

A tropical beach scene with several palm trees leaning over a sandy shore. The ocean is a vibrant blue, and the sky is clear. In the distance, two people are visible on the beach near some driftwood.

*Development of an Indian Ocean Moored Buoy Array for Climate**

Mike McPhaden
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Seattle, Washington

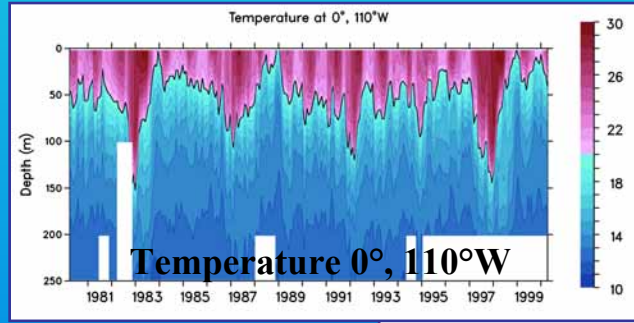
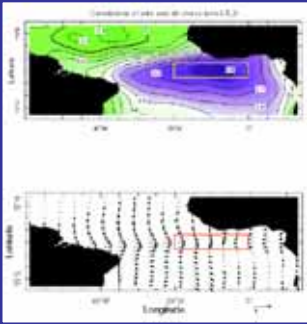
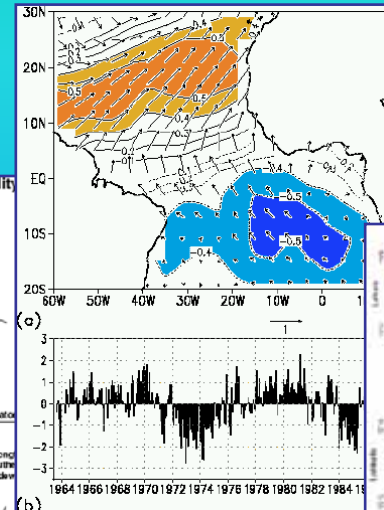
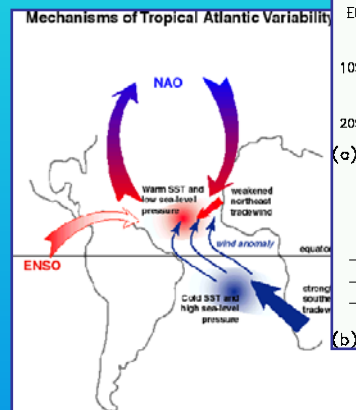
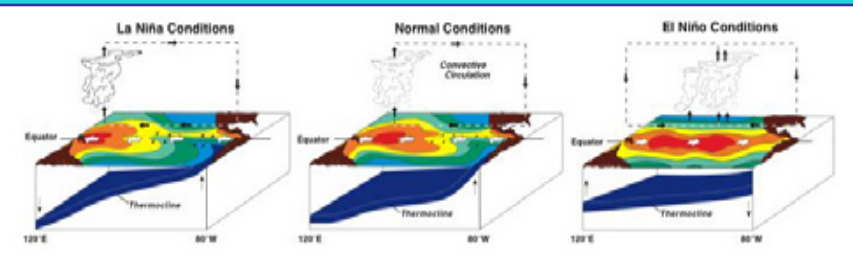
October 2006 issue of *CLIVAR Exchanges

Sustained Indian Ocean Biogeochemical and Ecological Research

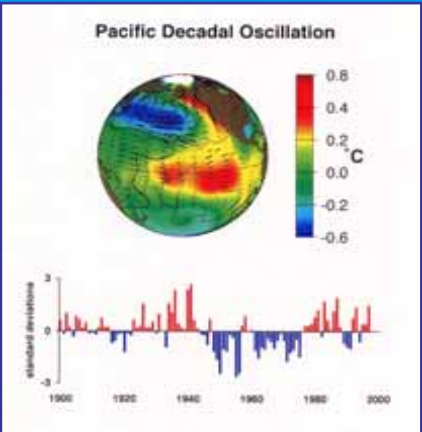
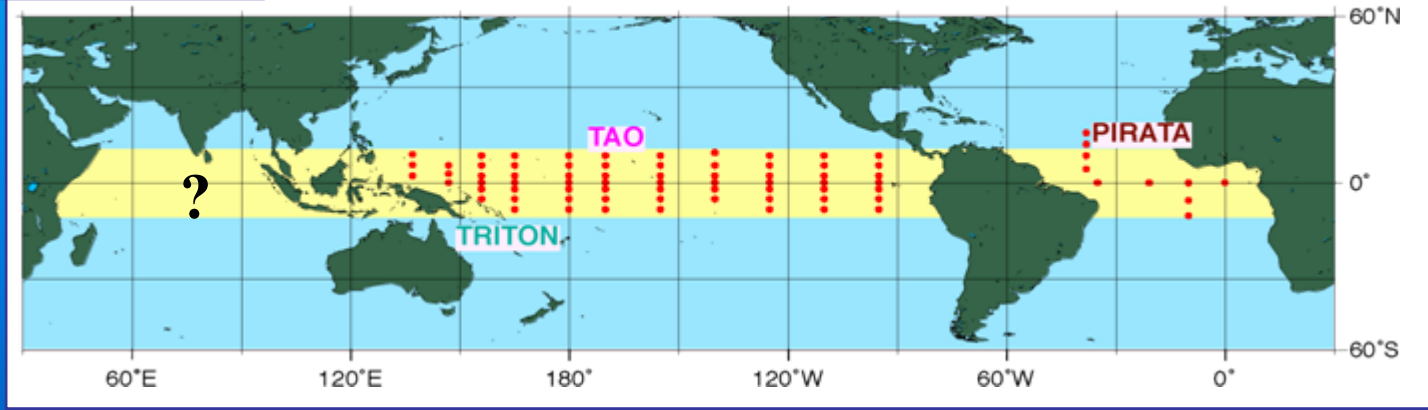
Goa, India

3-6 October 2006

Tropical Moored Buoy Arrays for Climate Studies

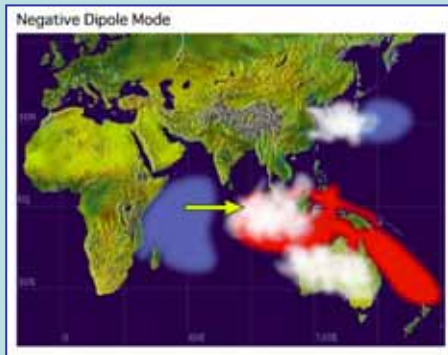
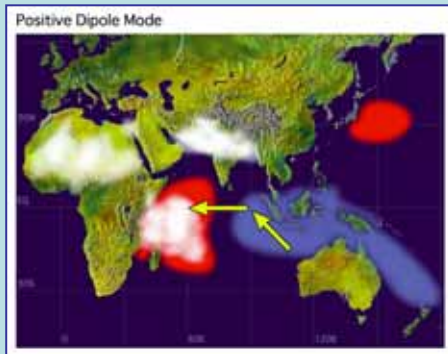


Tropical Moored Buoy Arrays



Indian Ocean Science Drivers

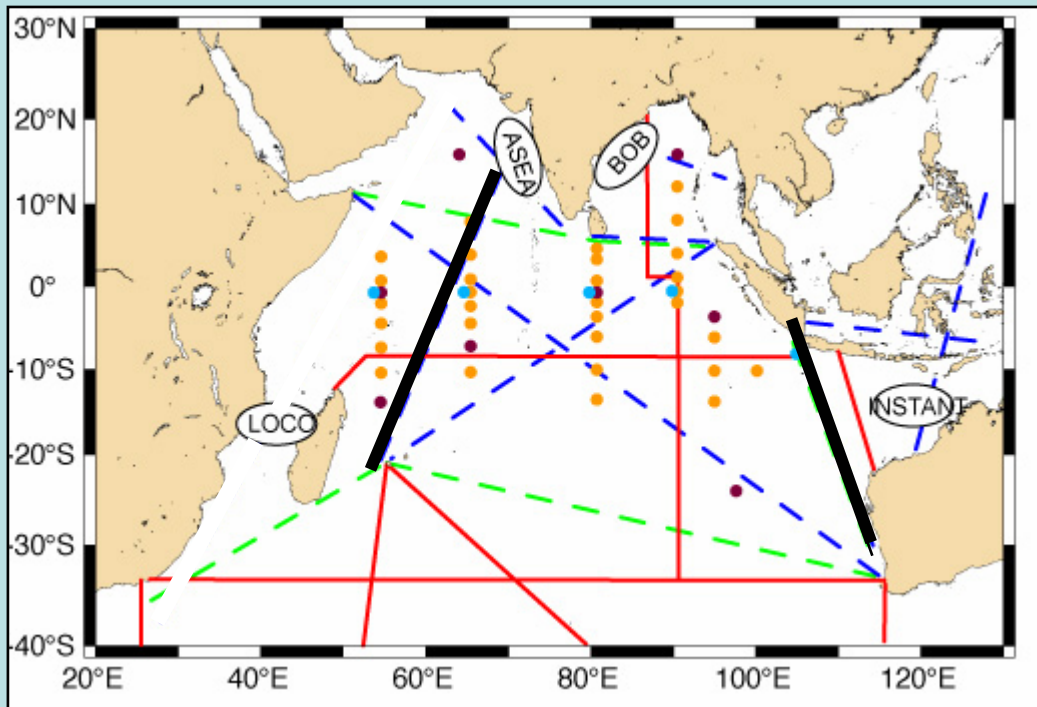
Improved description, understanding and prediction of:



Indian Ocean Dipole

- Seasonal monsoon variability
- Monsoon \Leftrightarrow ENSO interactions
- Indian Ocean Dipole (ENSO-like phenomenon in the Indian Ocean)
- Intraseasonal oscillations including both near and far field impacts (Asian monsoon active/break periods; west coast US rainfall, Atlantic hurricane formation, ENSO)
- Decadal variability & SST warming trends since the 1970s
- Indonesian Throughflow
- General ocean circulation, ocean heat transport, and their variability

Integrated Multi-platform Ocean Observing System



Emphasis on ocean,
but will provide surface
met data as well

Argo floats $3^\circ \times 3^\circ$
Drifters $5^\circ \times 5^\circ$

~20 real-time tide
gauges for IOTWS

— Carbon/hydro cruise

- - High density XBT

- - Frequently repeated XBT

— Enhanced XBT lines to monitor
Indonesian Throughflow, inflow to
western boundary, Java upwelling and
 10°S thermocline ridge

○ Regional mooring arrays

Typical Mooring (ATLAS or TRITON)

Standard

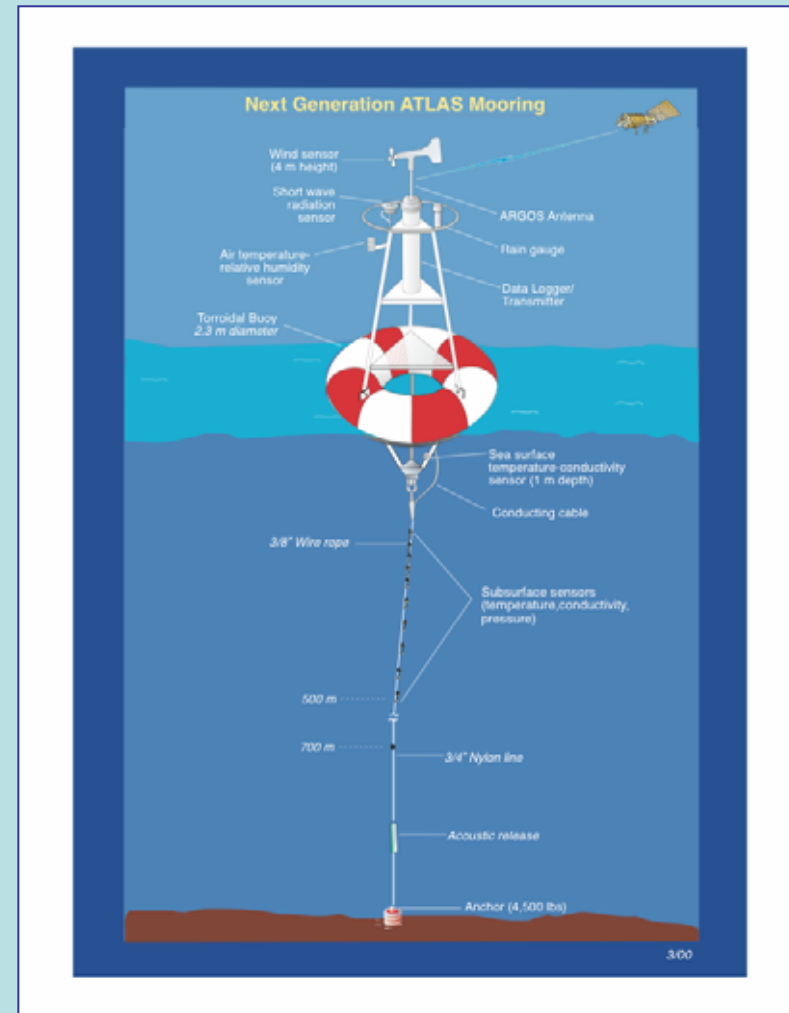
- **Meteorology:** wind, rel. humidity, air temp, solar irradiance, rain
- **Oceanography:** SST, SSS, T(10 depths), S(5 depths), velocity (10 m)

Flux Reference Sites: Standard plus--

- **Met:** longwave radiation, atmos. press.
- **Ocean:** additional T(z), S(z), v (z) in upper 100 m

All data (daily averages) transmitted to shore in real-time via Service Argos.

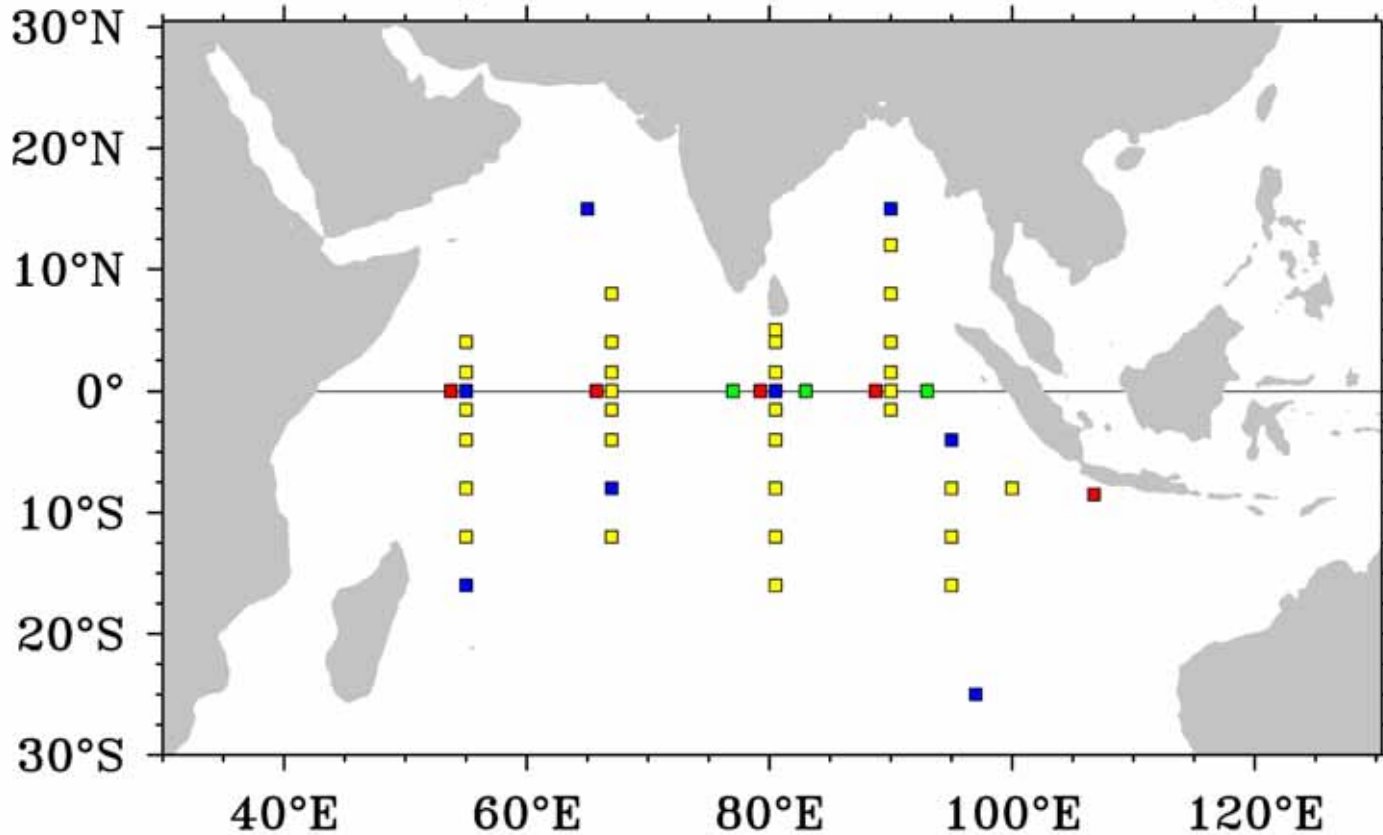
Internally recorded at 1-10 min intervals.



Strategy for Moored Buoy Array

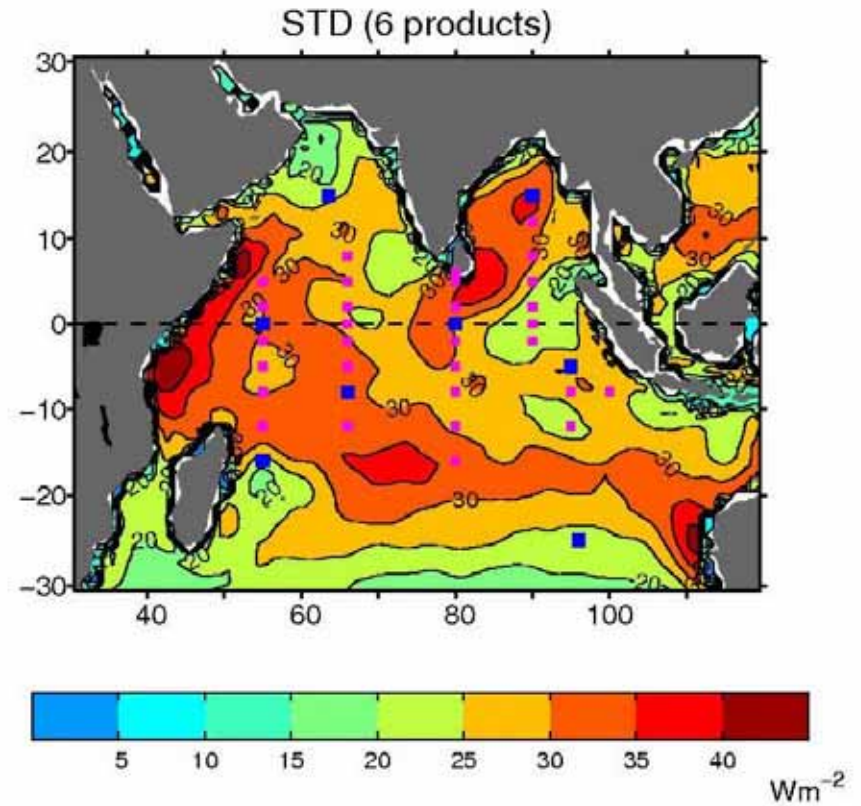
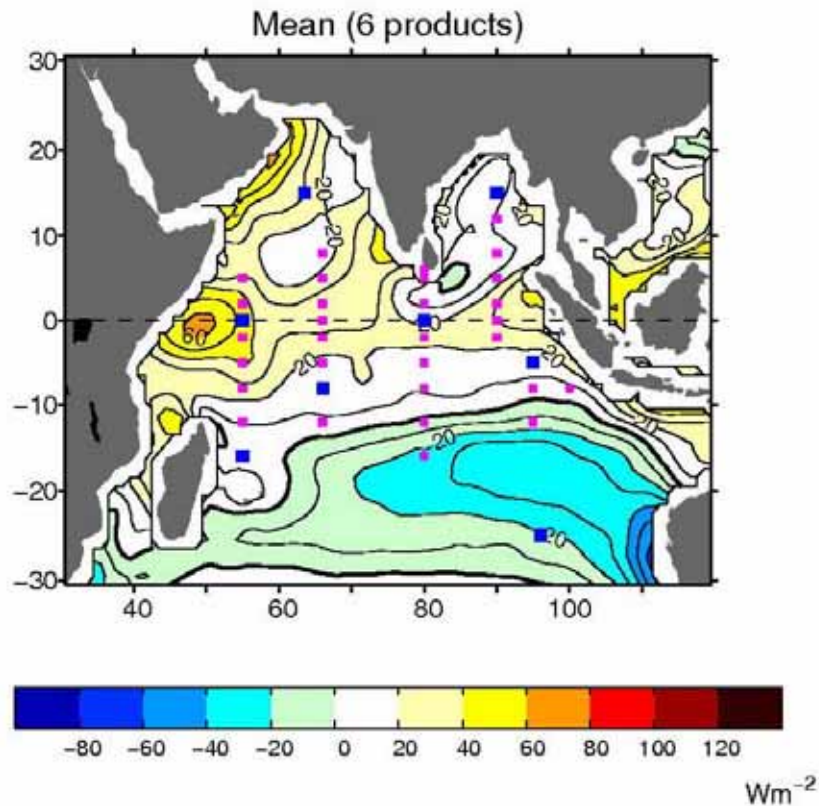
Indian Ocean Moored Buoy Array

■ Surface Mooring ■ Flux Reference Site ■ ADCP ■ Deep Ocean



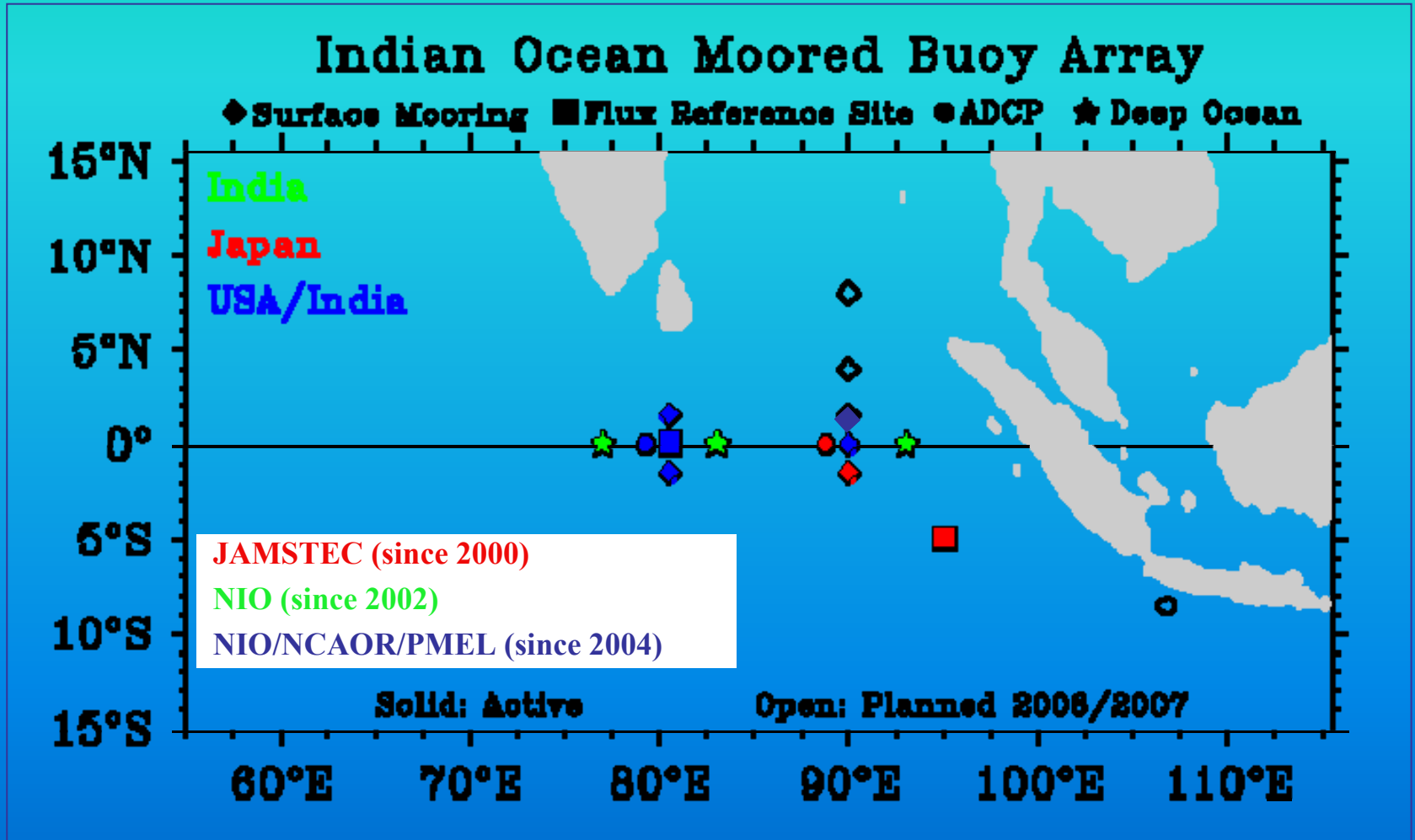
- Basin scale, tropical upper ocean (500 m) focus.
- Arabian Sea, Bay of Bengal, Eq. Waveguide, Thermocline ridge (5°-10°S), subtropical subduction, Java upwelling.
- Does not sample western boundary currents, ITF, coastal zones.
- Design supported by numerical model observing system studies.

Rationale for Flux Sites



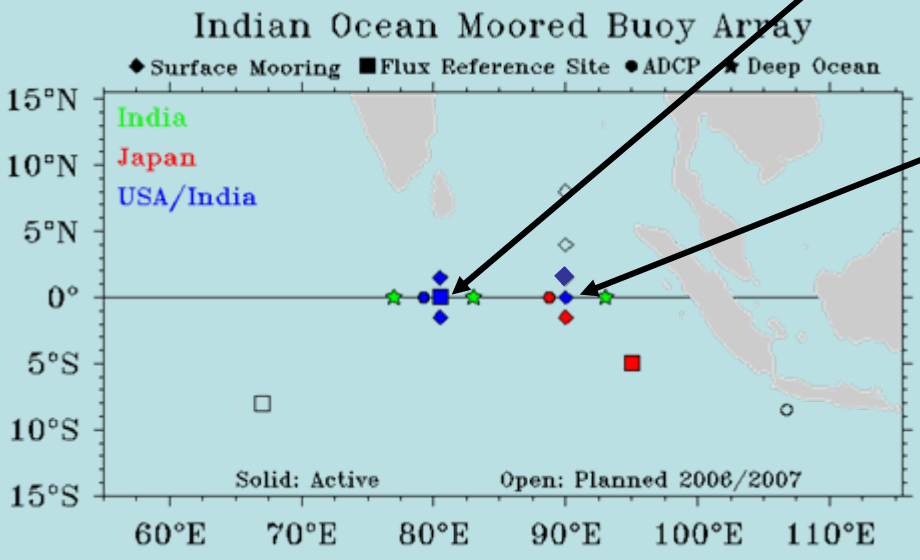
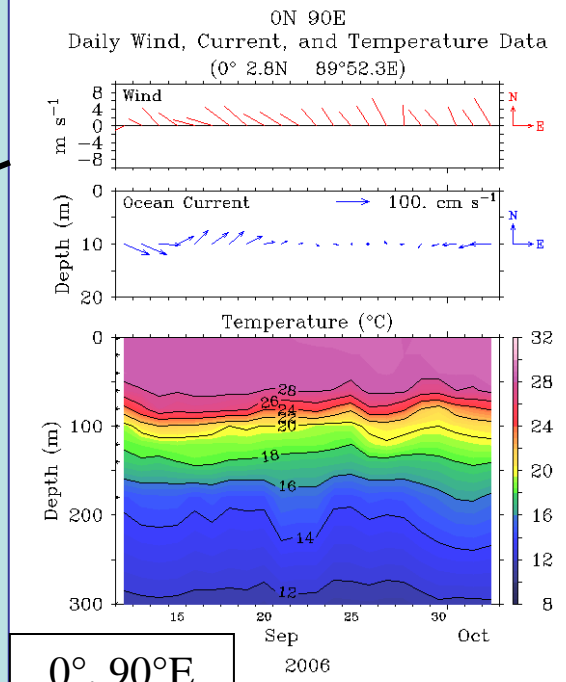
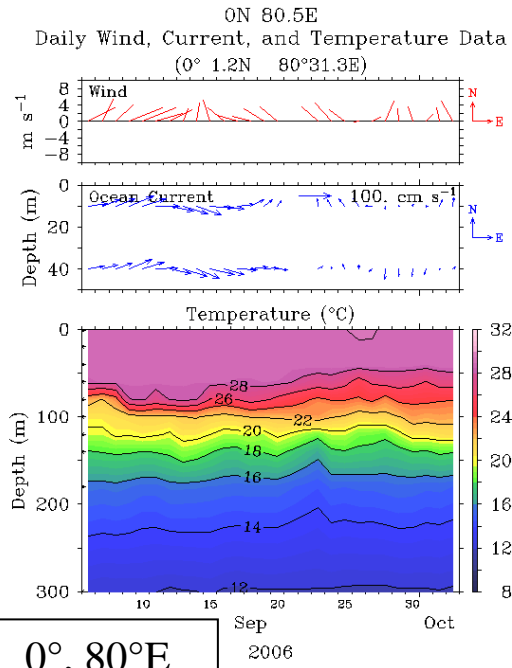
Lisan Yu, WHOI

Present Status

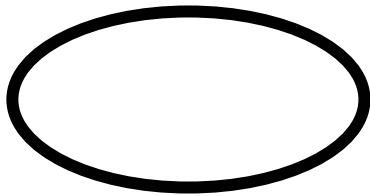


ORV Sagar Kanya

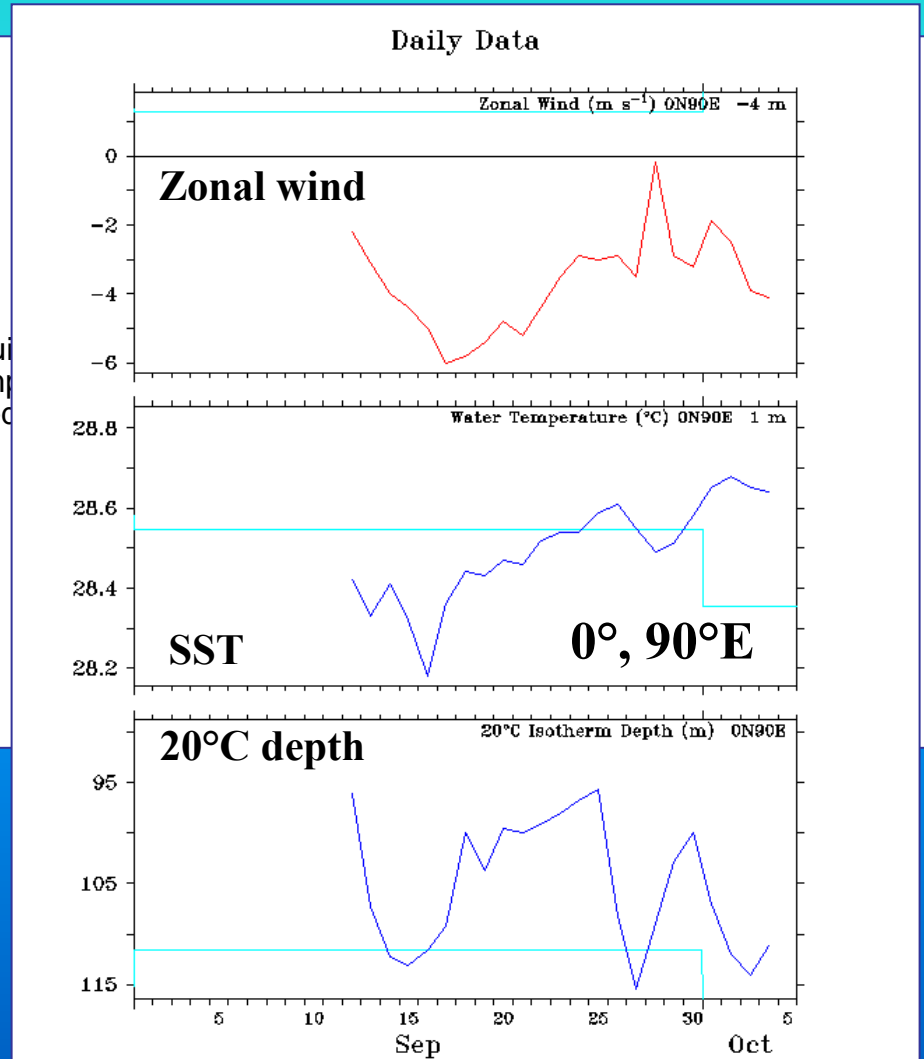
29 Aug – 5 Oct 2006



Indian Ocean Dipole September 2006



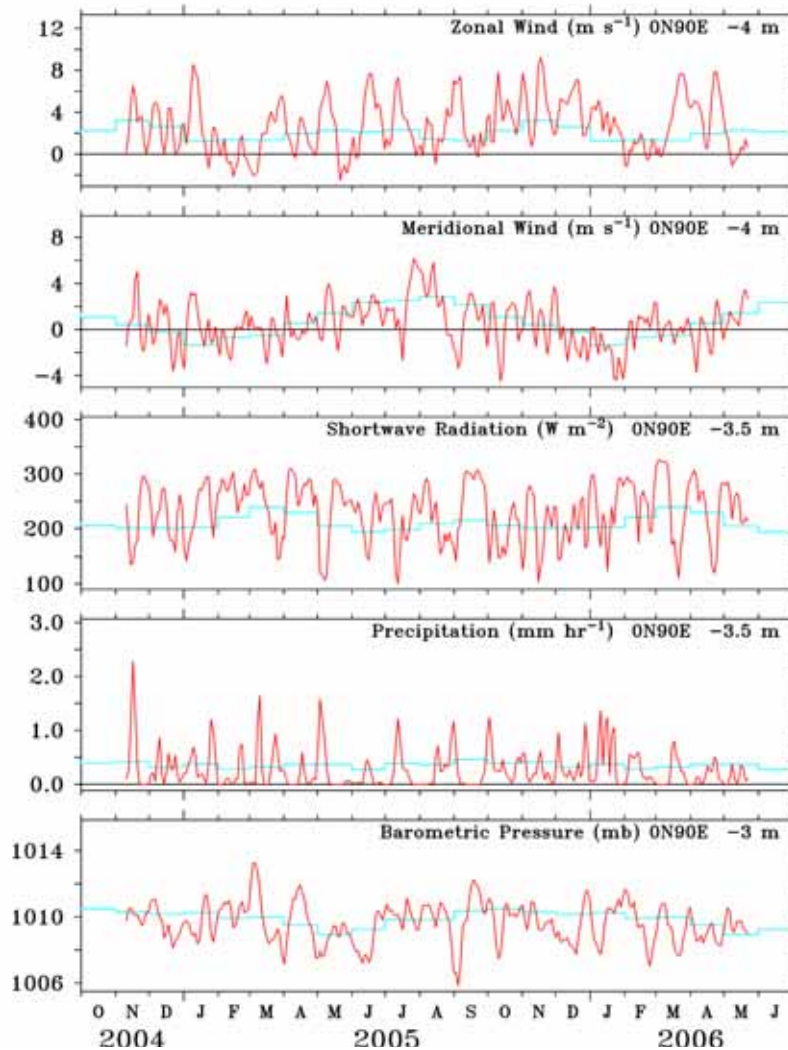
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are needed



Met Data 0°, 90°E

(Oct 2004-May 2006)

Five-Day Data



Zonal wind

Meridional wind

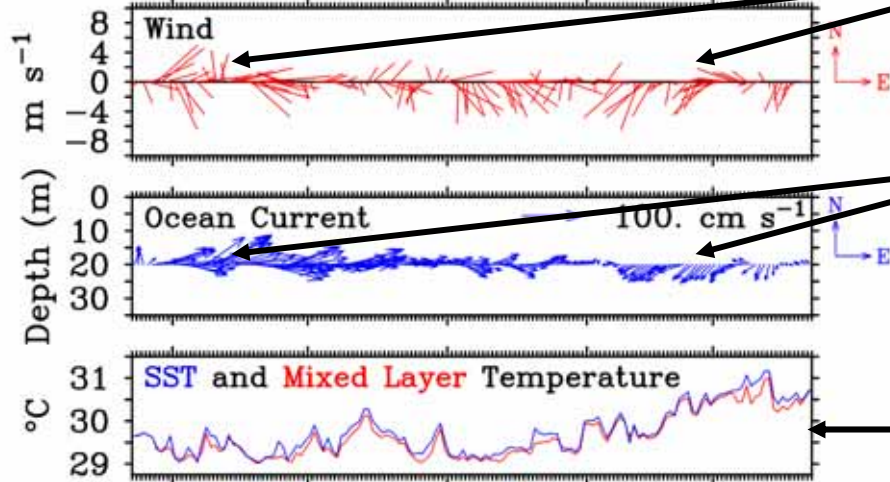
Solar irradiance

Rain rate

Barometric Pressure

0°, 80.5°E

Daily Wind, Current, and Temperature Data



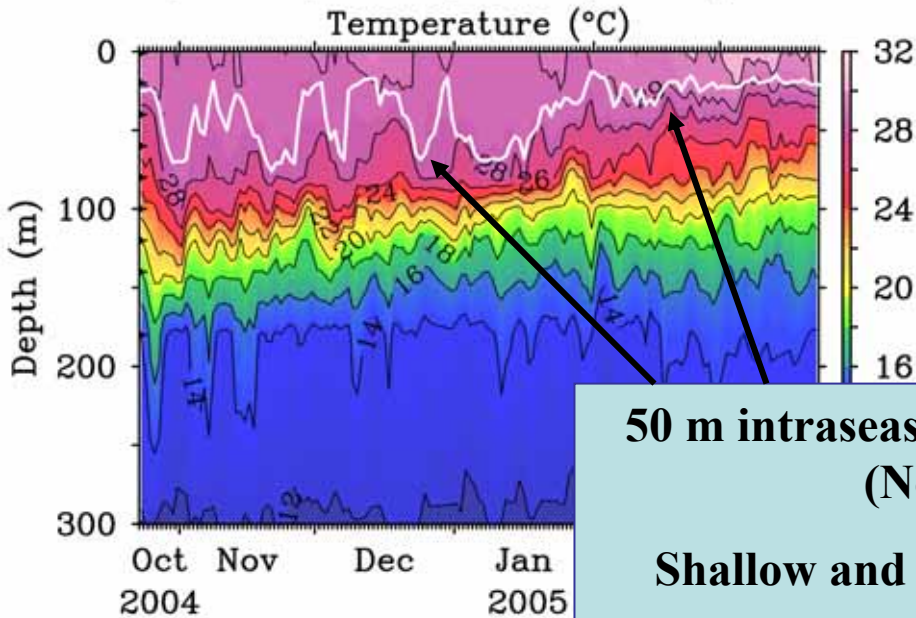
Transition winds (Nov-Dec)

Northeast Monsoon (Feb-Mar)

Wyrтки Jet (Nov-Dec)

Northeast Monsoon Current (Feb-Mar)

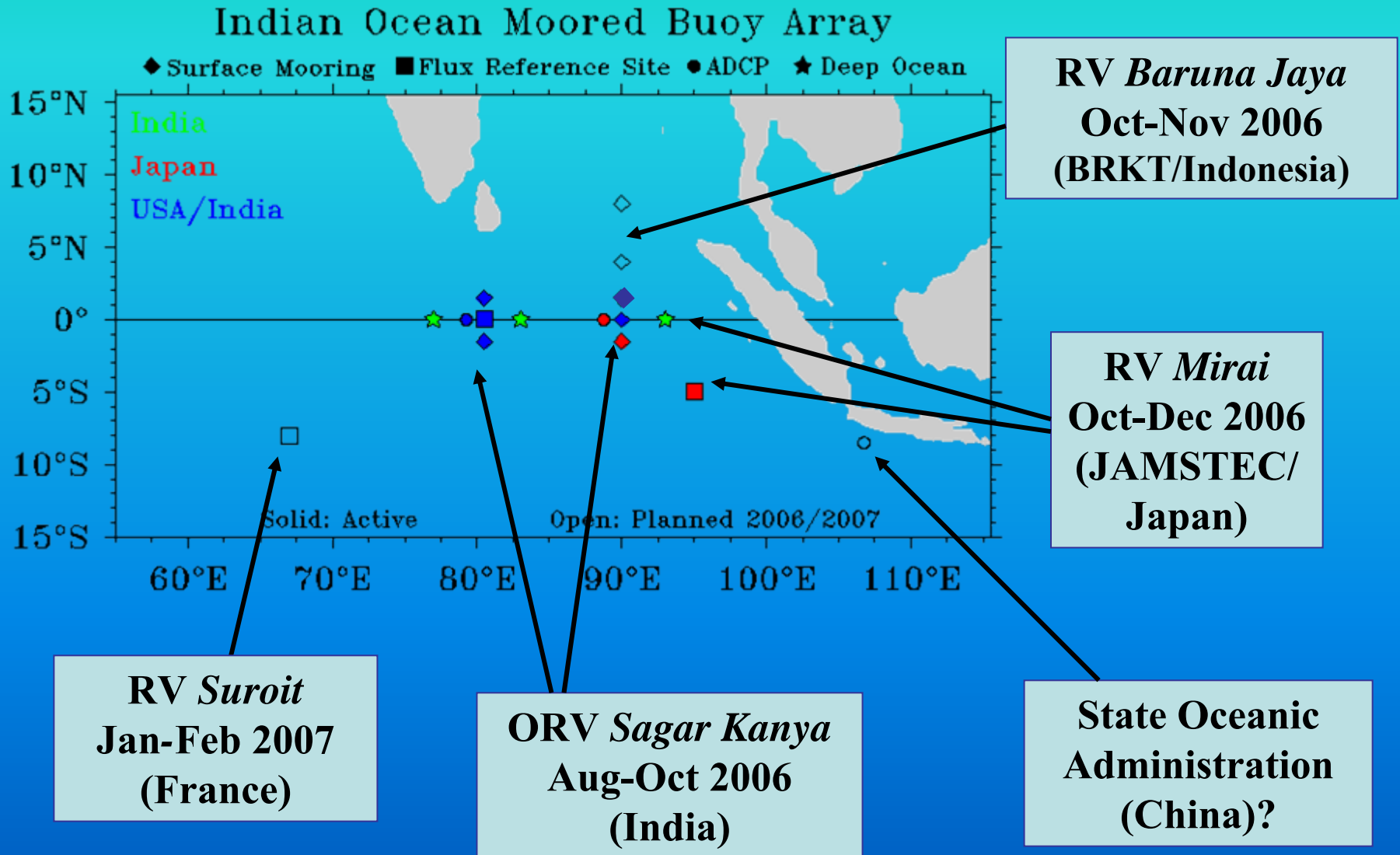
O(1°C) week-to-week and seasonal SST changes



50 m intraseasonal MLD changes (Nov-Jan)

Shallow and steady during NE monsoon (Feb-Mar)

Near-Term Mooring Array Plans



Funding

\$ NOAA Budget Initiative for Climate Observations and Services (2006):

“...[Funds] to expand the Tropical Atmosphere Ocean array... into the Indian Ocean. This expansion will enhance NOAA's capability to accurately document the state of ocean climactic conditions and improve seasonal forecasting capability.”

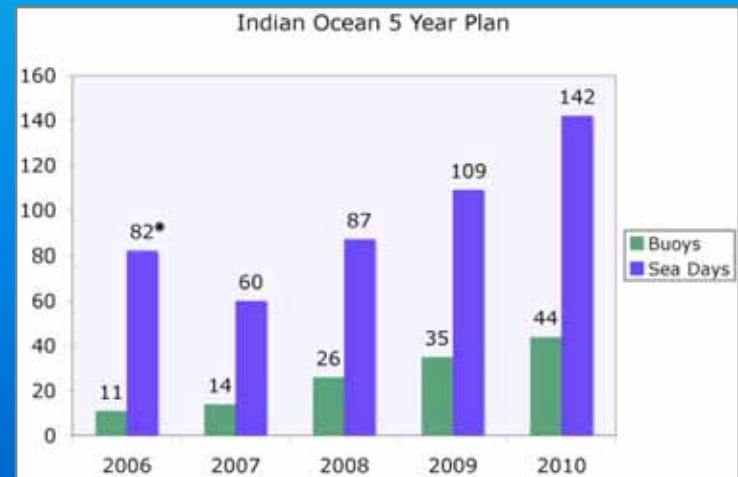
¥ JAMSTEC Budget Initiative for GEOSS (2006):

“Japan EOS (Earth Observation System) Promotion Program” (JEPP)-- a new 5-year program to enable the development of new small size TRITON buoy and the continuation of the present TRITON sites in the Indian Ocean.

Challenges: Ship Time

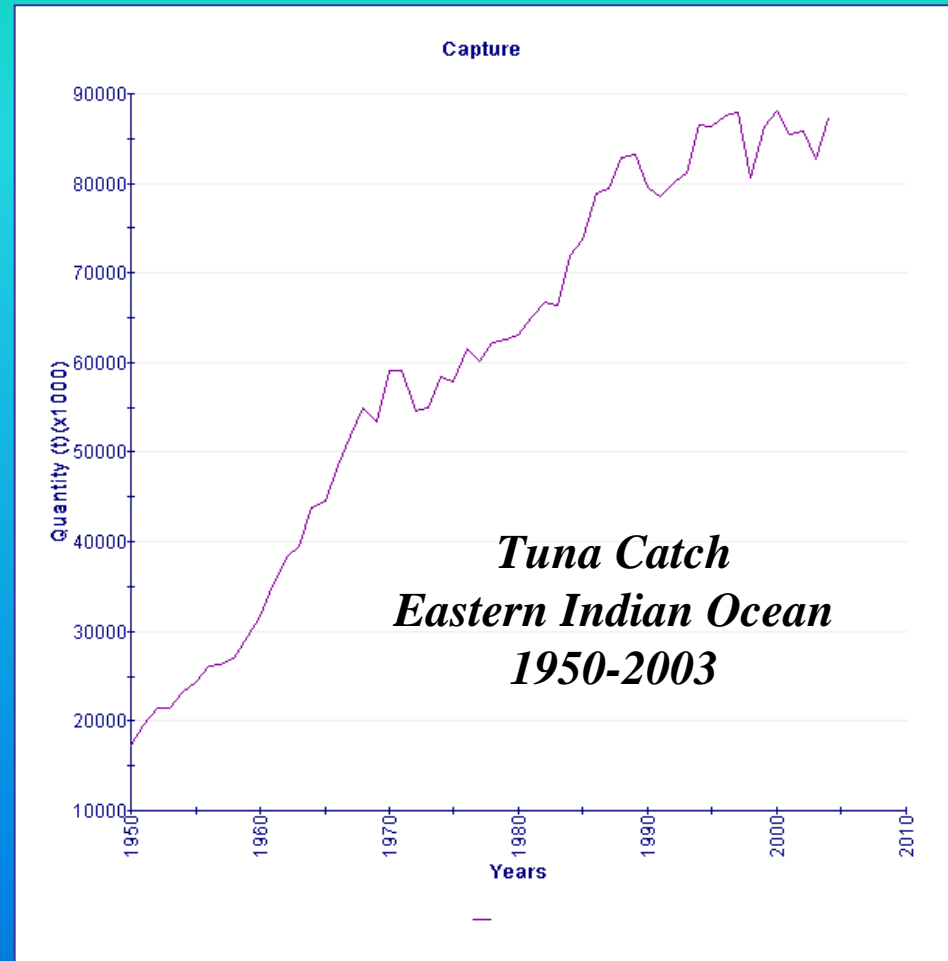
Requirements:

- ≥ 140 days per year to maintain full array
- Must be available routinely and with regularity
- Assumes 1-year mooring design lifetime and annual servicing cruises



*Actual sea days in 2006: involves more than just mooring work

Challenges: *Fishing Vandalism*



- Many nations involved
- Fishing effort is increasing with time (FAO statistics)

Interdisciplinary Studies

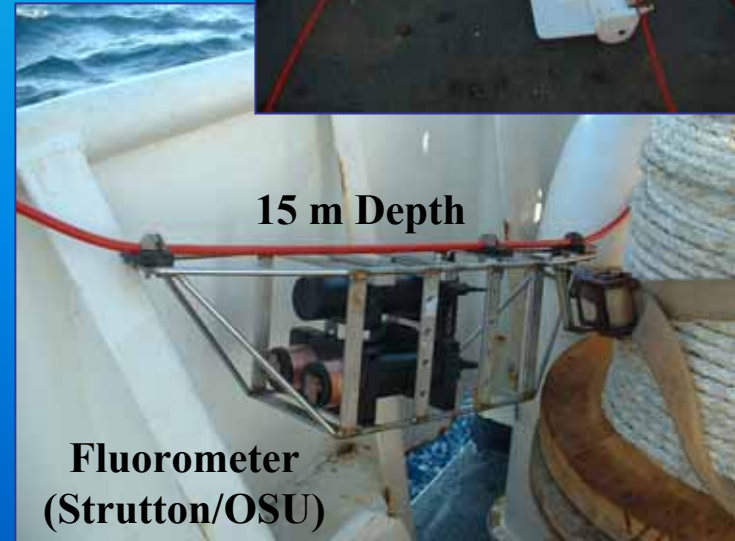


14 September 2006
0°, 140°W

pCO₂ (Sabine/Feely, PMEL)



Microstructure
(Moum/OSU)



15 m Depth

Fluorometer
(Strutton/OSU)

Interdisciplinary Studies

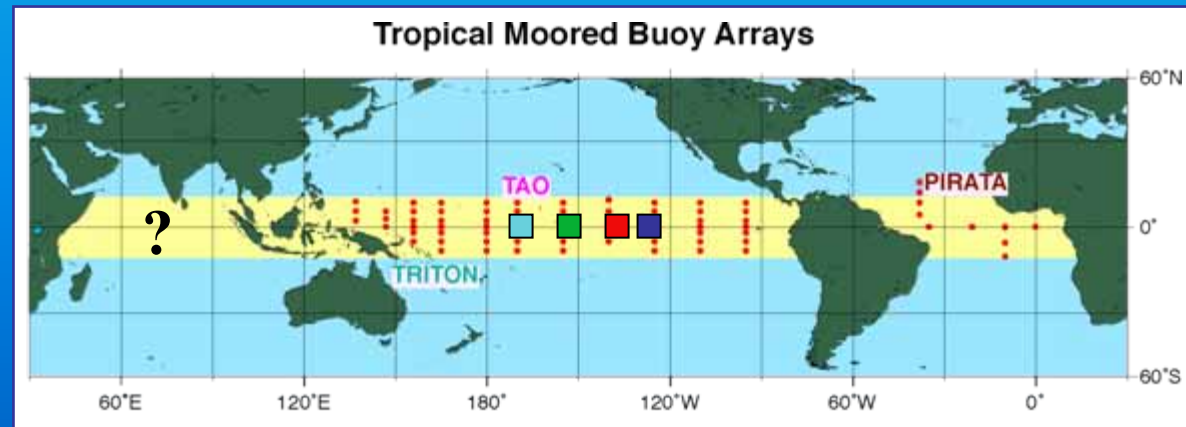
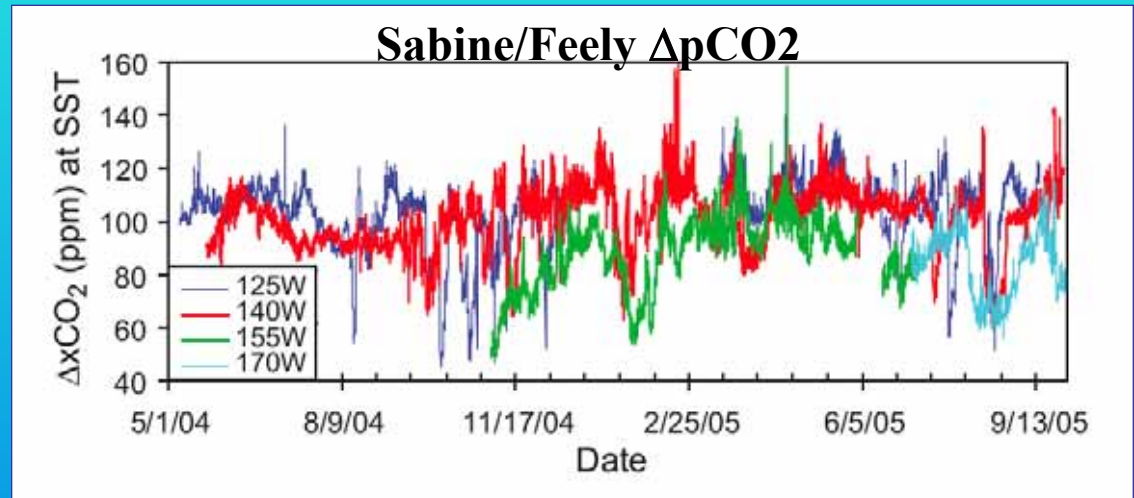
Chronology

TAO:

- USC (Dickey), Bio-optics, 1991-93
- MBARI (Chavez), Bio-optics & pCO₂, 1996-
- PMEL (Sabine/Feely), pCO₂, 2004-
- OSU (Strutton), Bio-optics, 2006-

PIRATA:

- U. Maryland (Ajit), Bio-optics, 2002-03
- U. Paris (Merlivat), pCO₂, 2006-



Summary

- The international CLIVAR and GOOS communities have developed plans for an integrated **Indian Ocean Observing System (IndOOS)**.
- The array design is based on **observing, understanding, and predicting** key ocean and climate phenomena that have significant socio-economics impacts on countries surrounding the basin and that affect global climate variability.
- **Implementation is underway** with contributions from several nations.
- The **newest component** of the observing system is a **basin scale moored buoy array**, with initial investments from the U.S., India, Japan, Indonesia, and France.
- There are many **challenges to full implementation (fishing vandalism, shiptime, funding, etc.)** but success promises significant scientific and societal benefits.
- There are **opportunities for cooperative interdisciplinary studies** leveraging investments from both physical and biogeochemical research communities.