

Tropical Moored Arrays in the Atlantic and Indian Oceans (PIRATA and RAMA)

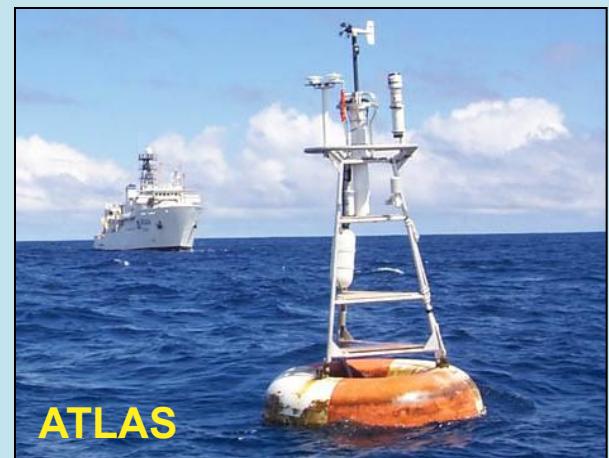
Renellys C. Perez

Kyla Drushka

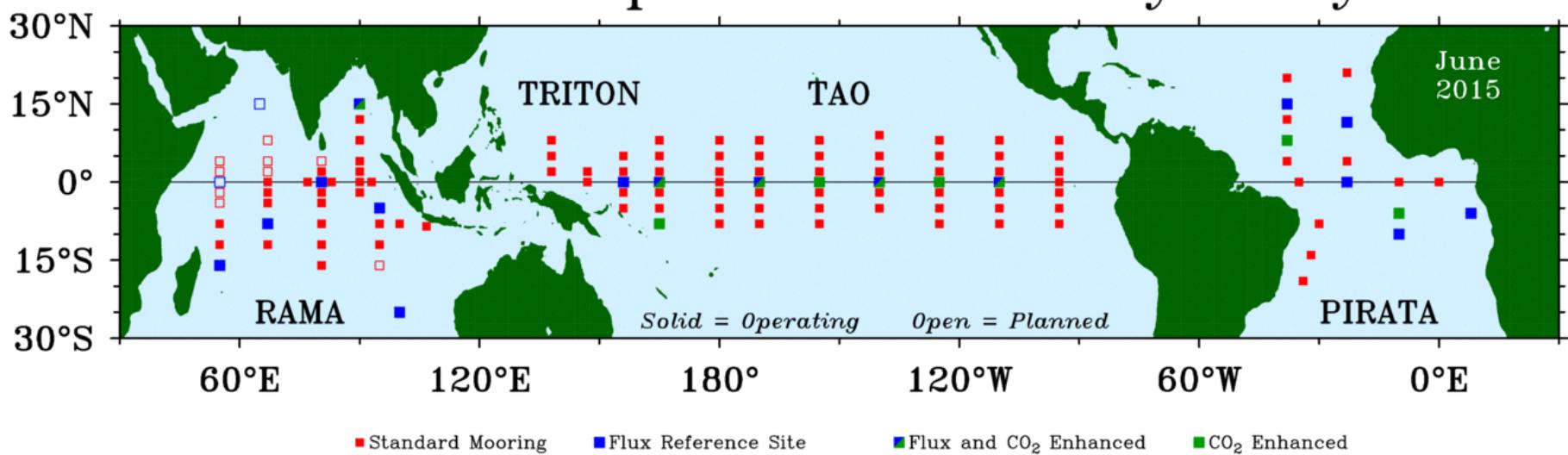
Information/slides for this presentation obtained from M. McPhaden

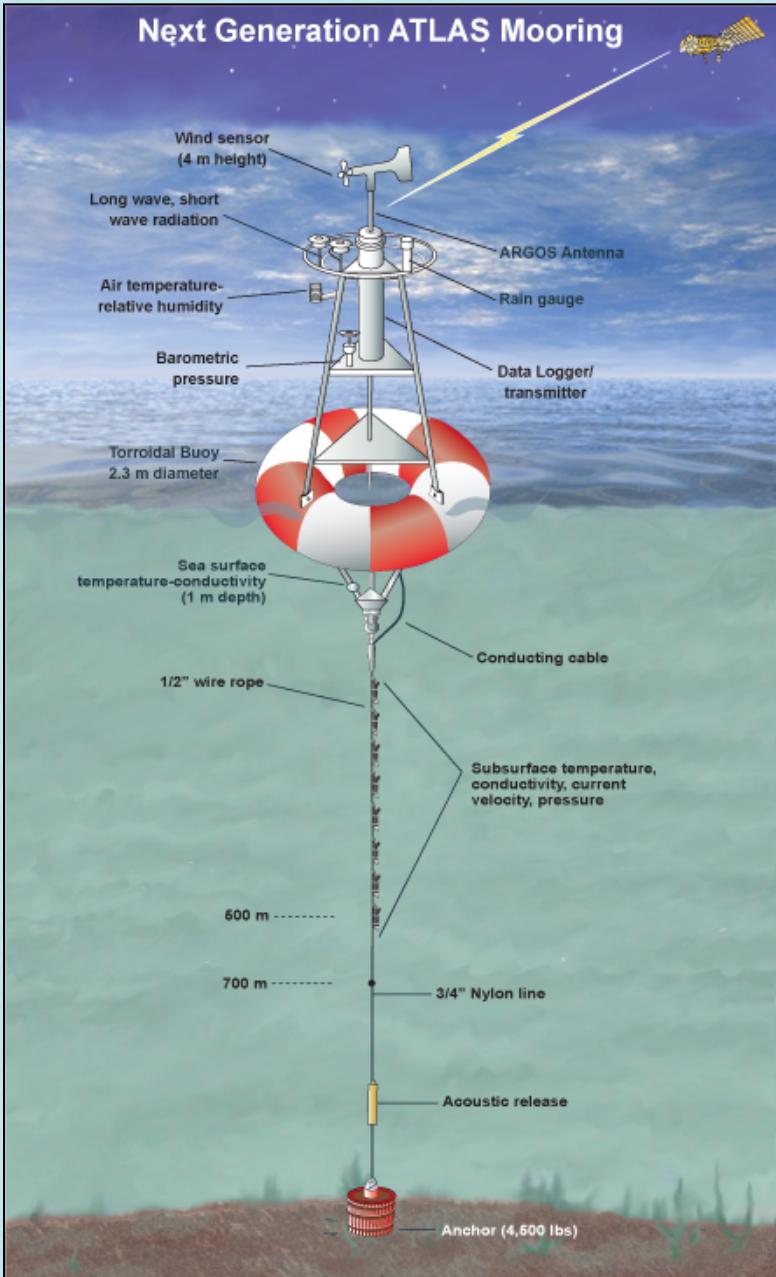
Global Tropical Moored Buoy Array:

A coordinated, sustained, multi-national effort to develop and implement moored buoy observing systems for climate research and forecasting throughout the global tropics, in support of DOC, NOAA, OAR, PMEL, and COD strategic plans



Global Tropical Moored Buoy Array





ATLAS Mooring:

- ✓ Rapid continuous sampling
- ✓ Relatively low cost
- ✓ Real-time data
- ✓ Ocean and atmosphere
- ✓ Platform of opportunity

Designed and built at PMEL

Original: 1984

Nextgen: 1995

T-Flex: 2015

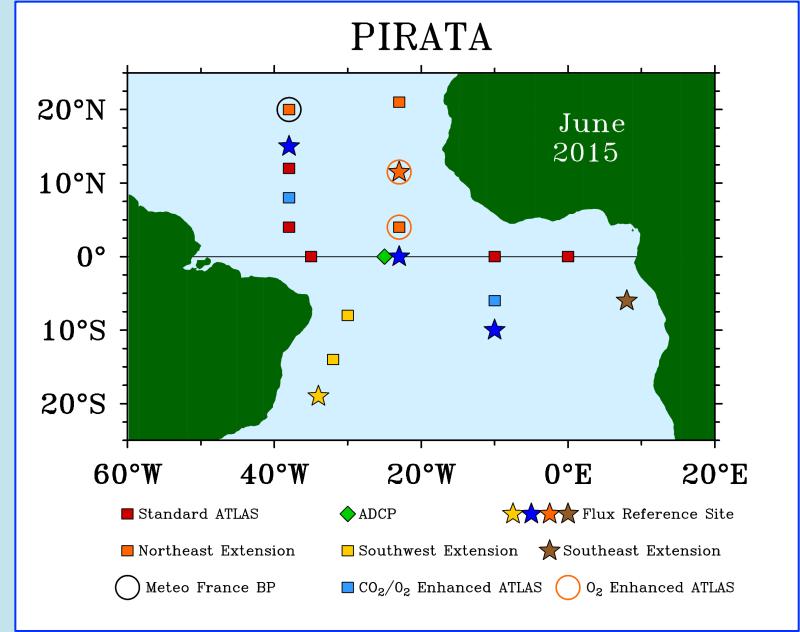
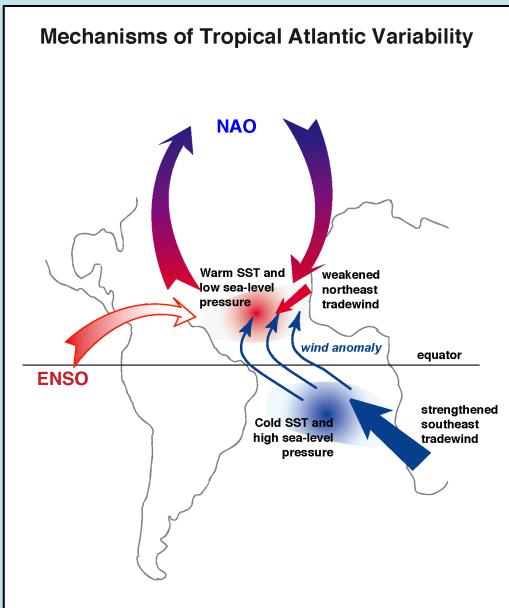
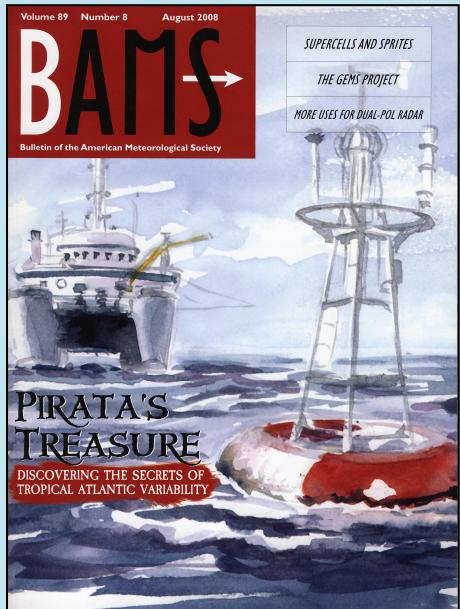
T-Flex Advantages:

- Commercially available components
- Argos → Iridium
- More flexibility to add new instruments
- Comparable or better data accuracy
- Decreased losses due to vandalism
- Improves GTS data latency

Tropical Atlantic: PIRATA



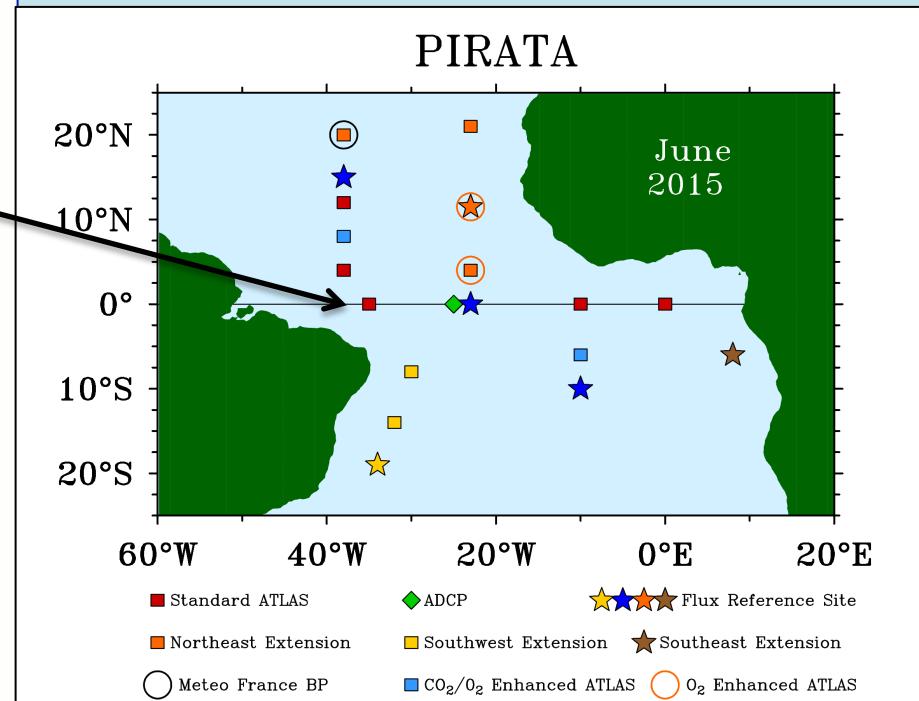
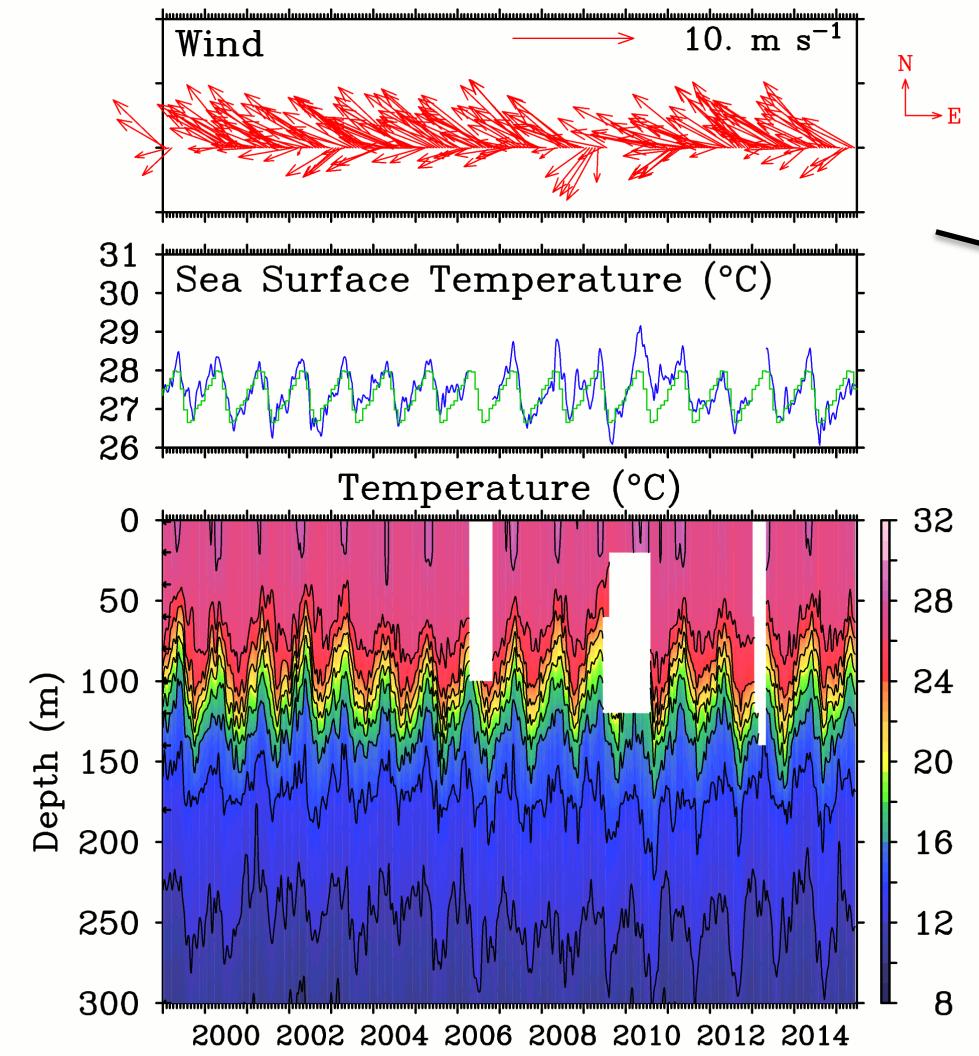
PIRATA: Centerpiece of the Tropical Atlantic Ocean Observing System



PIRATA: Prediction and Research Moored Array in the Tropical Atlantic

- ✓ Established in 1997 by France, Brazil and the US (NOAA/PMEL+AOML)
- ✓ Brazil & France provide logistic support & most ship time
- ✓ NOAA provides most mooring equipment & data processing

0° , 35°W
Monthly Wind and Temperature Data

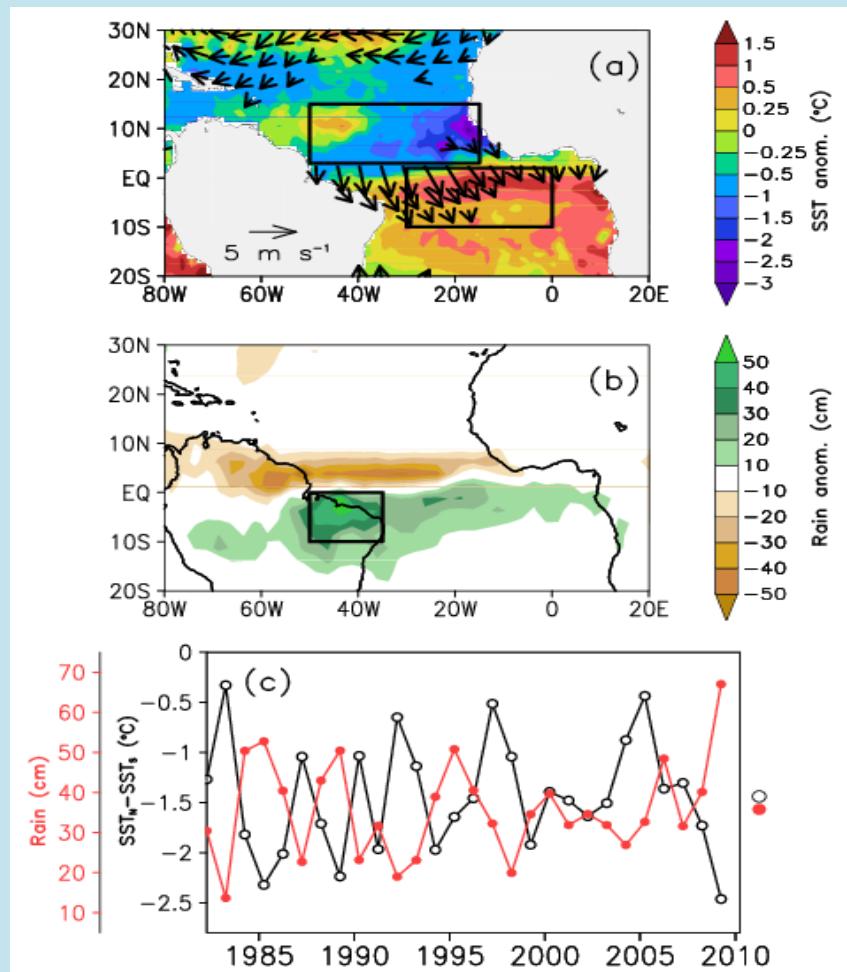


2009 Cooling Event

- Strong negative AMM event
- Caused intense flooding in Northern Brazil
- 2015 showing strong similarities
- PIRATA data used to examine oceans role in 2009, 2015

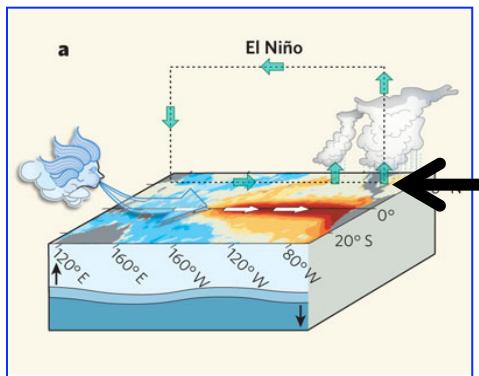


Slide courtesy of Allyson Rugg,
Hollings undergraduate scholar

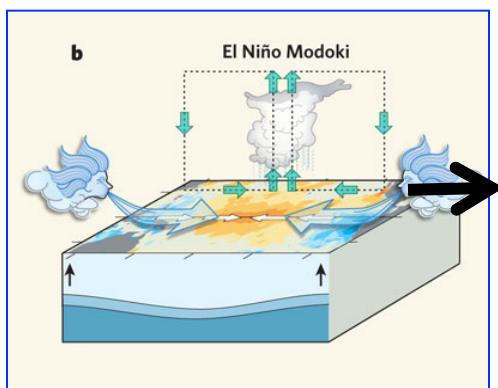


El Niño Effects on Tropical Atlantic and NE Brazil Rainfall

Eastern Pac El Niño

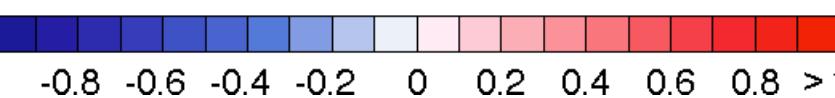


Central Pac El Niño

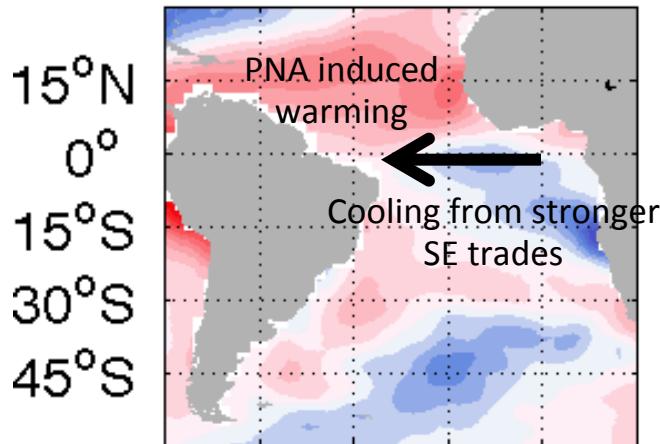


2011-2012 Severe drought in NE Brazil

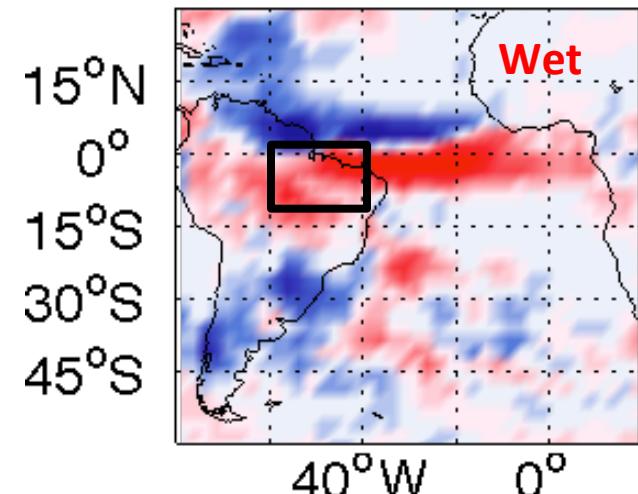
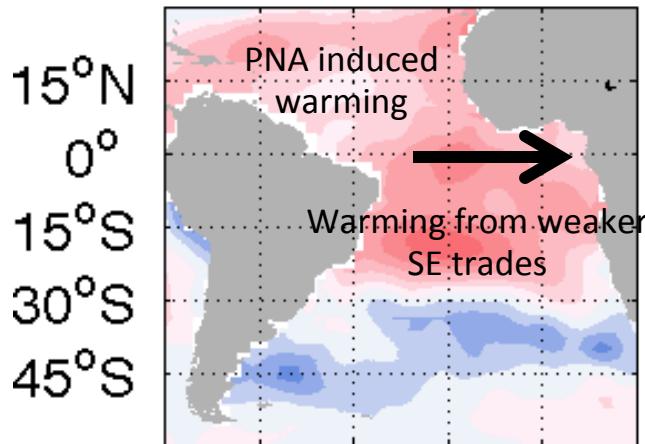
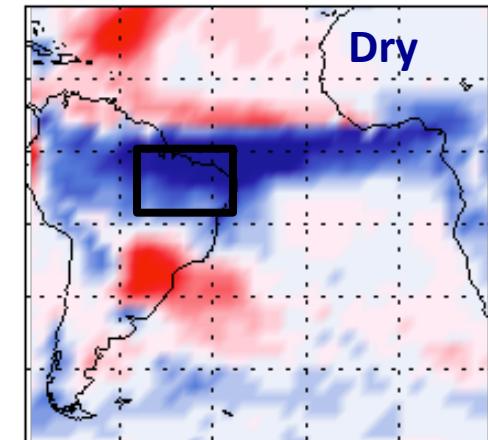
Rodrigues & McPhaden, 2014



March-May SST



March-May Rain

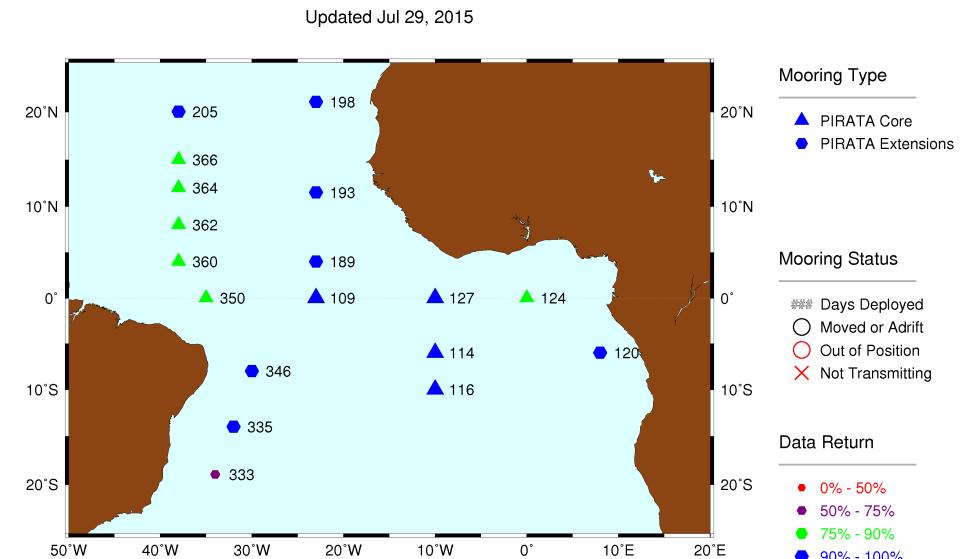


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PIRATA: Accomplishments

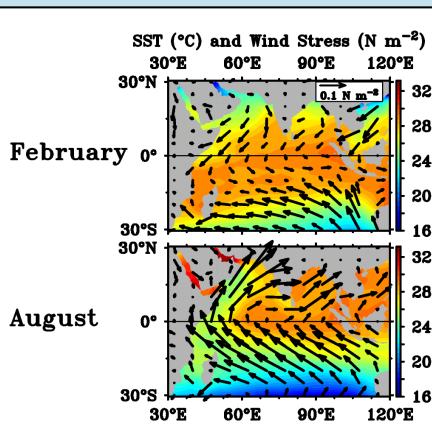
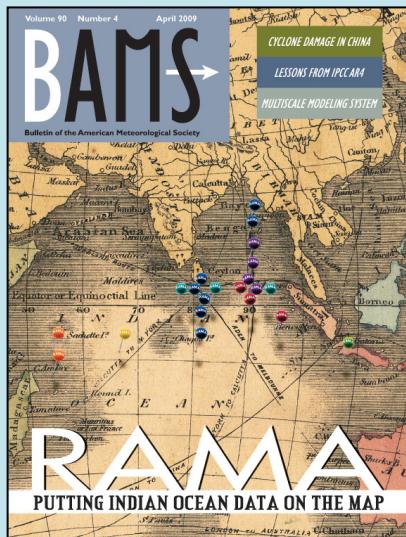
PIRATA

- TACE (2009-13) and EU PREFACE (2013-17) embedded PIRATA
- Enhancements implemented for NASA SPURS program (2012-13)
- O₂ maintained to 4°N & 12°N, 23°W
- Two new flux sites
- 6°S, 8°E re-established (2013)
- Ocean Tracking Network (OTN) partnership with Dalhousie U. (2013)
- OSU Chi-pods added (2014)
- TACOS Local Dynamics Experiment @ 4°N, 23°W (2015)
- US/FR/BR MOU renewed for 5-yr (2014)



Tropical Indian: RAMA

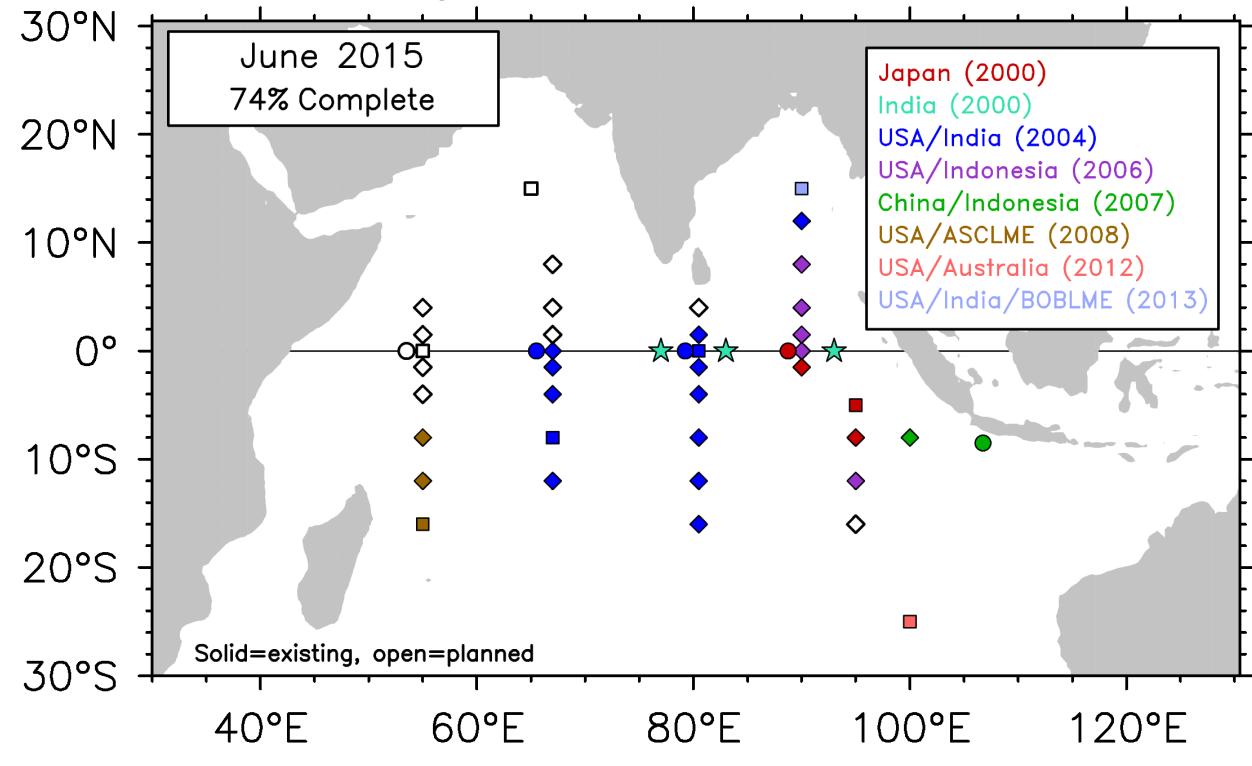
RAMA: Moored buoy array in the data-sparse Indian Ocean provides measurements to advance monsoon research and forecasting



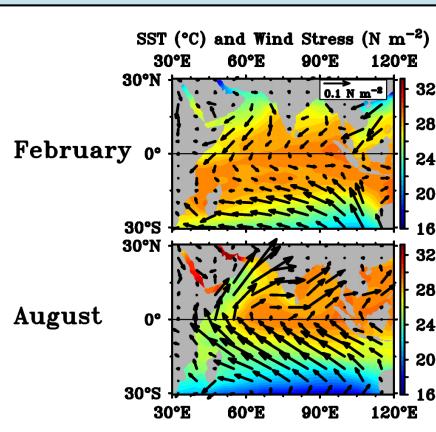
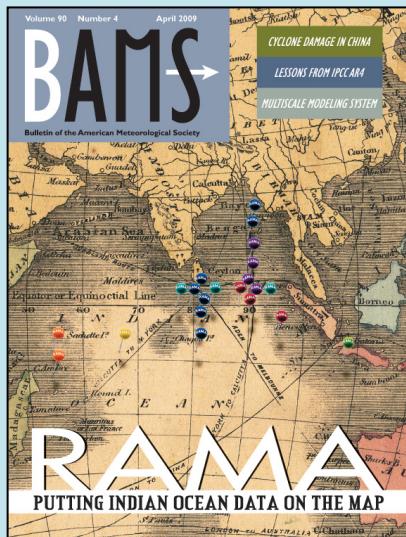
RAMA

Research Moored Array for African–Asian–Australian Monsoon Analysis and Prediction (RAMA)

◆ Surface Mooring ■ Flux Reference Site ● ADCP ★ Deep Ocean



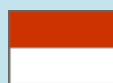
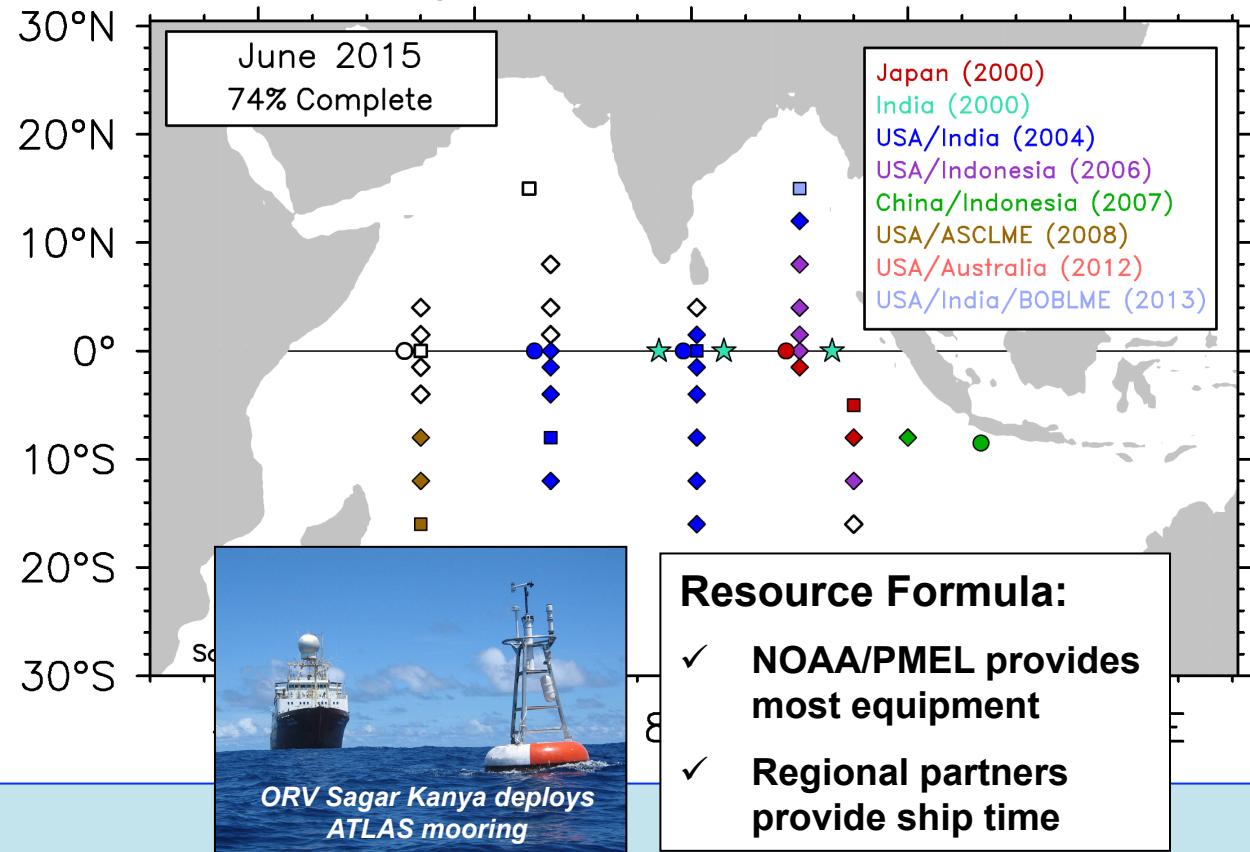
RAMA: Moored buoy array in the data-sparse Indian Ocean provides measurements to advance monsoon research and forecasting



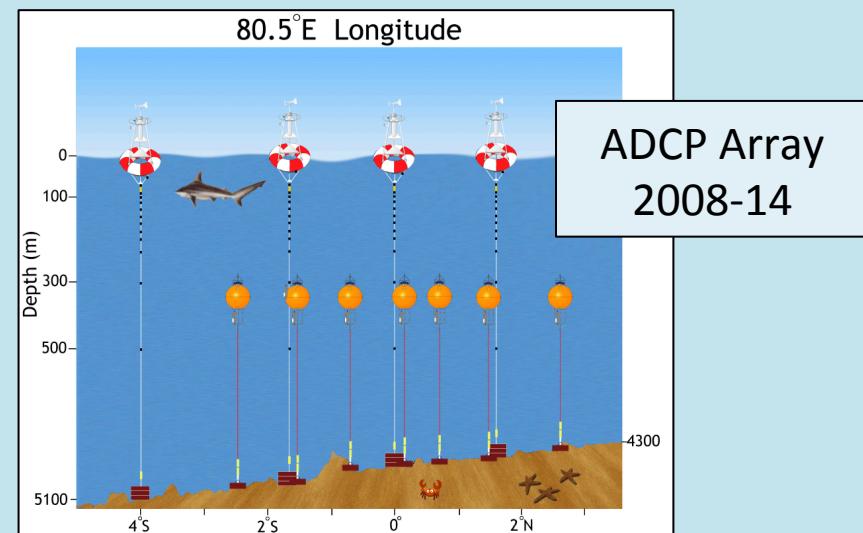
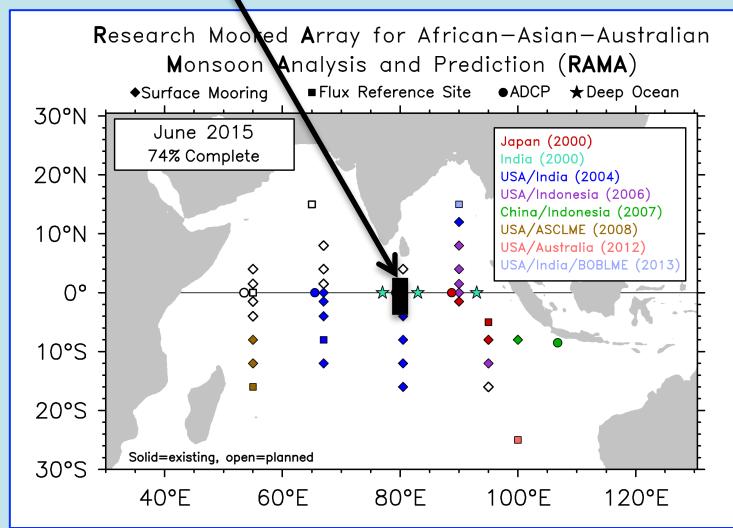
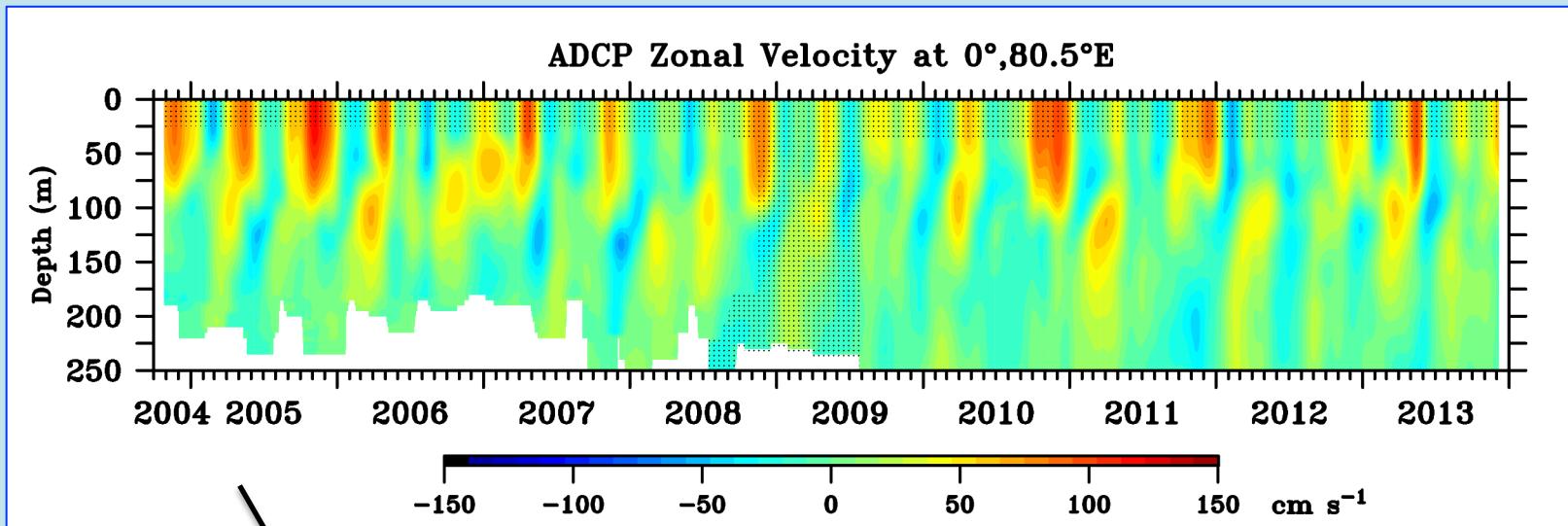
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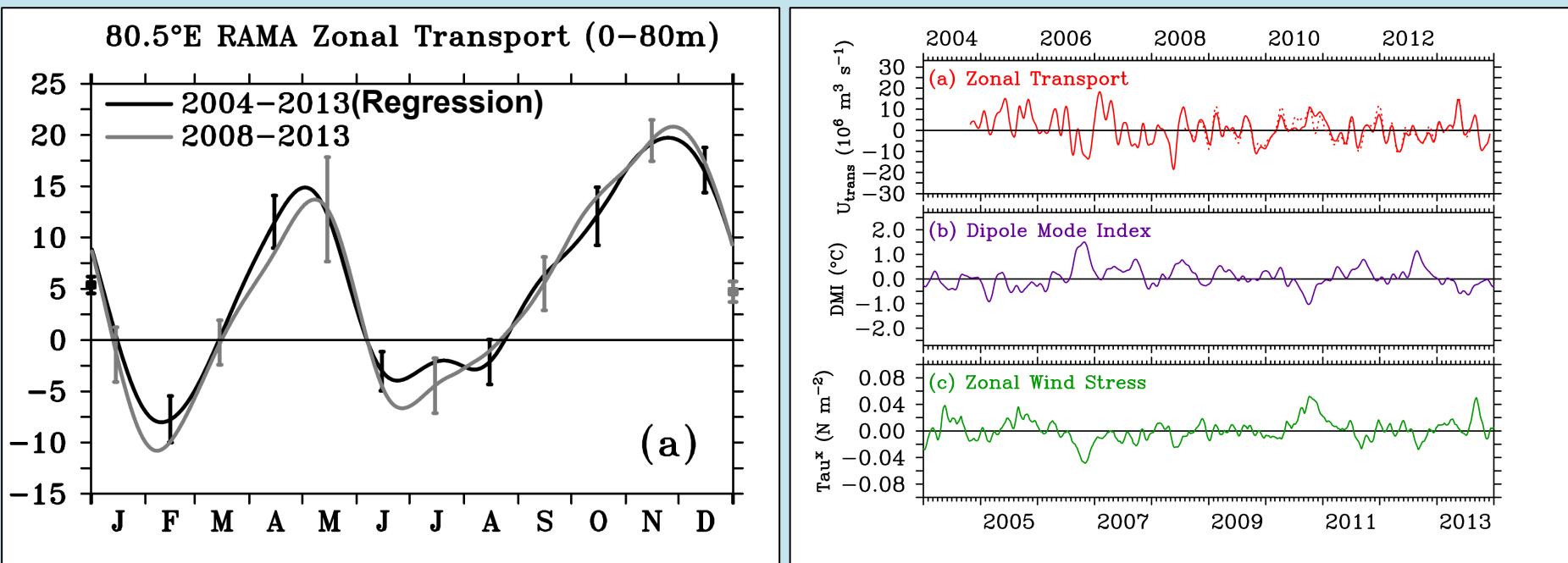
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Seasonal-to-Interannual Variability of the Wyrtki Jets



Seasonal-to-Interannual Variability of the Wyrtki Jets

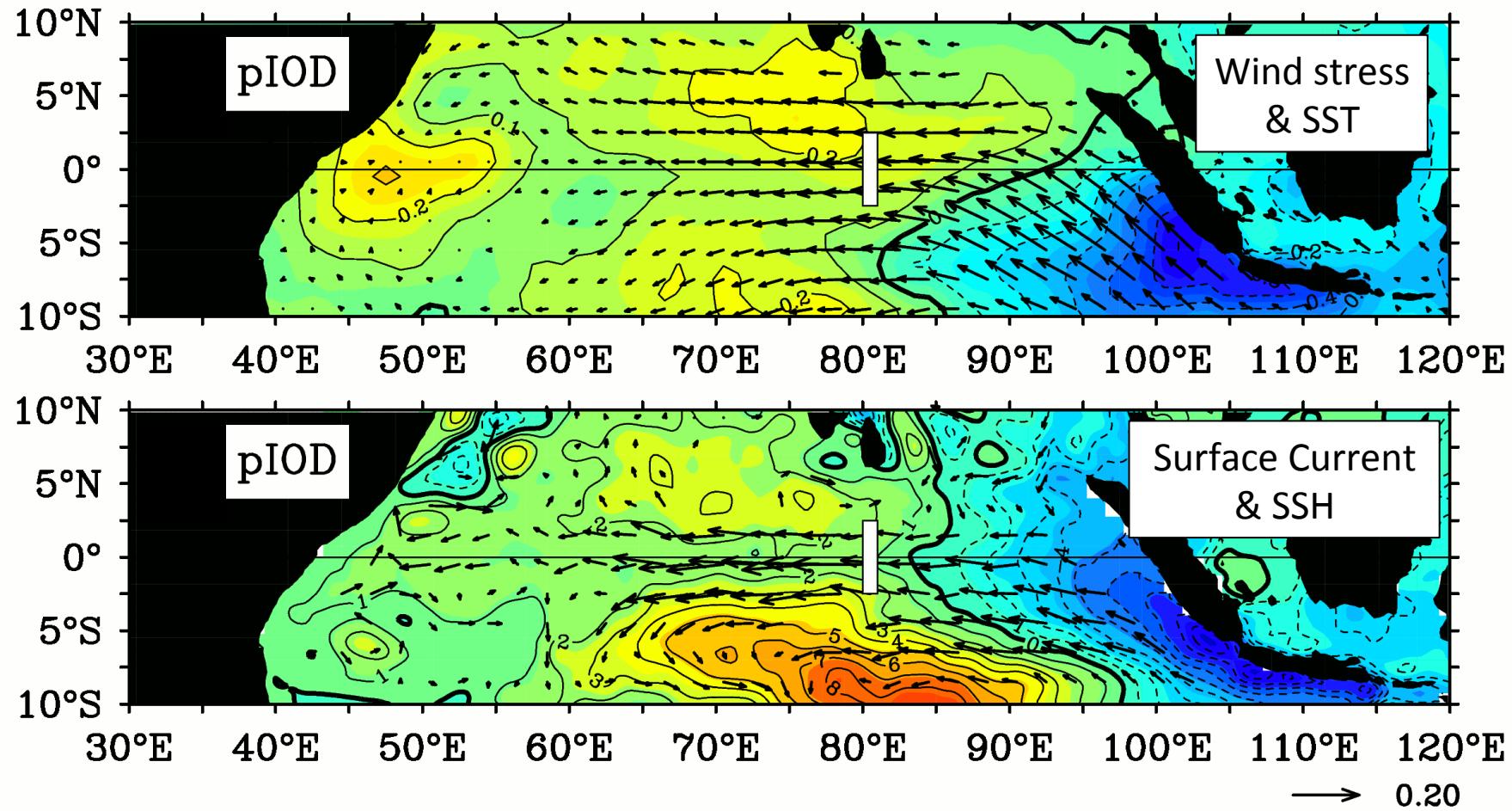


Mean Seasonal Cycle

Interannual Anomalies

Weak Wyrtki Jet in SON?

SST, Wind Stress, Surface Currents, SSH from Regression



RAMA: Accomplishments

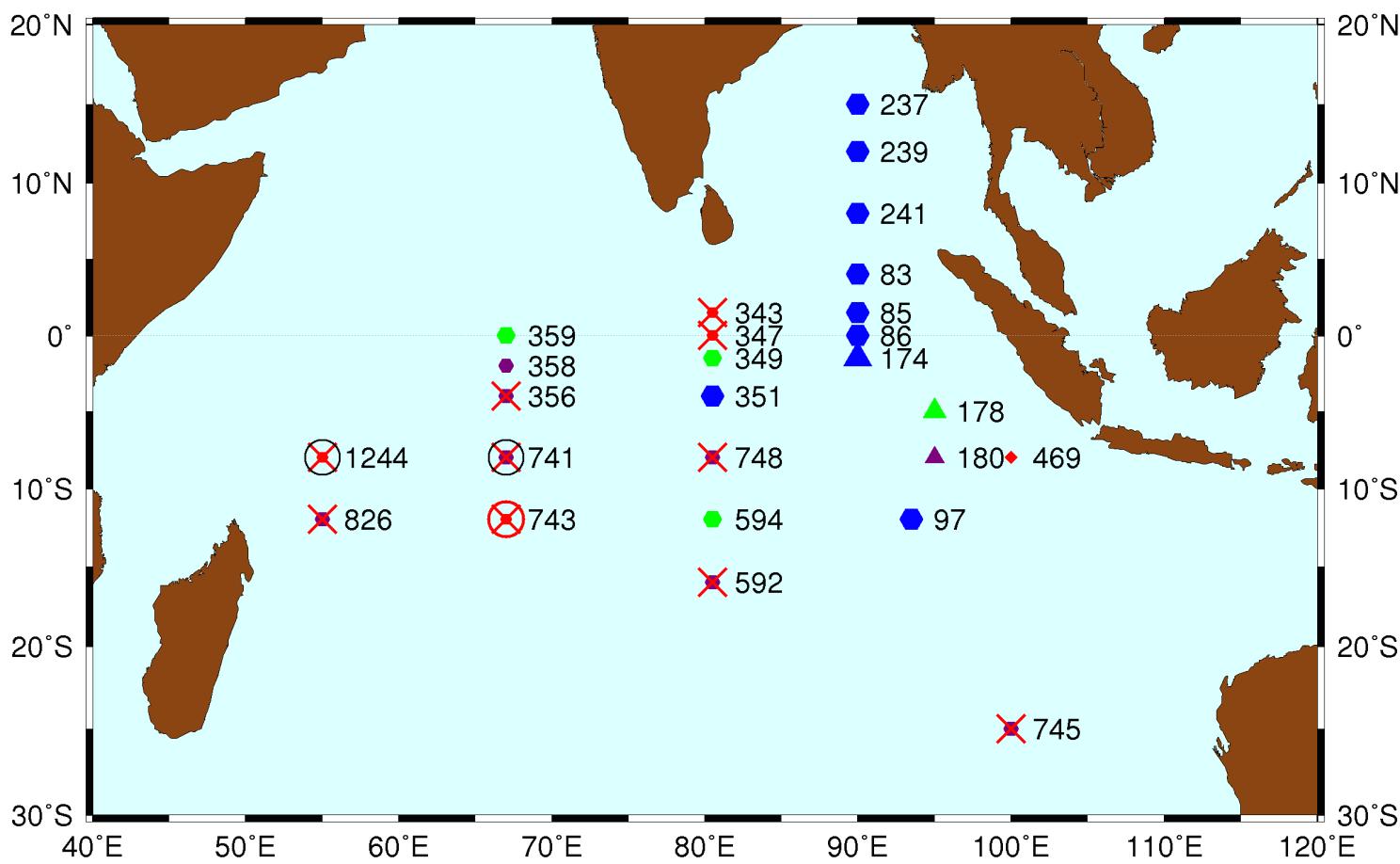
- New partners added (Meteo-France, UTAS, BOBLME, BMKG, OTN)
- 20 → 34 moorings
- Maintained ADCP array along 80°E
- Meteo-France adds BP @ 4 sites for cyclone forecasting (2010)
- Ocean color added to two sites by U. Tasmania (2010 & 2013)
- Ocean Acidification measurements initiated @ 15°N, 90°E (Nov 2013)
- CINDY/DYNAMO (2012-13), International study of the MJO, embedded in RAMA
- OSU Chi-pods to be added (late-2015)

Bay of Bengal
Ocean
Acidification
Mooring



Status of Presently Deployed RAMA Moorings

Updated Jul 31, 2015



Mooring Type

- ATLAS (PMEL)
- TRITON (JAMSTEC)
- Bai-Long (FIO)

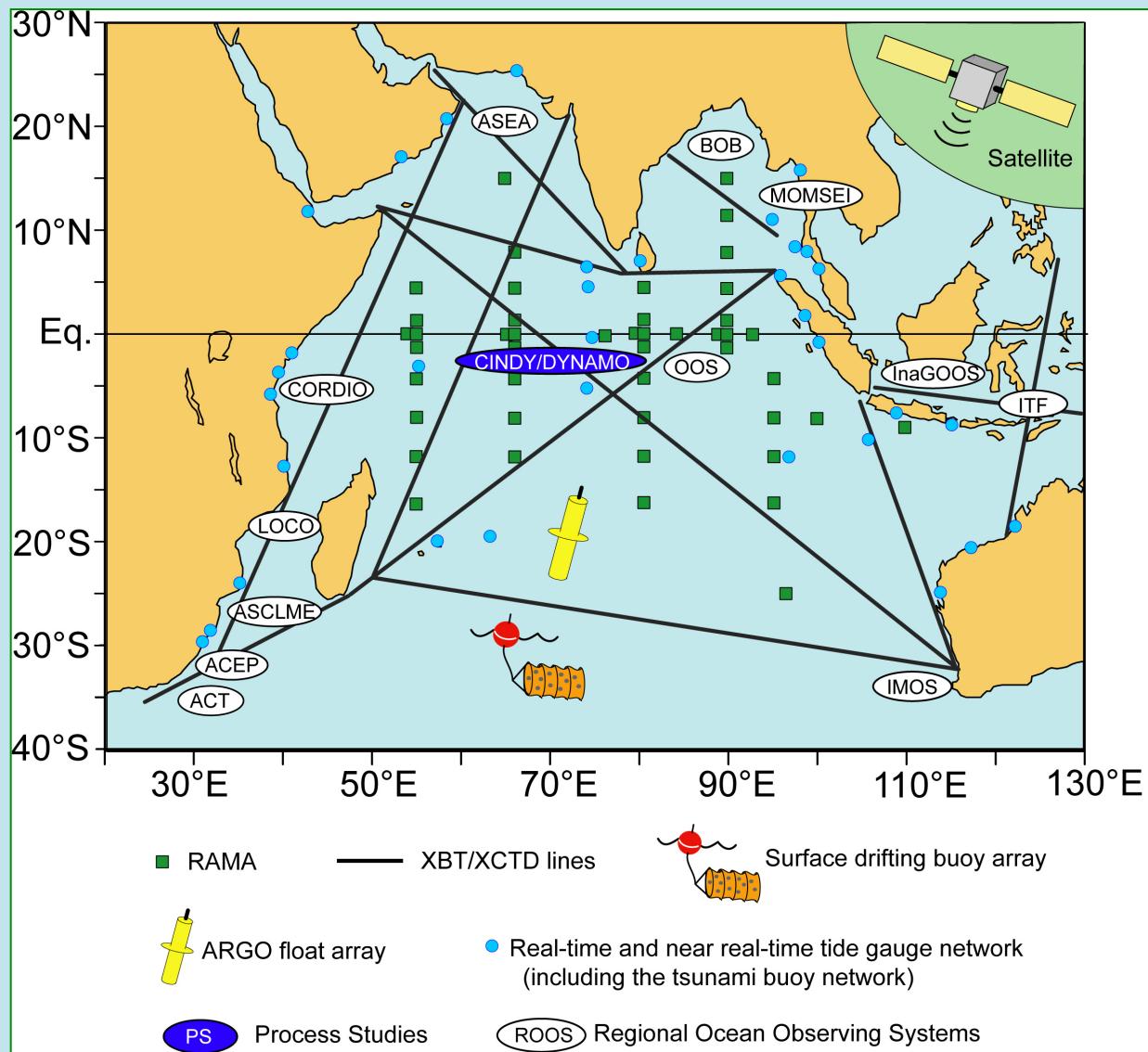
Mooring Status

- ### Days Deployed
- Moved or Adrift
- Out of Position
- Not Transmitting

Data Return

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

Indian Ocean Observing System (IndOOS)



- Planned by CLIVAR/GOOS Indian Ocean Panel in 2004
- Basin scale with regional elements
- Supports short term process studies
- Design supported by numerical model observing system simulation studies
- Links to SIBER/BOBLEM → multidisciplinary measurements

Next Five Years (2015-20):

- Complete RAMA**
- Contribute to the development of IIOE-2 (2015-20)***
- Begin transition from ATLAS to T-Flex in 2015**
- Increase multidisciplinary measurements in
RAMA & PIRATA**
- Conduct research, contribute to assessments,
coordinate with operational community**

*Hood, R. H., M. J. McPhaden, E. Urban, 2014: The Second International Indian Ocean Expedition (IIOE-2). *EOS, Trans. Am. Geophys. Union.*

PIRATA: Ideas for Augmentation and Concerns

- Some suggested measurements:
 - Minimum one current meter at 10 m depth
 - More velocity shear estimates in surface mixed layer
 - More salinity measurements in the upper 100m
 - Multidisciplinary biogeochemical observations (O₂, CO₂, DIC...)
 - Self-cleaning radiometers
- Suggested sites/moorings to add:
 - More off-equatorial sites
 - Along African coast in Benguela region, where model biases largest
 - In biological active coastal zone/river discharge regions
 - Dust deposition moorings
- More int'l meteo-oceanographic cruises to study stratus deck formation-upwelling system in eastern Atlantic
- US ship time continues to be a concern, NATO R/V Alliance US PIRATA cruise Nov-Dec 2015, NOAA R/V Ronald H. Brown French PIRATA/US PIRATA in Feb-Mar 2017

RAMA: Ideas for Augmentation and Concerns

- Suggested actions:
 - Replace the out-of-commission sites (especially in the central/western Indian Ocean)
 - Which sites are critical?
- Some suggested measurements:
 - Higher vertical resolution (5-10 m) of salinity sensors within the upper 50 m to resolve the mixed layer / barrier layer (currently 1,10,20,40,60,100m)
 - Increase high-resolution (10-min) rain data
 - More velocity shear estimates in surface mixed layer
 - Multidisciplinary biogeochemical observations (Ocean color, O₂, CO₂, DIC...)
 - Chipods for turbulent temperature microstructure
 - Partner and US ship time continues to be a concern, NOAA R/V Ronald H. Brown will tentatively go to Indian Ocean in December 2017
- Vandalism is a concern
 - JAMSTEC is replacing some of its TRITON moorings (western Pacific/eastern Indian) with Wave Gliders
- Piracy has been in steep decline in the past two years with the promise of opening the Arabian Sea to mooring work in partnership with India