An Indian Ocean Observing System for Ocean-Atmosphere Interactions

✓ **Motivation**

✓ **Design**

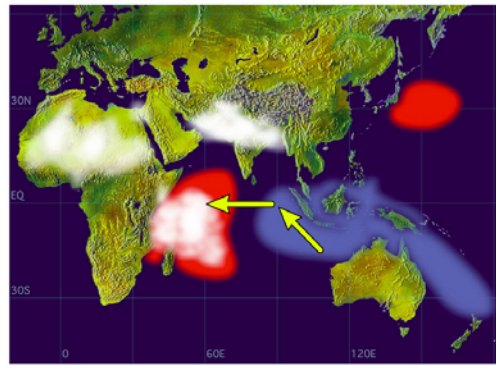✓ **Status**

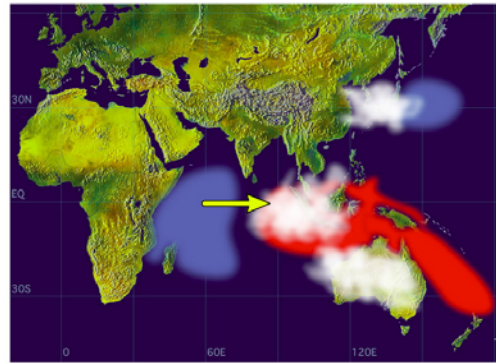✓ **Plans**

Mike McPhaden
NOAA/PMEL
Seattle, WA

DYNAMO Workshop
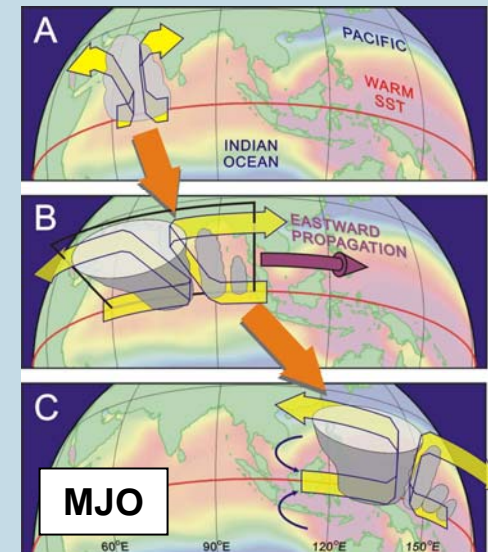*Boulder, CO*
13 Apr 2009

Indian Ocean Science Drivers
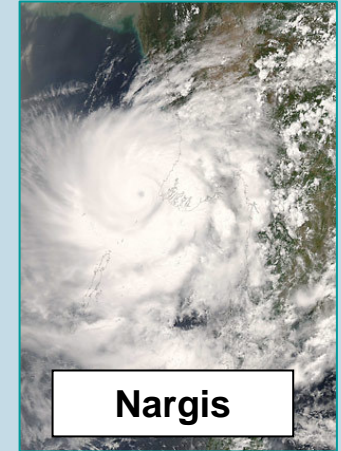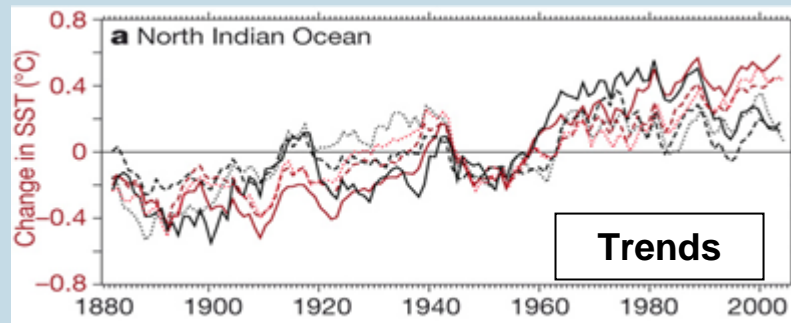

Positive Dipole Mode
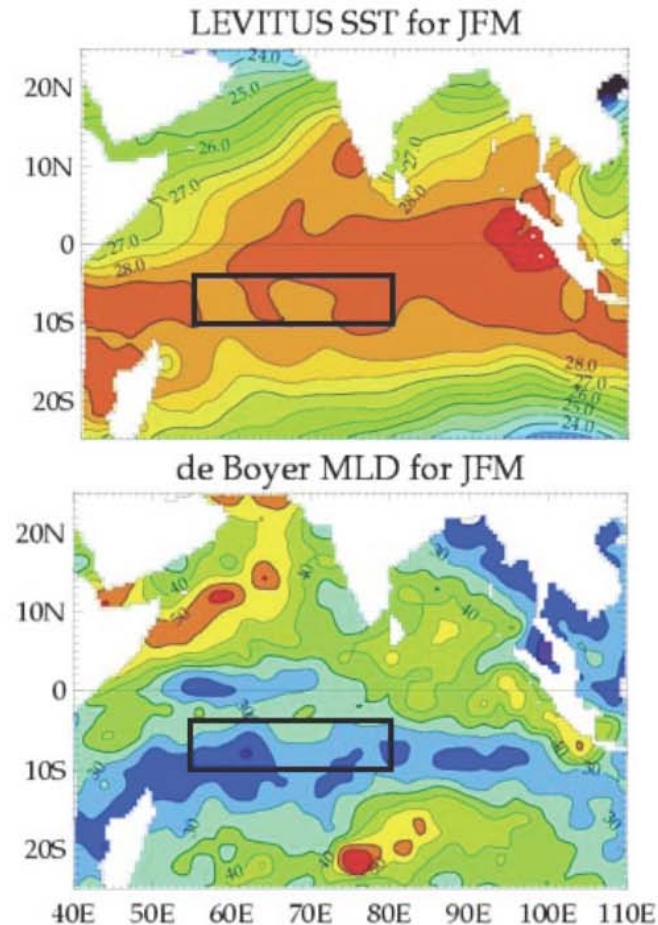

Negative Dipole Mode

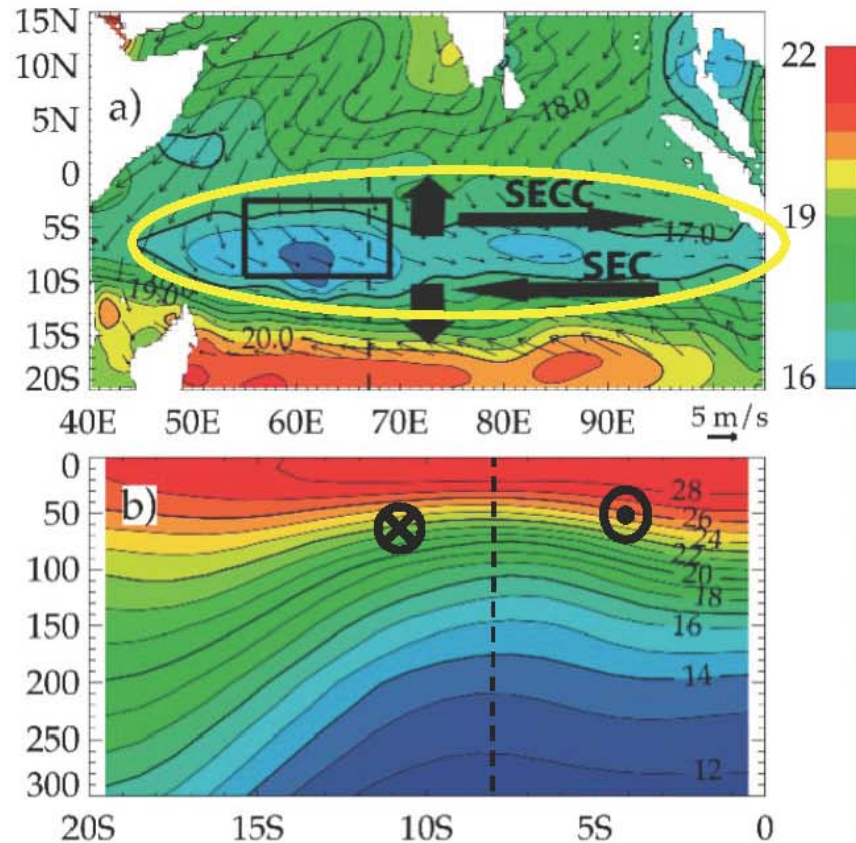**Indian Ocean Dipole**

- **Seasonal monsoons**

- **Severe weather events & cyclones**

- **Intraseasonal (30-60 day) Madden Julian Oscillation (affects cyclones & hurricanes, monsoon rains, ENSO, US weather)**

- **Interannual variations: the Indian Ocean Dipole**

- **Decadal variability and warming trends (affects North American climate, Sahel rainfall, NAO)**

Nargis

a North Indian Ocean

Change in SST (°C)

Trends

1880 1900 1920 1940 1960 1980 2000

A PACIFIC WARM SST INDIAN OCEAN

B EASTWARD PROPAGATION

C

MJO

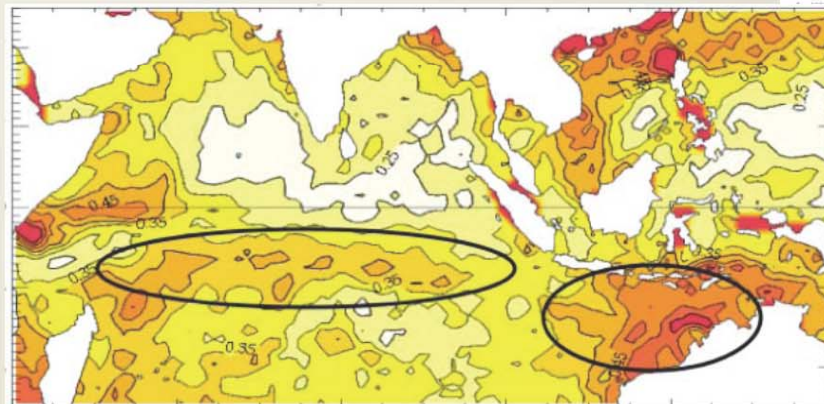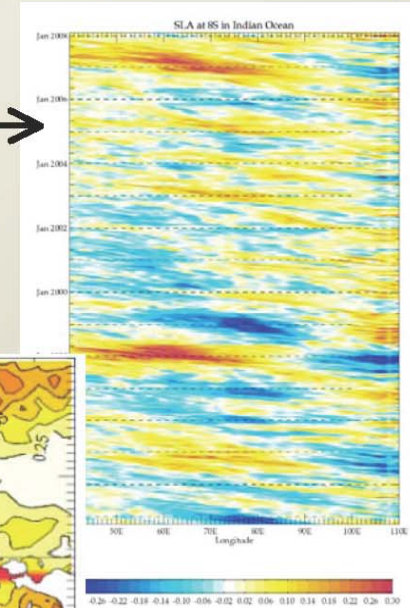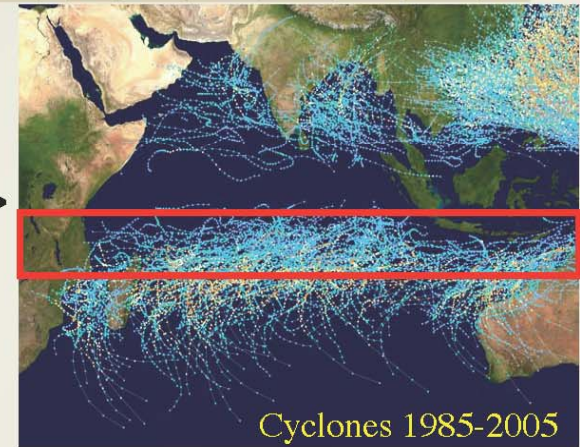# The Seychelles-Chagos thermocline ridge

High SST, shallow thermocline and mixed layer => strong Air-Sea coupling

(Vialard et al. 2008a; in press in BAMS)
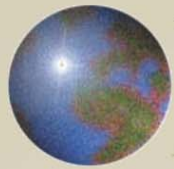
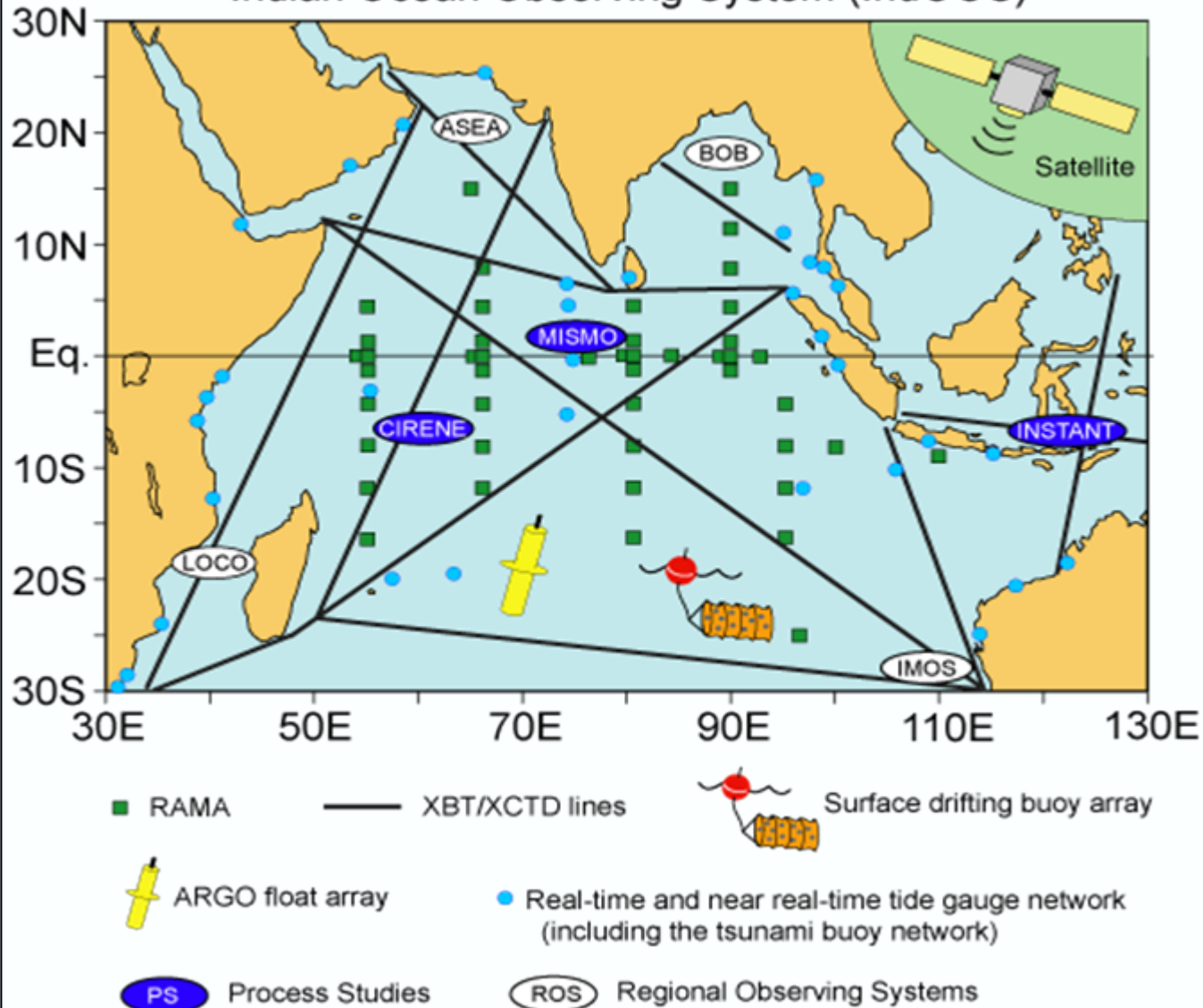- **Generation region for** cyclones $\longrightarrow$

- **Strong SST signature to MJO at intraseasonal timescale**

- **Interannual variability**: signature of IOD / ENSO with strong climatic consequences

Cyclones 1985-2005

SLA at 8S in Indian Ocean

Indian Ocean Observing System (IndOOS)

Legend:
- ■ RAMA
- —— XBT/XCTD lines
- Surface drifting buoy array
- ARGO float array
- ● Real-time and near real-time tide gauge network (including the tsunami buoy network)
- PS Process Studies
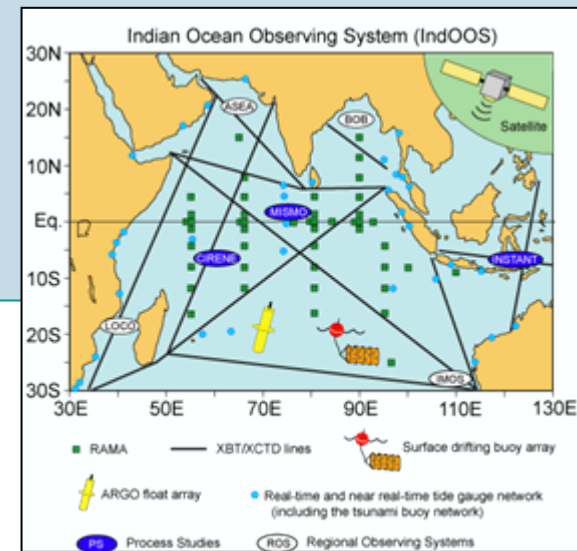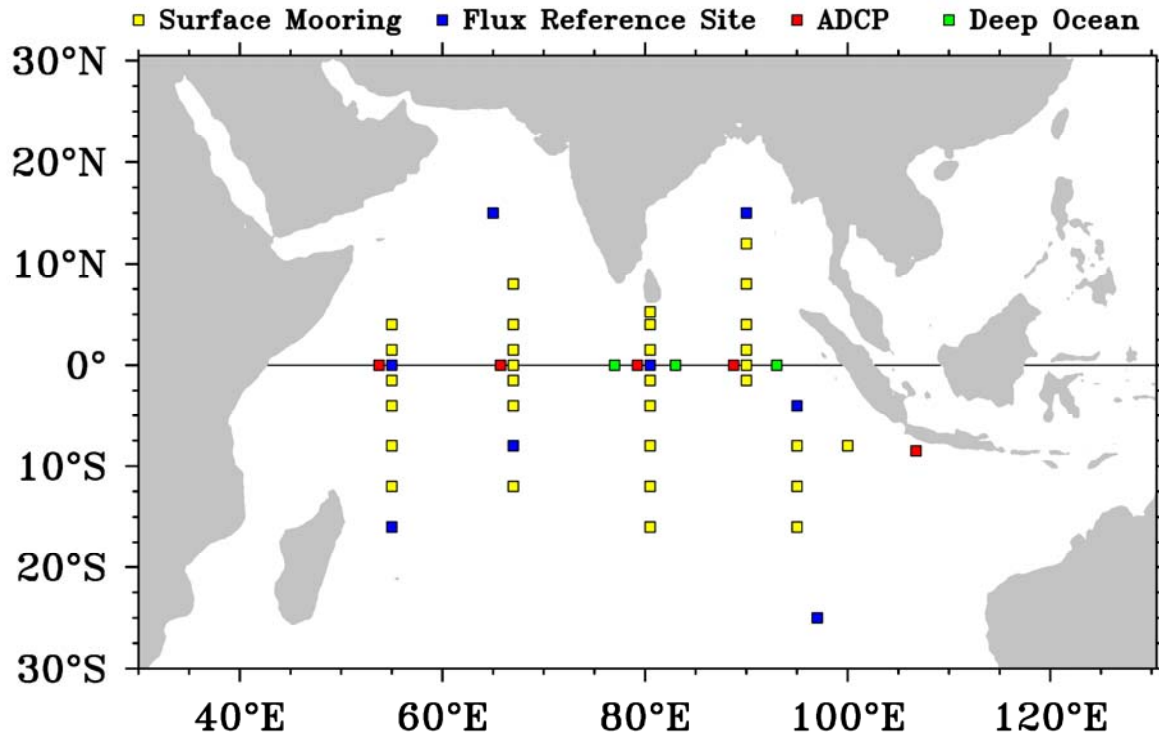- ROS Regional Observing Systems

IndOOS

- **Plan developed by the International CLIVAR/GOOS Indian Ocean Panel in 2004**

- **Basin scale, upper ocean (2000 m) focus.**

- **Design supported by numerical model observing system simulation studies.**

RAMA

Indian Ocean Observing System (IndOOS)

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

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

RAMA

McPhaden et al, 2009: RAMA. Bull. Am. Met. Soc., April issue

RAMA: Ancient king of India and hero of the epic "Ramayana".

Next Generation ATLAS Mooring
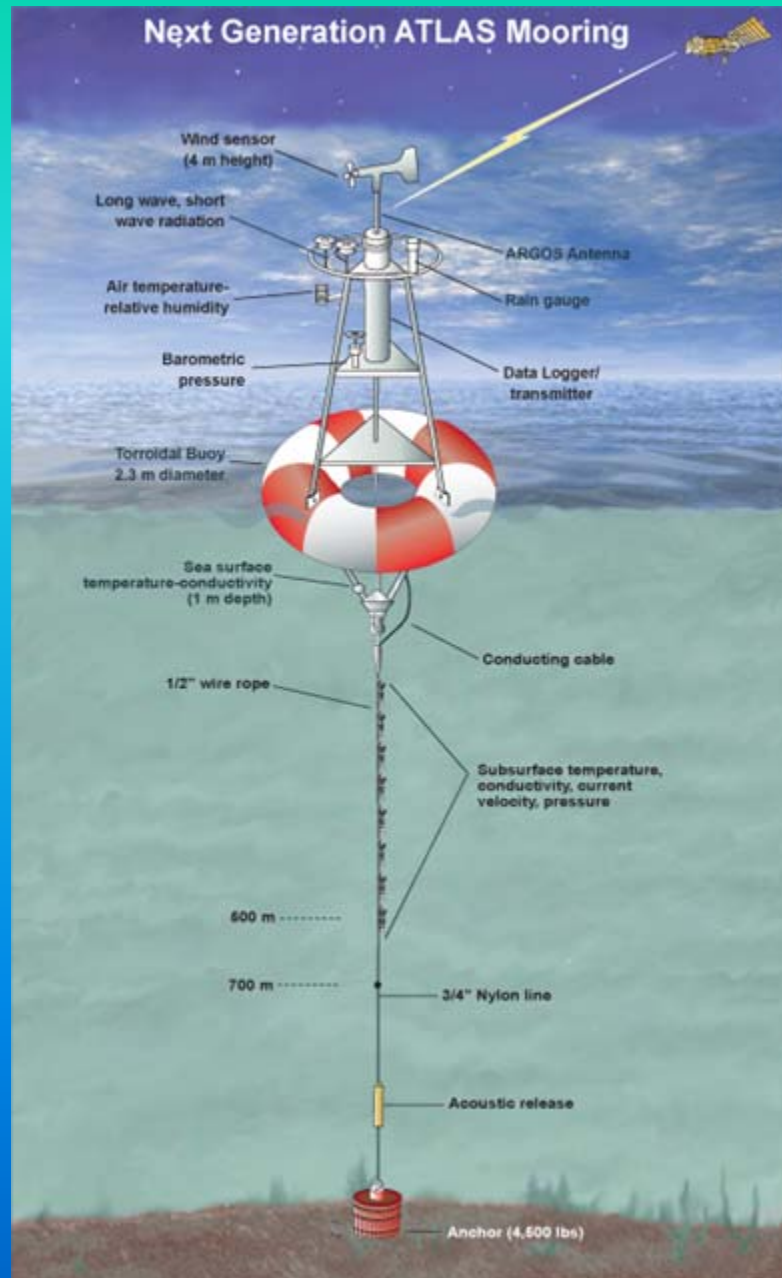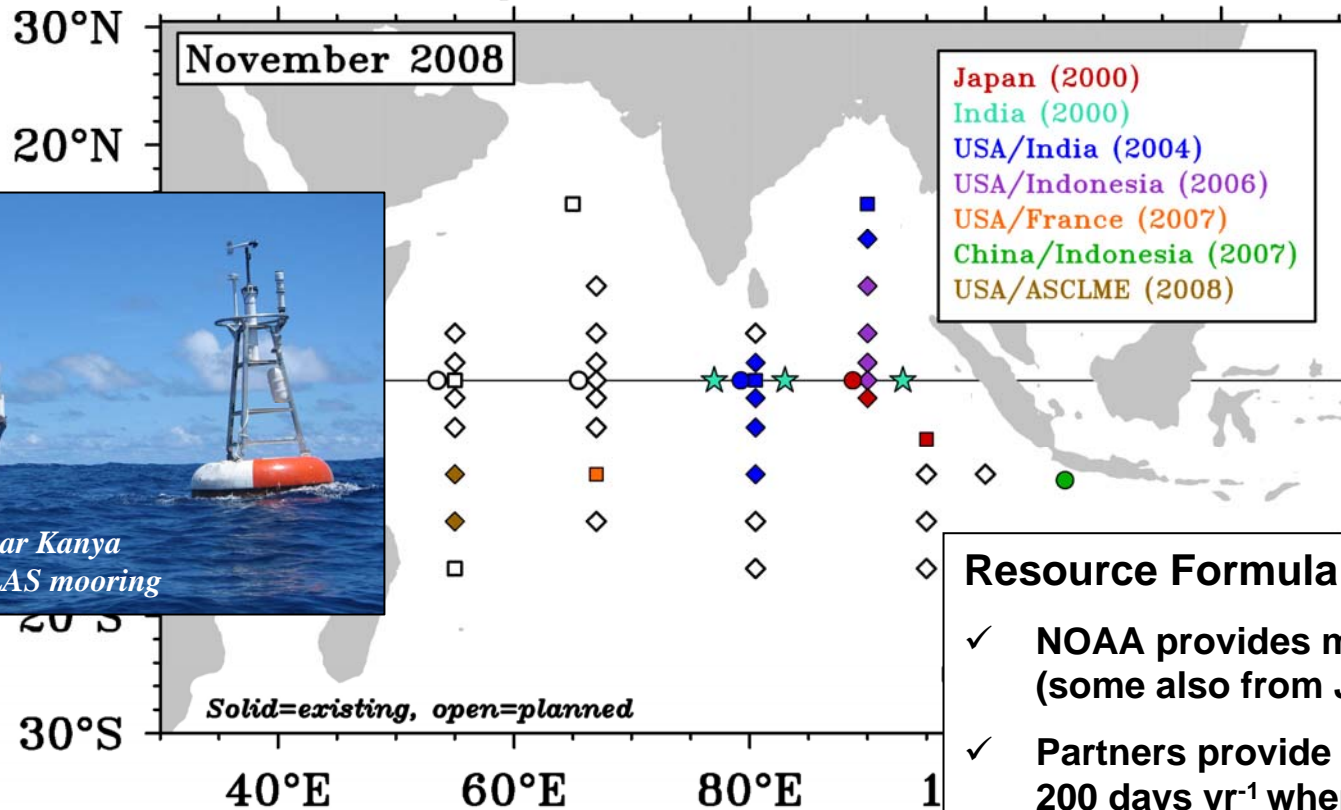
Surface Moorings

✓ **Rapid sampling in time to resolve rather than alias high frequencies**

✓ **Multi-variate (ocean, atmosphere, biogeochemical)**

✓ **Fixed grid array so time and space are not mixed**

✓ **Real-time data transmission (Service Argos & Global Telecommunications System)**

ATLAS

TRITON
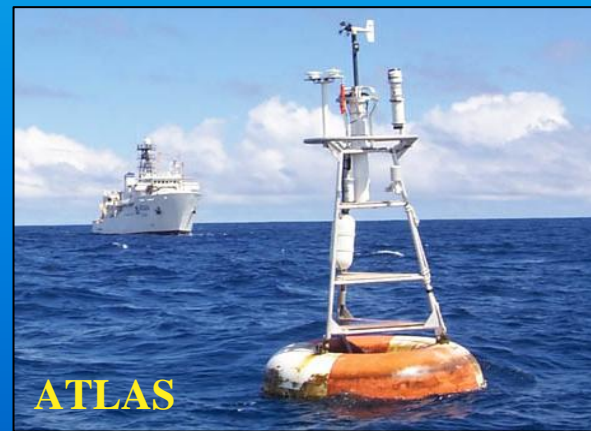
RAMA: Present Status

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

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

November 2008

Japan (2000)
India (2000)
USA/India (2004)
USA/Indonesia (2006)
USA/France (2007)
China/Indonesia (2007)
USA/ASCLME (2008)

Solid=existing, open=planned

ORV Sagar Kanya deploys ATLAS mooring
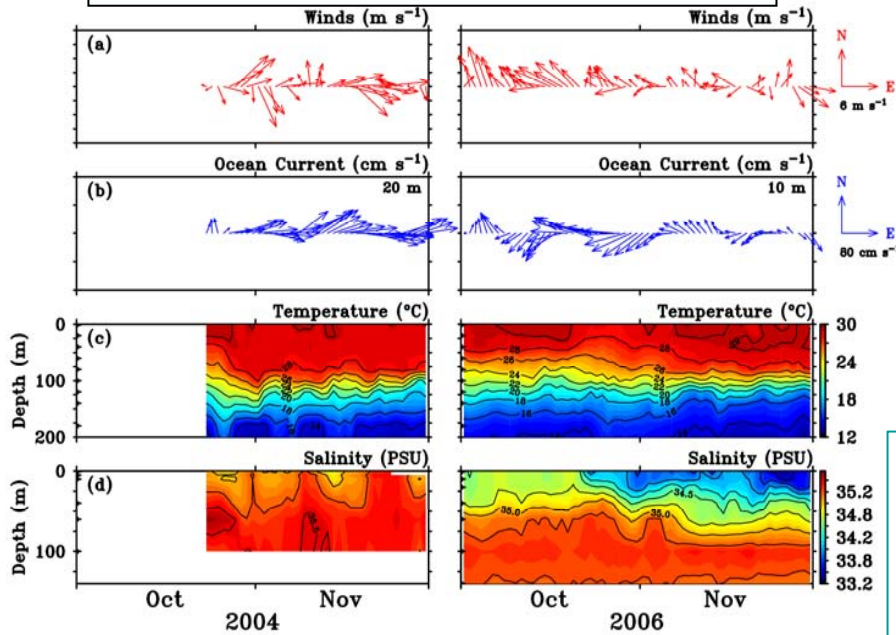
Resource Formula:

✓ **NOAA provides most equipment (some also from Japan & India)**

✓ **Partners provide ship time (~150-200 days yr^{-1} when complete)**

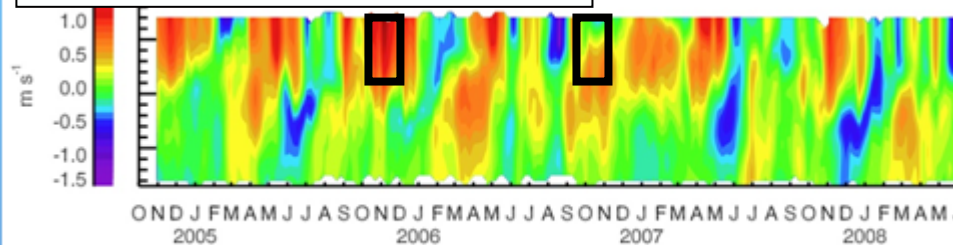*47% of sites occupied at present (22 of 46)*
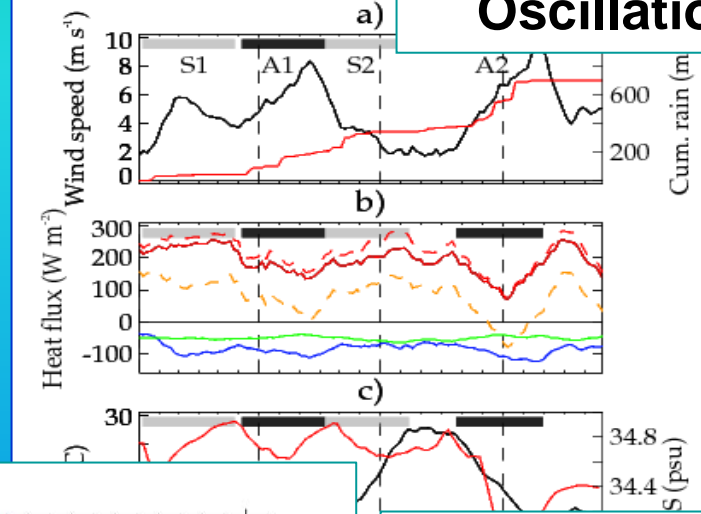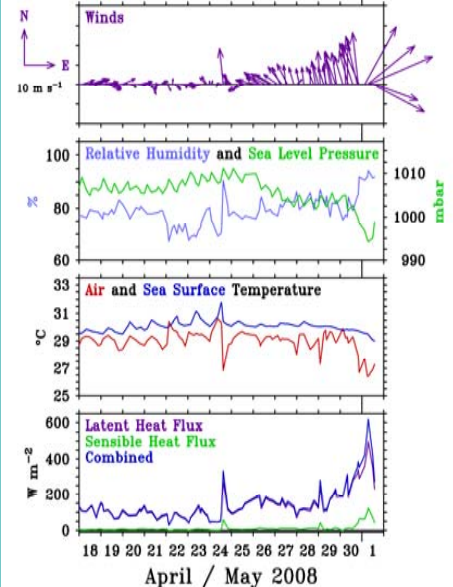
Scientific Progress

Indian Ocean Dipole

Madden-Julian Oscillation

Vialard et al, GRL, 2008

Ocean Circulation

Nagura & McPhaden, GRL, 2008

Cyclone Nargis

TMI/AMSR SST
2 May 2008

McPhaden et al, EOS, 2009
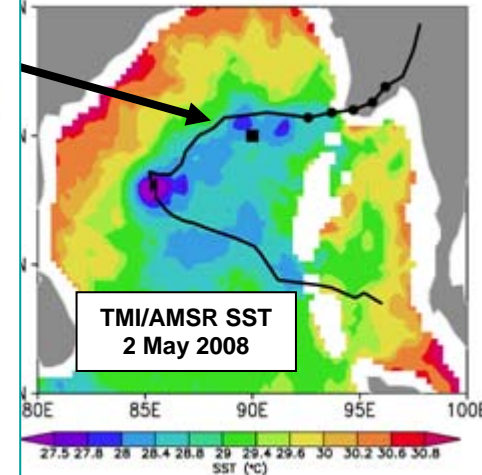
RAMA: Plans for 2009
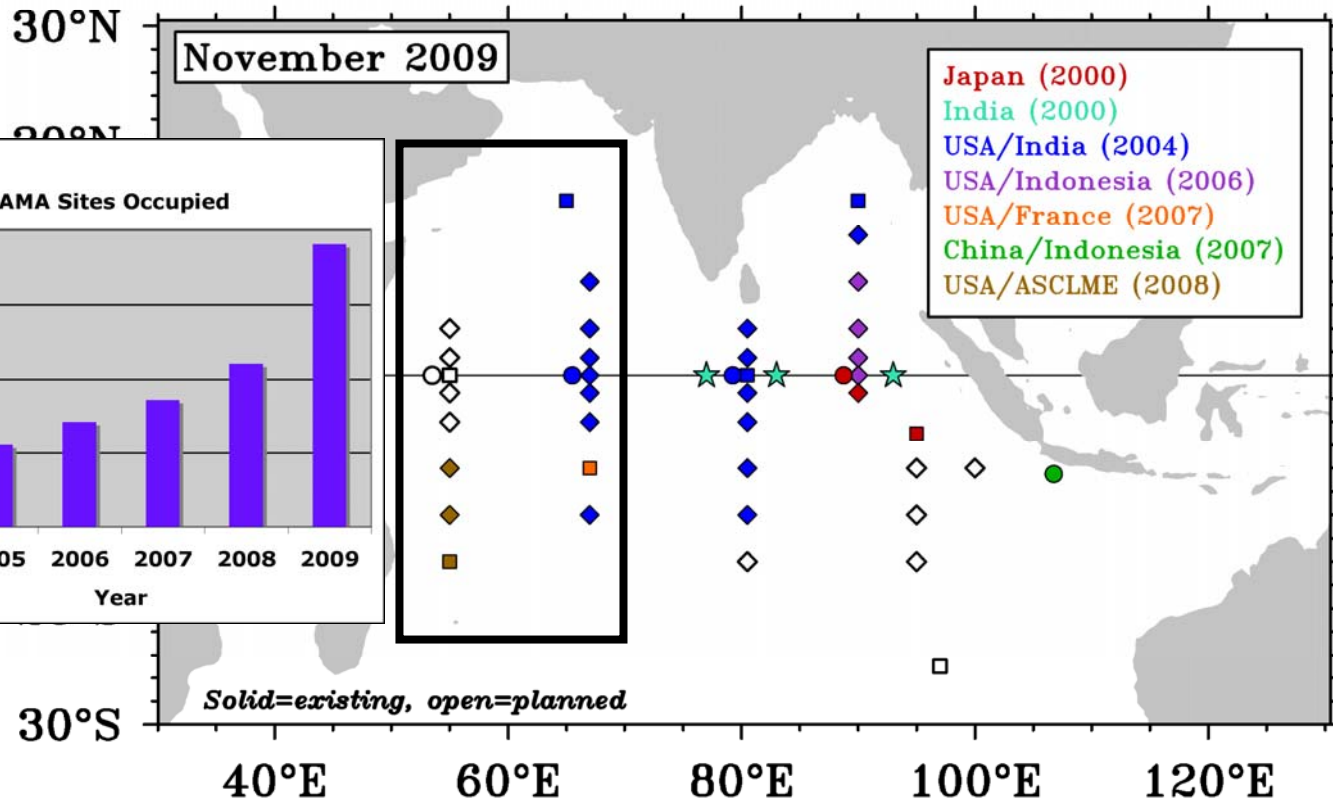
83% of sites occupied by November 2009 (38 of 46)

Summary

- ✓ *IndOOS and RAMA will be ~complete by late 2011*

- ✓ *Valuable contribution for studies of ocean-atmosphere interaction, ocean mixed layer dynamics, ocean circulation*

- ✓ *Real-time data for weather and climate forecasting & analysis*

- ✓ *Large scale, long term oceanographic context for CINDY/DYNAMO*

- ✓ *CINDY/DYNAMO ship support for some basic mooring work*
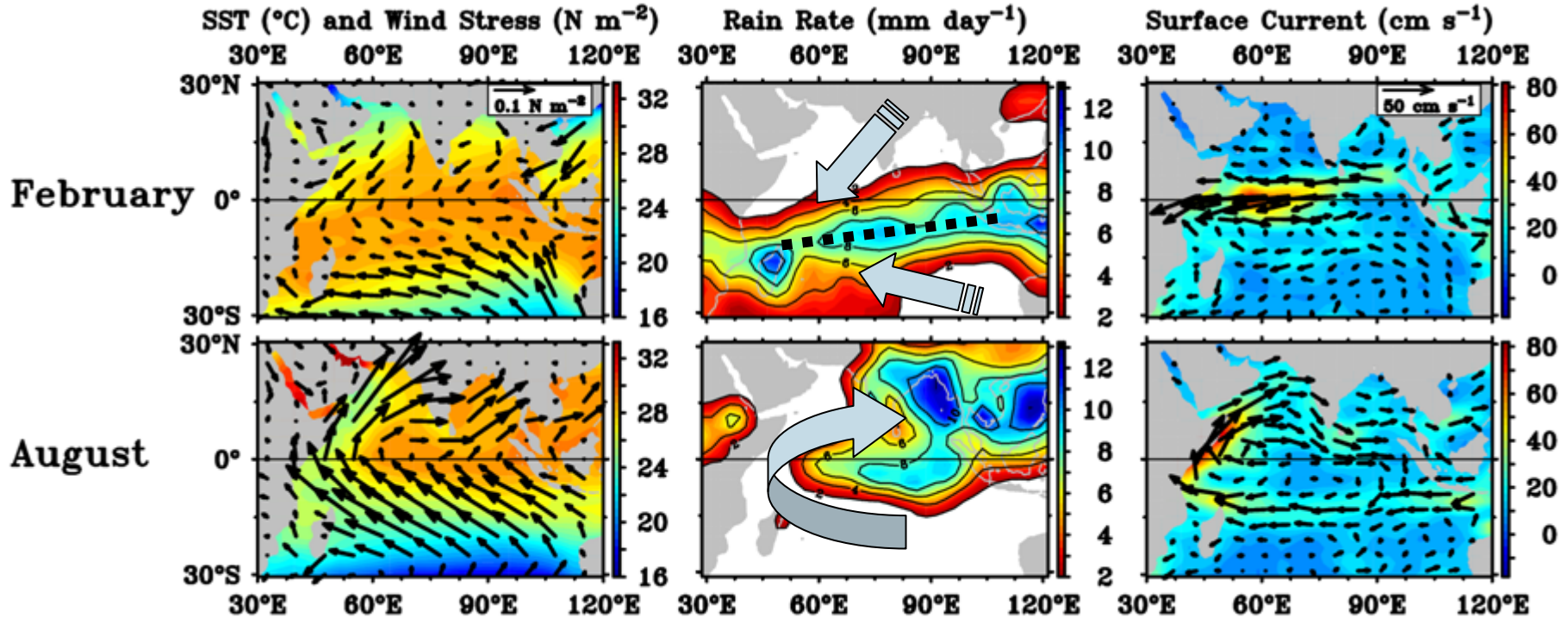
International Cooperation

DART/RAMA cruise

RV Baruna Jaya III
Sept 2007
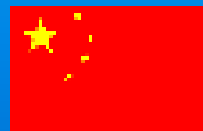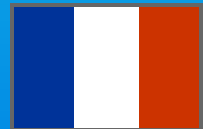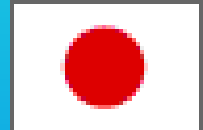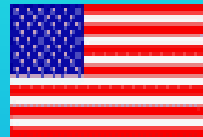
Bilateral agreements between NOAA & agencies in:

- **Indonesia--signed in 2007**
- **India--signed in 2008**
- **Japan--signed in**
- **ASCLME (East African countries)--planned in 2009**
- **materials: Indonesia with a) China; b) Japan**

International IndOOS Resource Forum

The Monsoons

One third of the world's population depends on monsoon rainfall