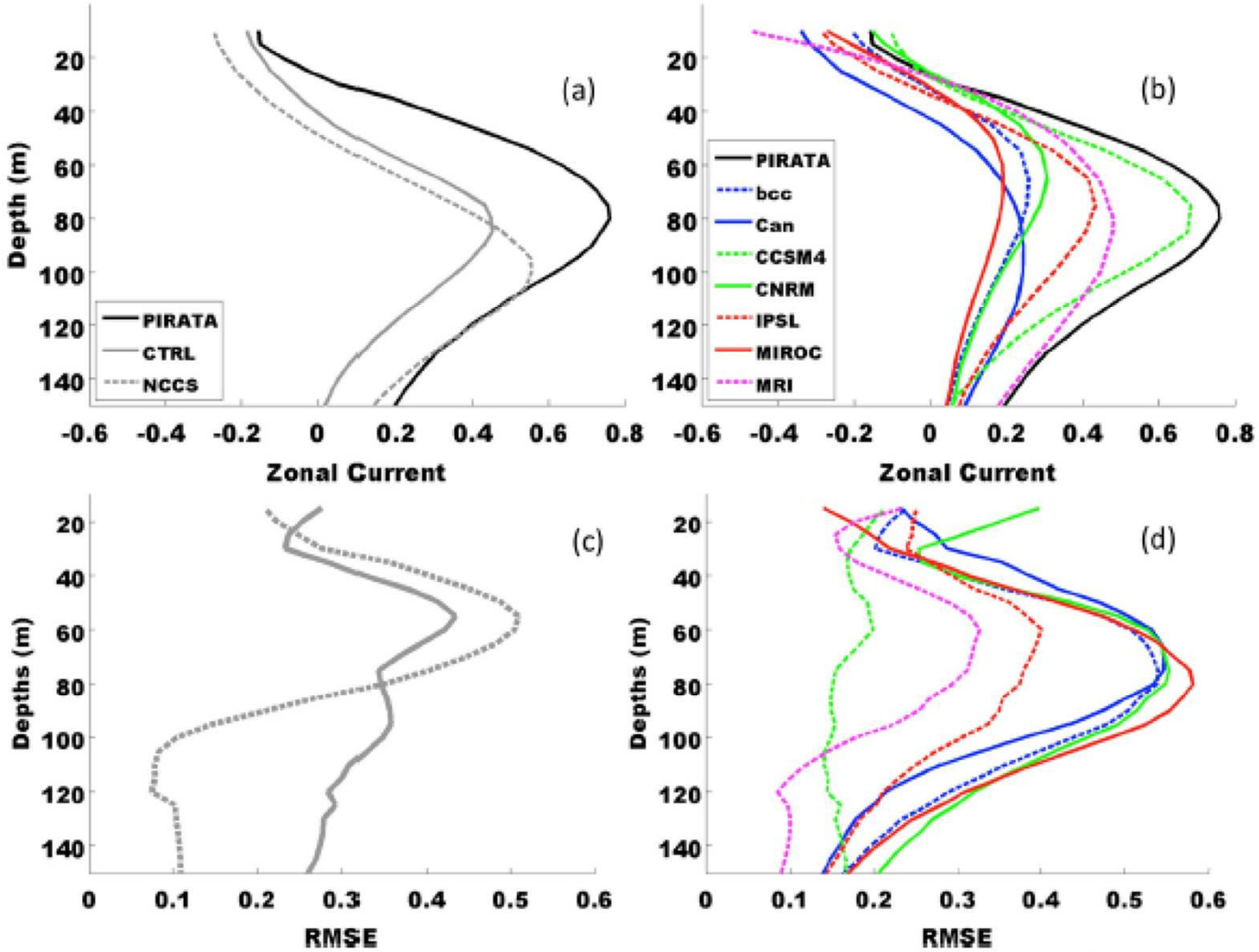


Fig. 9 (**a**) Mean zonal current at 0° N, 23° W. The solid black line represents PIRATA ADCP. The other lines represent the CTRL (solid grey) and NCCS experiments (dashed grey), and (**b**) the other CMIP5 models (as indicated by the legend) in m s^{-1}, and the root mean square errors along depths computed between PIRATA and (**a**) model results for CTRL, NCCS and (**b**) other CMIP5 models (same legends)

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Oceans
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Equatorial Undercurrent and North Equatorial Countercurrent at 38°W: A new perspective from direct velocity data

D. F. Urbano, R. A. F. De Almeida, P. Nobre

First published: 30 April 2008 Full publication history

DOI: 10.1029/2007JC004215 View/save citation

Cited by: 10 articles Citation tools

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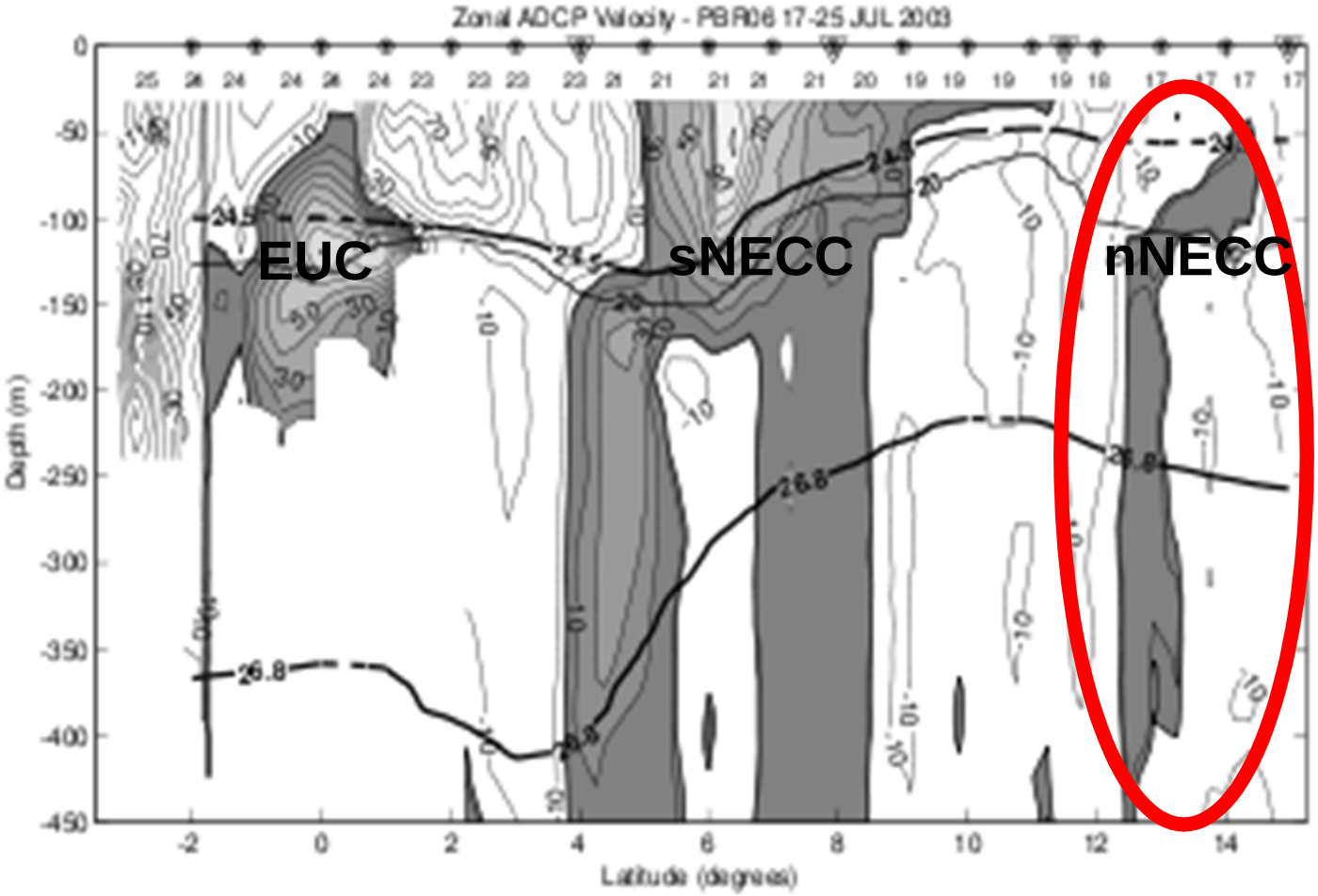
Volume 113, Issue C4
April 2008

Urbano et al. (2008, JGR)

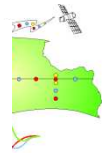
Zonal Currents Vertical Profiles

revealed by Noc. ANTARES ADCP PIRATA Cruises Data



First observational evidence of NECC's northern branch, with ADCP PIRATA Data

Urbano et al. (2008, JGR)



Coupled Ocean–Atmosphere Variations over the South Atlantic Ocean

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ABSTRACT

The impact of ocean–atmosphere interactions on summer rainfall over the South Atlantic Ocean is explored through the use of coupled ocean–atmosphere models. The Brazilian Center for Weather Forecast and Climate Studies (CPTEC) coupled ocean–atmosphere general circulation model (CGCM) and its atmospheric general circulation model (AGCM) are used to gauge the role of coupled modes of variability of the climate system over the South Atlantic at seasonal time scales. Twenty-six years of summer [December–February (DJF)] simulations were done with the CGCM in ensemble mode and the AGCM forced with both observed sea surface temperature (SST) and SST generated by the CGCM forecasts to investigate the dynamics/thermodynamics of the two major convergence zones in the tropical Atlantic: the intertropical convergence zone (ITCZ) and the South Atlantic convergence zone (SACZ). The results present both numerical model and observational evidence supporting the hypothesis that the ITCZ is a thermally direct, SST-driven atmospheric circulation, while the SACZ is a thermally indirect atmospheric circulation controlling SST variability underneath—a consequence of ocean–atmosphere interactions not captured by the atmospheric model forced by prescribed ocean temperatures. Six CGCM model results of the Ensemble-based Predictions of Climate Changes and their Impacts (ENSEMBLES) project, NCEP–NCAR reanalysis data, and oceanic and atmospheric data from buoys of the Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) Project over the tropical Atlantic are used to validate CPTEC's coupled and uncoupled model simulations.

Nobre et al. (2012a, JClimate)

TABLE 1. ACCs between surface air temperature (SAT), sea surface temperature (SST), rainfall (PREC), and downward shortwave radiation (SWR) for the PIRATA buoys at 8°S, 30°W and 19°S, 34°W. Daily values smoothed with a 30-day-running-mean filter for the DJF periods of 2005–10, totaling 450 pairs of data for each time series. Cross-correlation values greater than 0.35 (italic) [0.6 (boldface)] are statistically significant at the 90% (99%) level according to a one-sided Student's *t* test with 15 degrees of freedom.

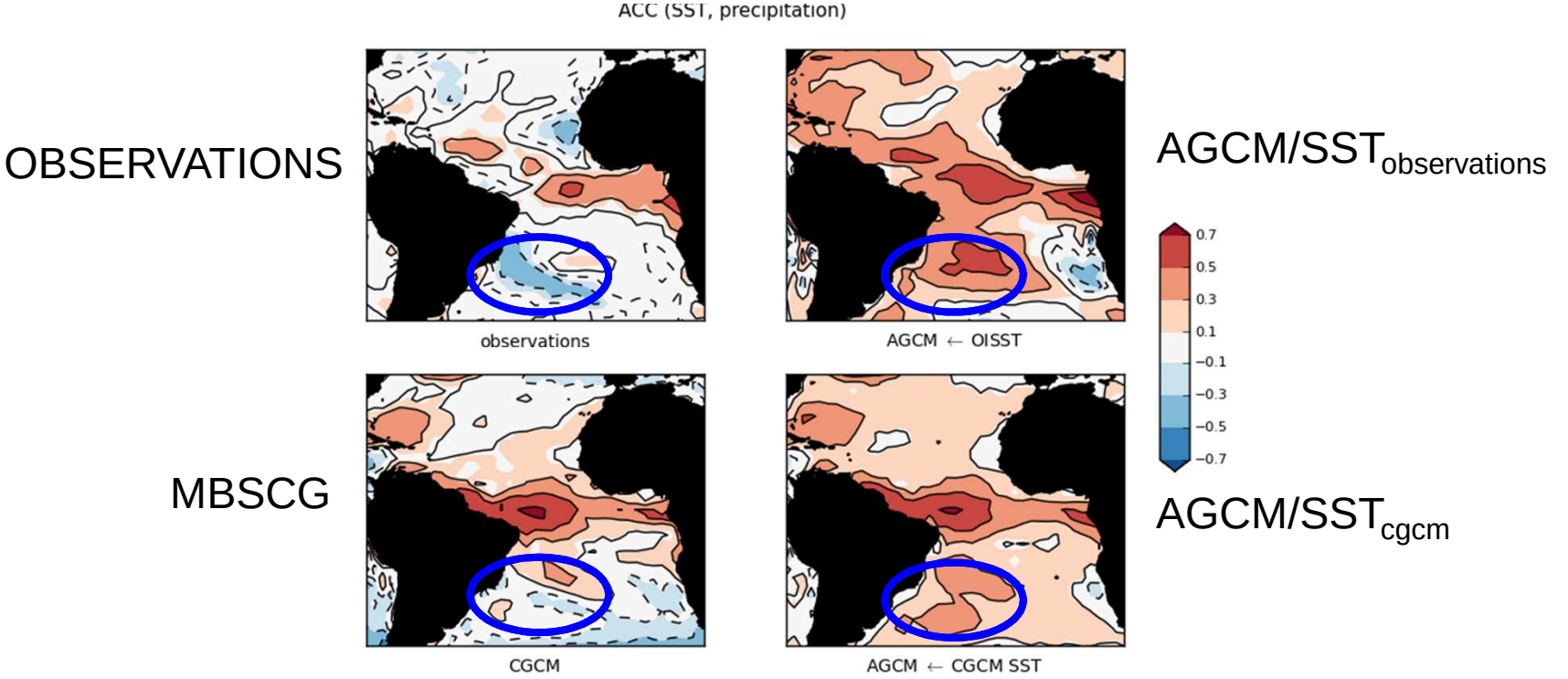
Cross correlation	Buoy at 8°S, 30°W	Buoy at 19°S, 34°W
SAT–SST	**0.91**	**0.94**
SWR–PREC	**−0.64**	**−0.74**
SAT–SWR	*−0.38*	*0.49*
SST–SWR	−0.18	*0.41*
SAT–PREC	*0.56*	−0.32
SST–PREC	0.33	−0.19

the AGCMs, the results are only marginally statistically significant over the area of the SACZ. Yet, one could expect that the more physically sound representation of the SACZ dynamics and thermodynamics by the CGCM can leave its imprint on rainfall predictability over the southwestern Atlantic. Figure 5 shows DJF rainfall hindcast skill as measured by ACC between observed and simulated rainfall. The AGCM runs forced by OISST (Fig. 5a) depict the same robust correlation pattern of positive correlations along the equatorial area and negative correlations over the SACZ area, reproducing previous results that used AGCMs forced by observed SSTs to simulate the SACZ (Nobre et al. 2006; Robertson et al. 2003). It is noteworthy, however, that the strong negative ACC shown for the AGCM runs forced by observed SST is drastically reduced on the

Nobre et al. (2012a, JClimate)

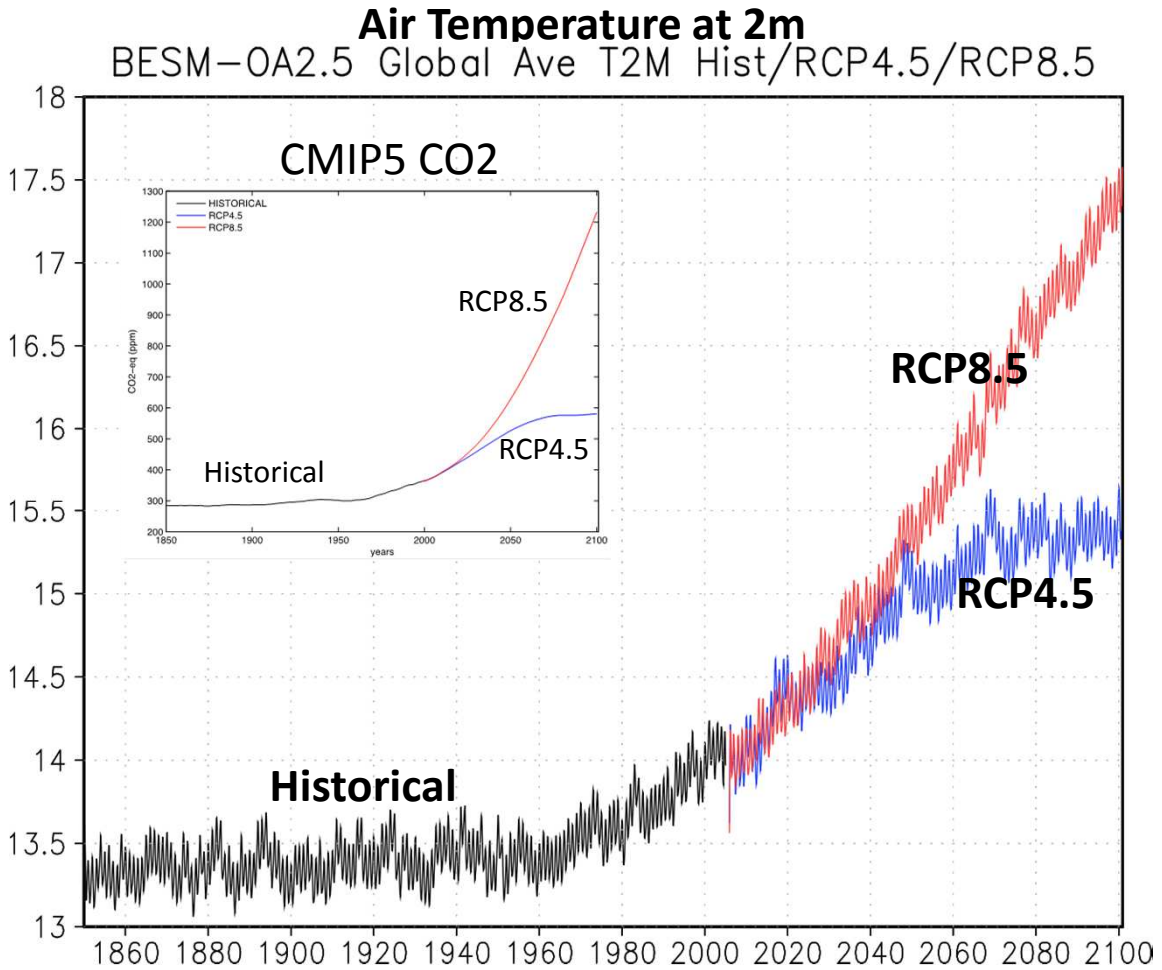
BESM Predicts SACZ over colder Waters

SST-RAINFAL ANOMALY CORRELATIONS



Nobre et al. (2012a, JClimate)

BESM2.5 CMIP5 Runs 1850-2100

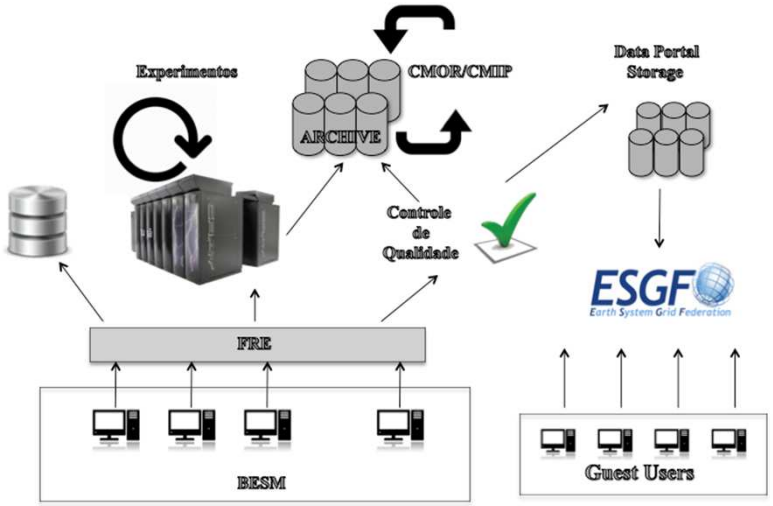


Courtesy: V. Capistrano, INPE

BESM CMIP5 scenarios

available through ESGF at:

https://dm2.cptec.inpe.br/projects/esgf-inpe/



http://besm.ccst.inpe.br/produtos/

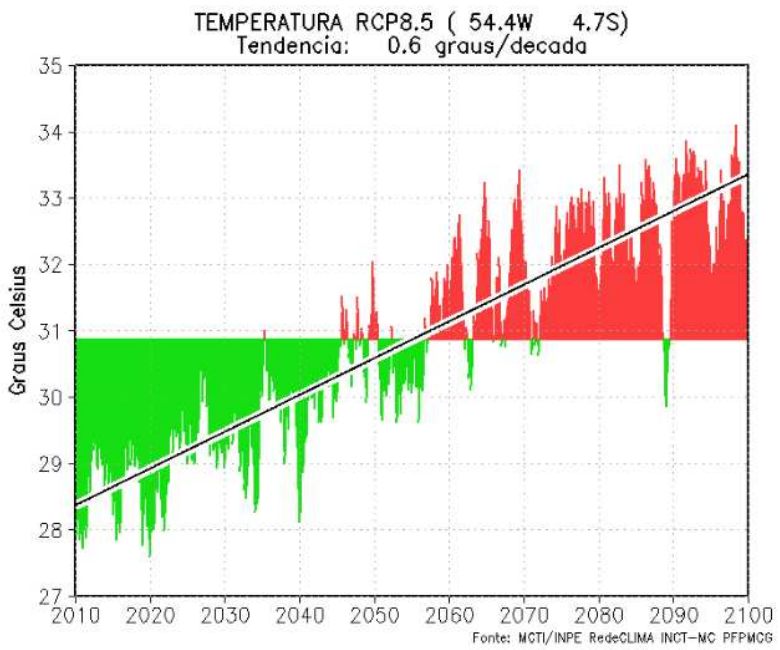
BESM
Brazilian Earth System Model

Pesquisar

Home | Sobre BESM | ESGF | Notícias | Produtos | Equipe BESM

Produtos

Valor médio para todo período de 2010 a 2100



Selecione as opções:

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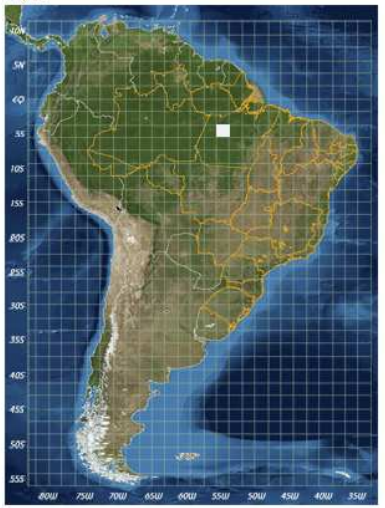


Cenário: RCP8.5 Variável: temperatura

The PIRATA Project in Brazil:

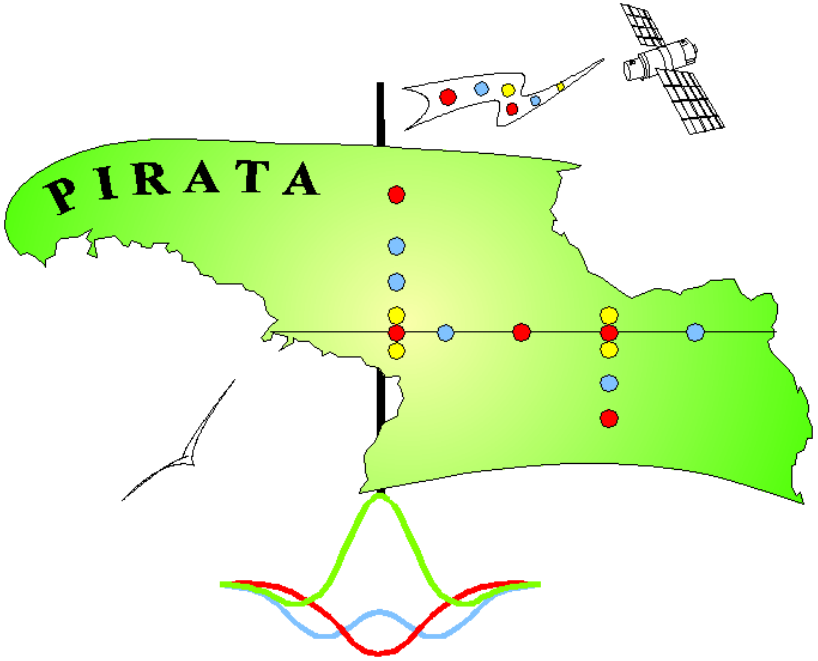
- **Brazilian contribution:** understanding the Atlantic Ocean role:
  - On the interannual climate variability over South America
  - On the global climate change.
- **Utilizes national technical capabilities for:**
  - Ocean data collection with Brazilian Satellites
  - Data processing at INPE/CPTEC
  - Marine operations with Brazilian Navy
- **Institutional Base:**
  - In Brazil: MCTIC-INPE, DHN, IOUSP, UFPE, INMET, FUNCEME, GOOS/BRASIL, CIRM
  - Abroad: IRD, MeteoFrance & NOAA
- **Endorsements: CLIVAR e OOPC**.

The Vision

- **PIRATA-BR:**
  - NPqHo Vital de Oliveira
  - MultiScience
  - Multi institutional;
- **International projection:**
  - Public access to PIRATA data;
  - Endorsements from CLIVAR, OOPC, GEOTRACES
- **Brazilian capacity to monitor and predict the blue ocean**
  - Development of the Brazilian Earth System Model BESM
  - Supercomputing capacity at INPE
  - Maintenance of DHN vessels

PIRATA 20 Years Celebration

1997-2017



November 5th-
10th 2017
FORTALEZA

PIRATA 1997-2017:
20 YEARS!
Bravo Zulu!