IndOOS (Indian Ocean Observing System):

Present status and recent highlights on air-sea interactions in the Indian Ocean

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Outline

- Indian Ocean Observing System

  - Background and present status

- Examples of key phenomena observed by IndOOS

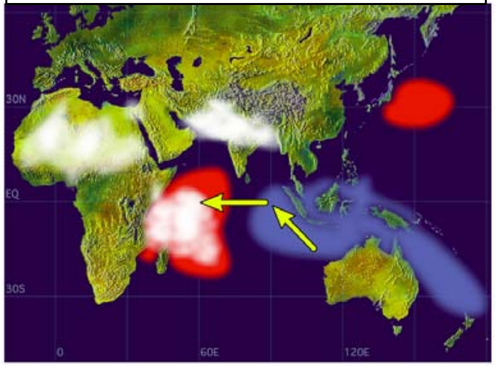
  - Ocean responses and air-sea interactions associated with cyclone Nargis

  - Strong upwelling in the equatorial Indian Ocean during MISMO

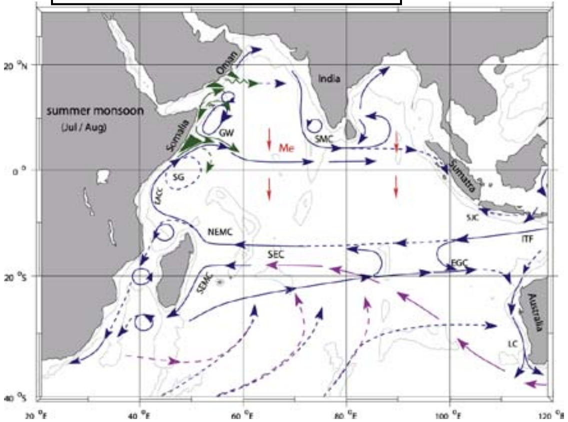
  - IOD variations

Indian Ocean Science Drivers

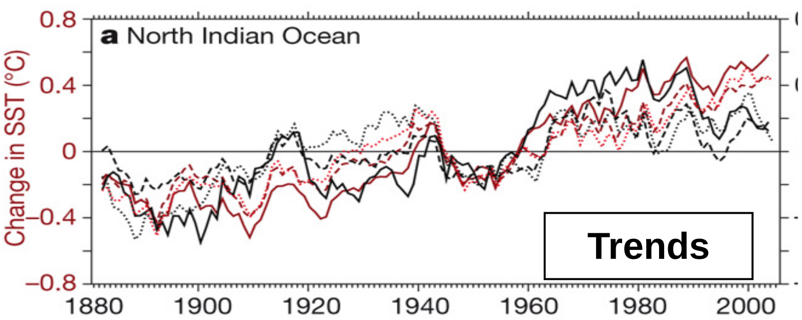
Indian Ocean Dipole

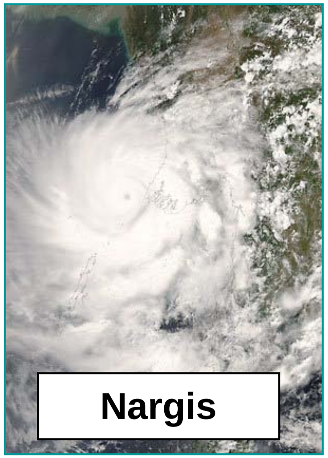


Ocean circulations

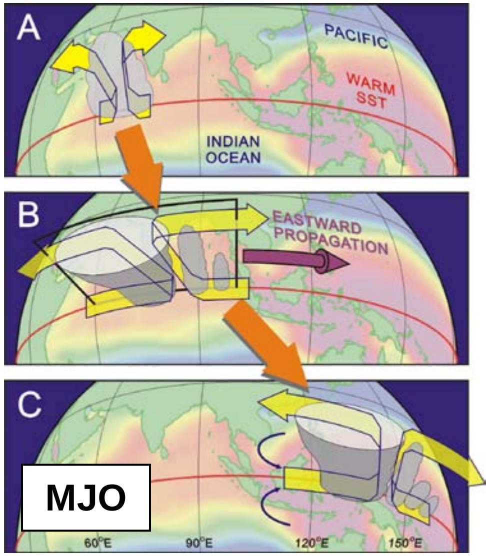


- Seasonal monsoons
- Severe weather events & cyclones
- Intraseasonal (30-60 day) variations, Madden Julian Oscillation
- Interannual variations: the Indian Ocean Dipole, Influence of ENSO
- Decadal variability and warming trends
- Ocean circulations and biogeochemistry

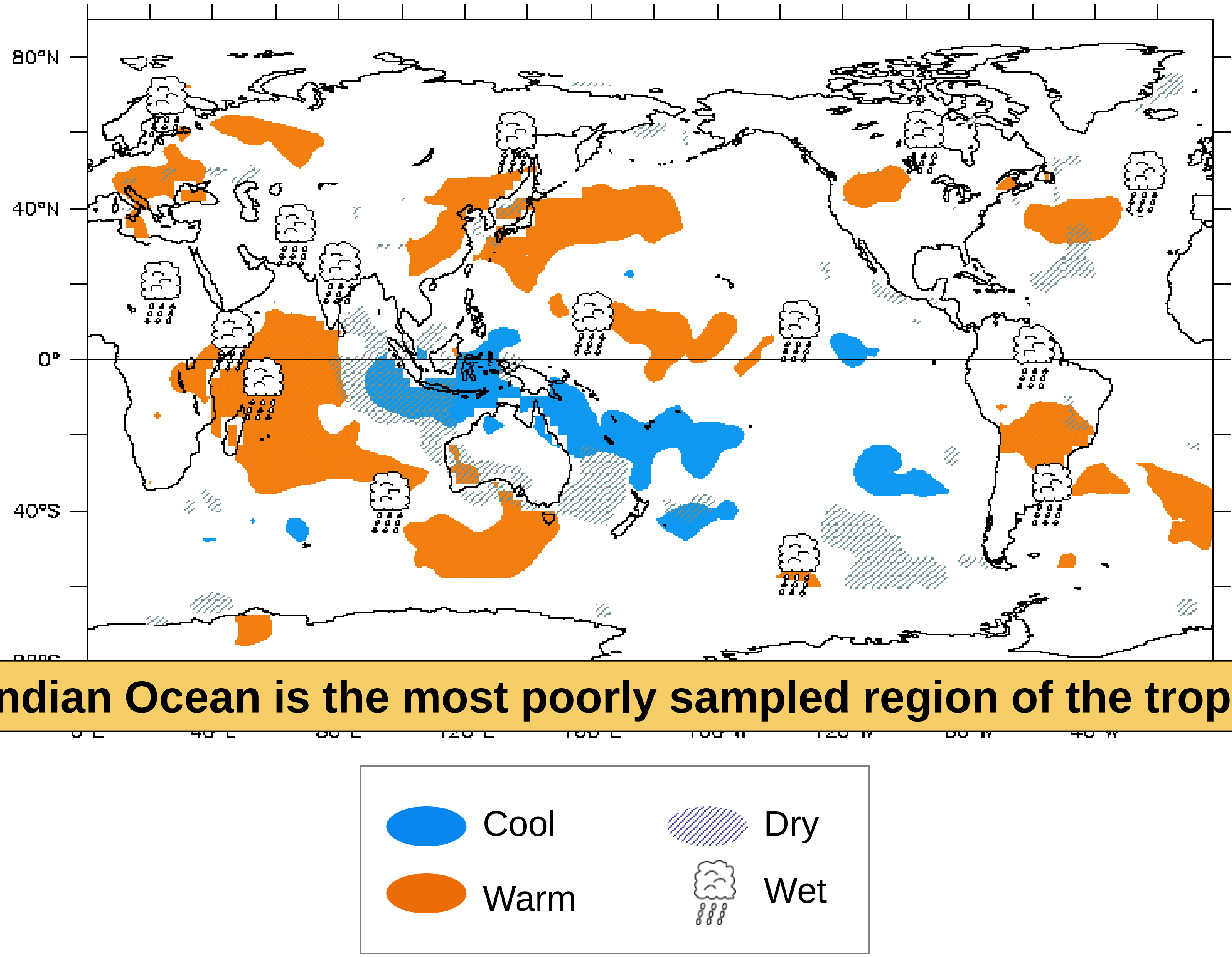




Nargis

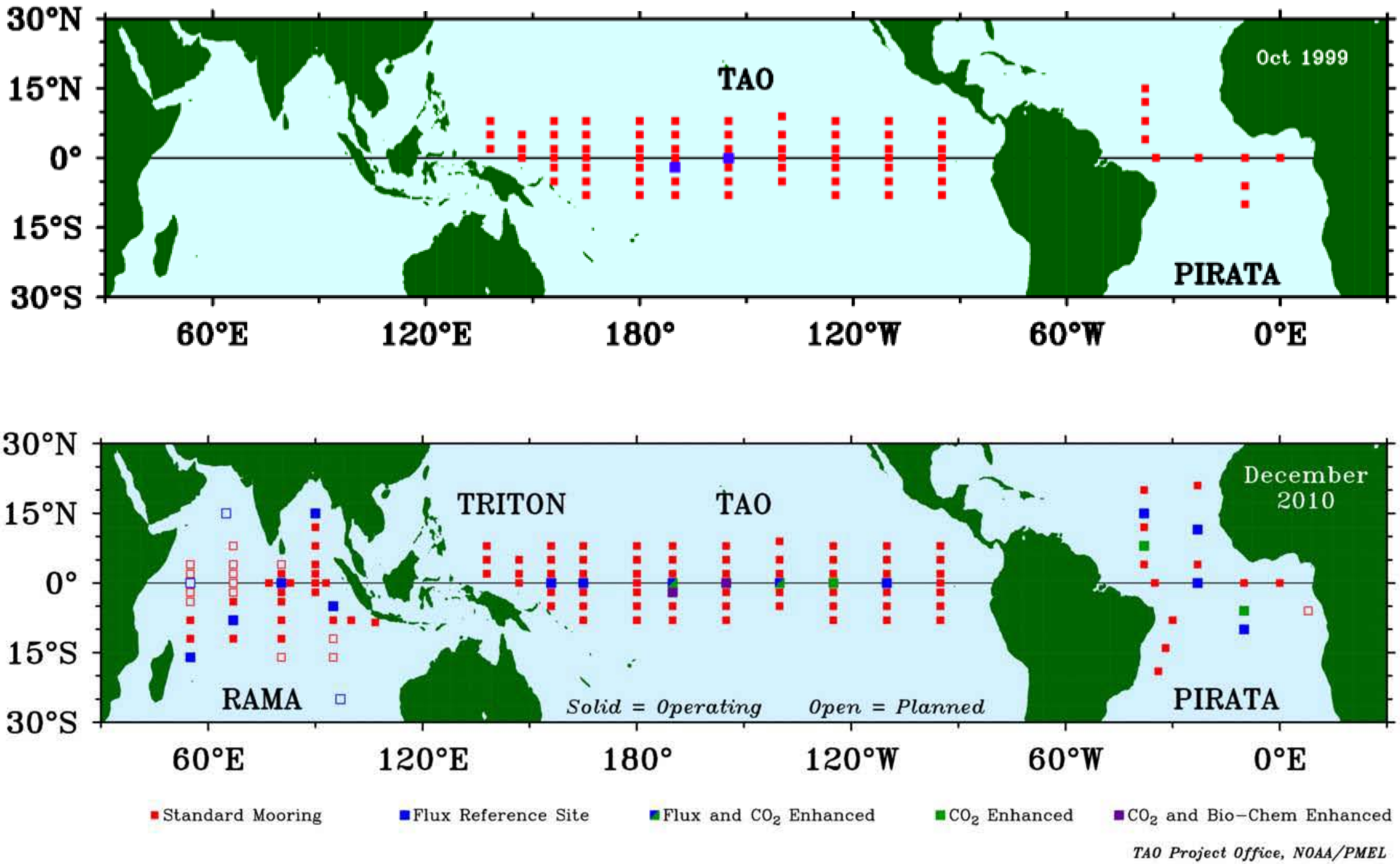


Impacts of positive IOD during boreal summer

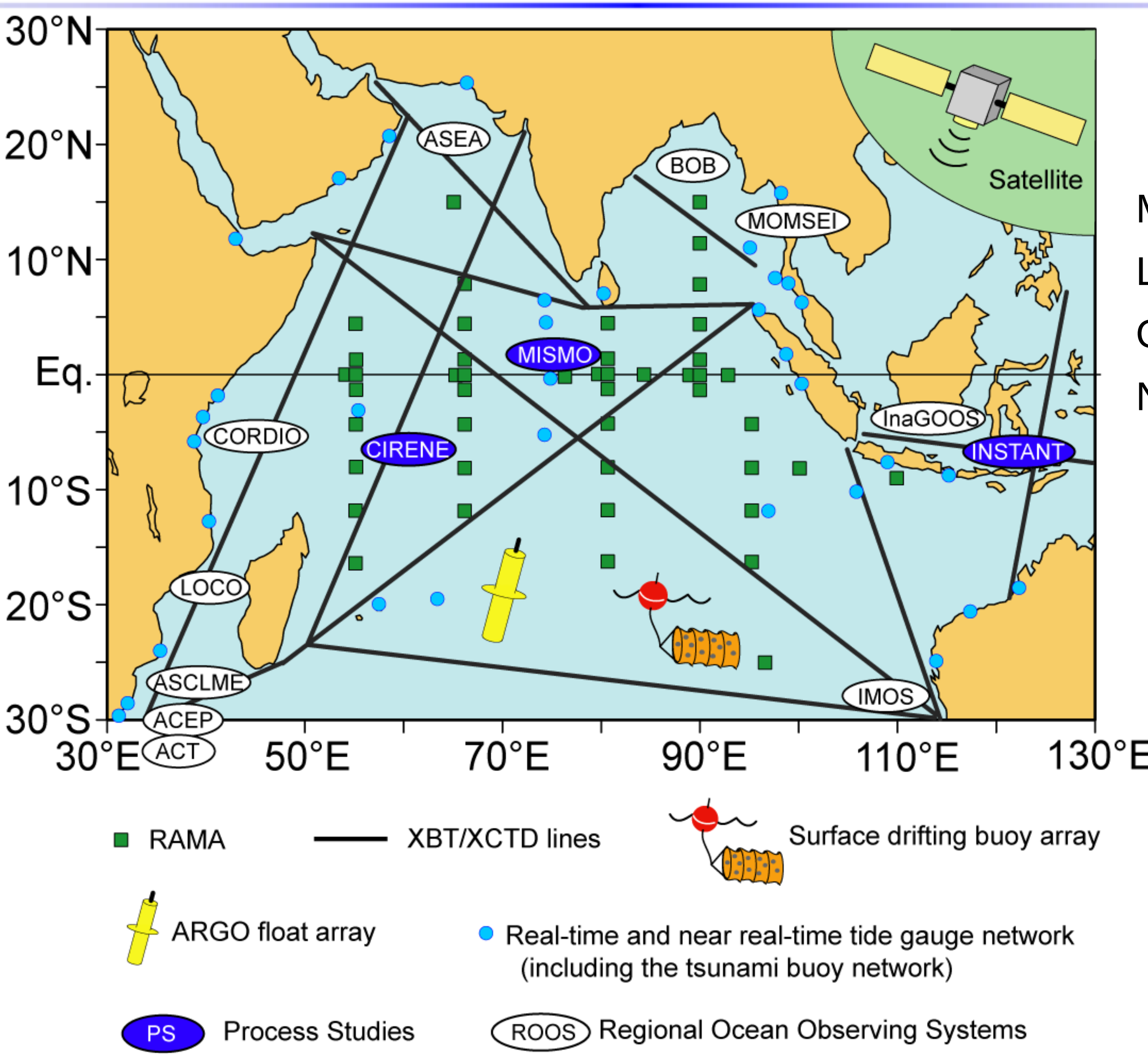


Indian Ocean is the most poorly sampled region of the tropics

Global Tropical Moored Buoy Array



Indian Ocean Observing System (IndOOS)



Multi-platform

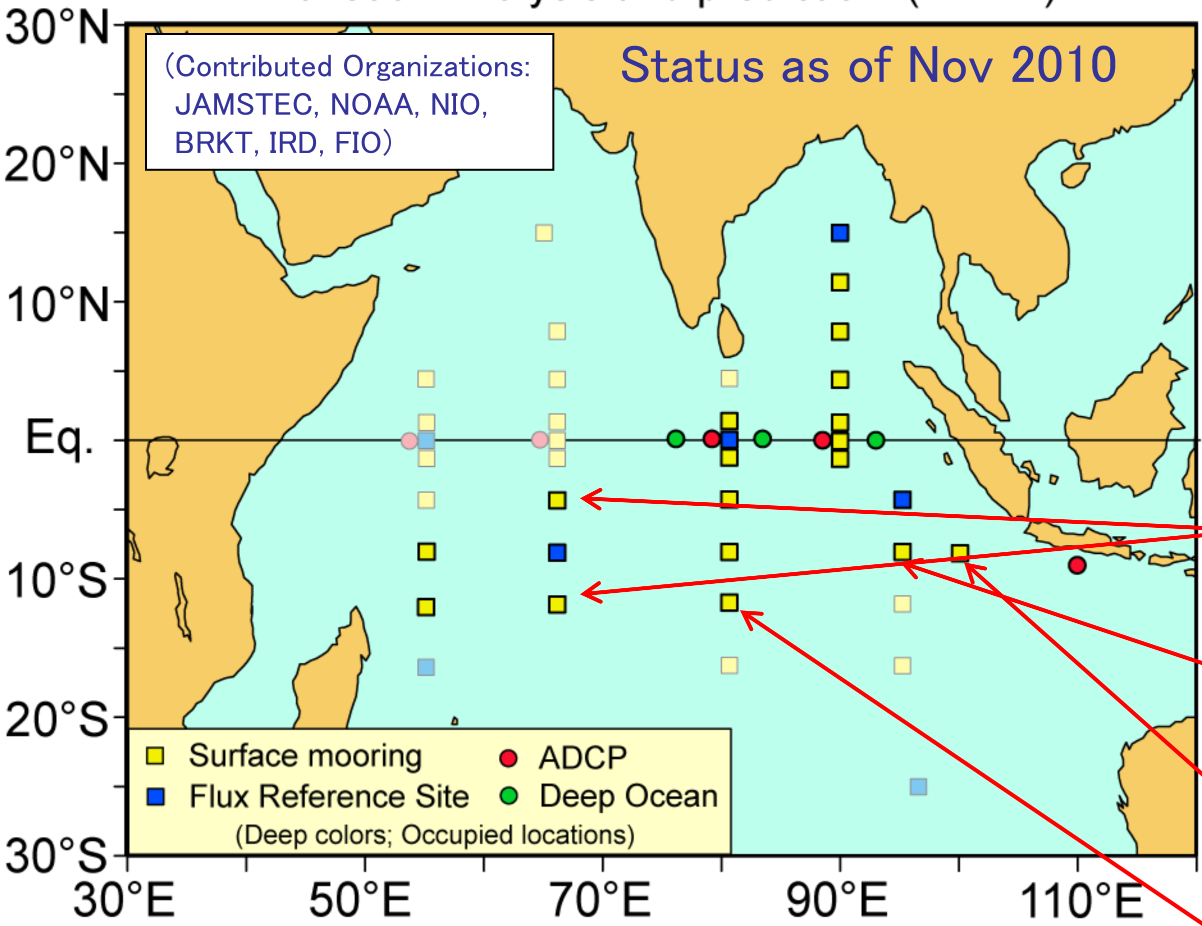
Long-term

Observation

Network

Mooring Array: Present Status

Research moored Array for African-Asian-Australian Monsoon Analysis and prediction (RAMA)



- 59% complete

  (27 out of 46 Sites;

  4 Flux Reference Sites)

- Recent deployments

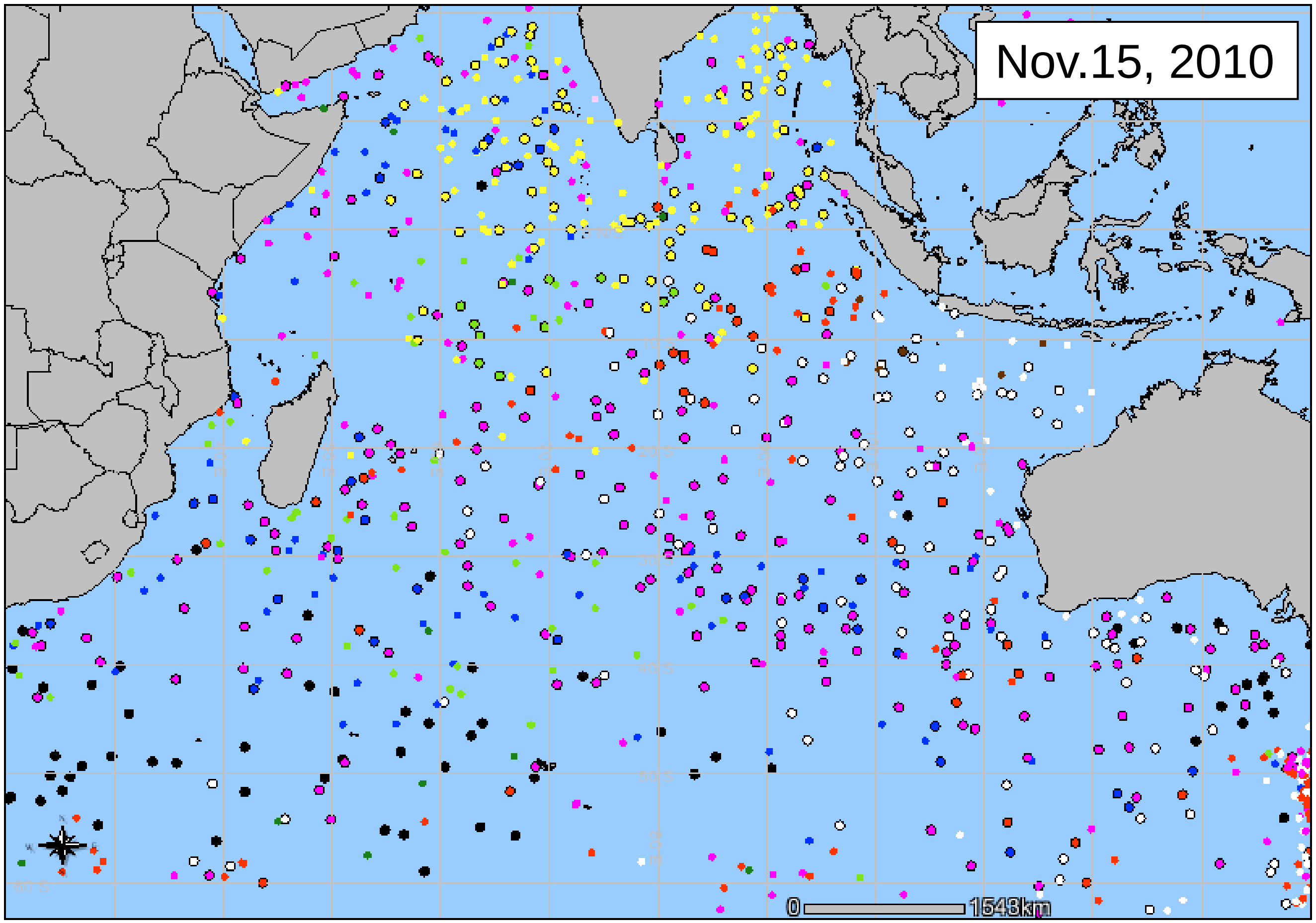
  ATLAS: 4° S, 12° S at 65° E (NOAA+NIO)

  m-TRITON: 8° S, 95° E (JAMSTEC)

  ATLAS: 8° S, 100° E (FOI+BRKT)

  ATLAS: 12° S, 80.5° E (NOAA+NIO)

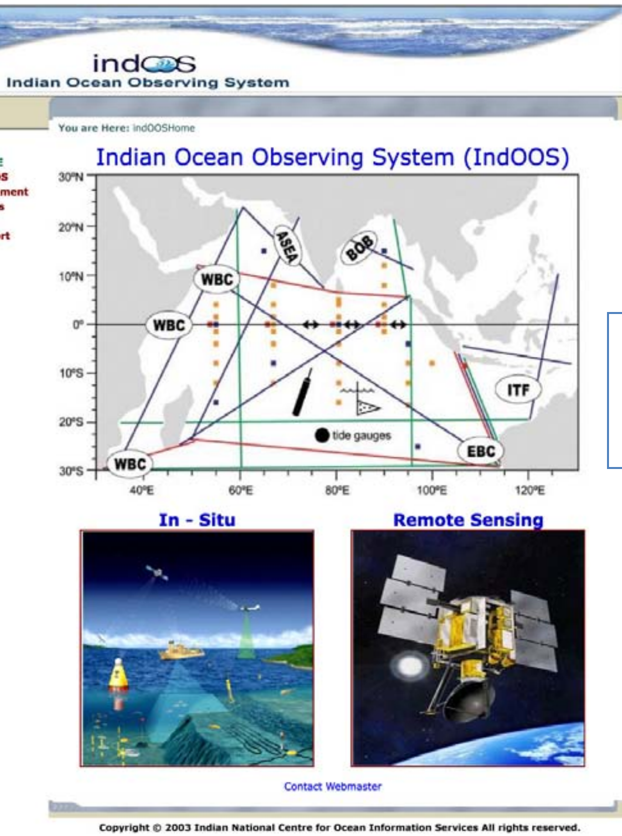
Present status of Argo in the Indian Ocean sector



Active Number of floats: 674

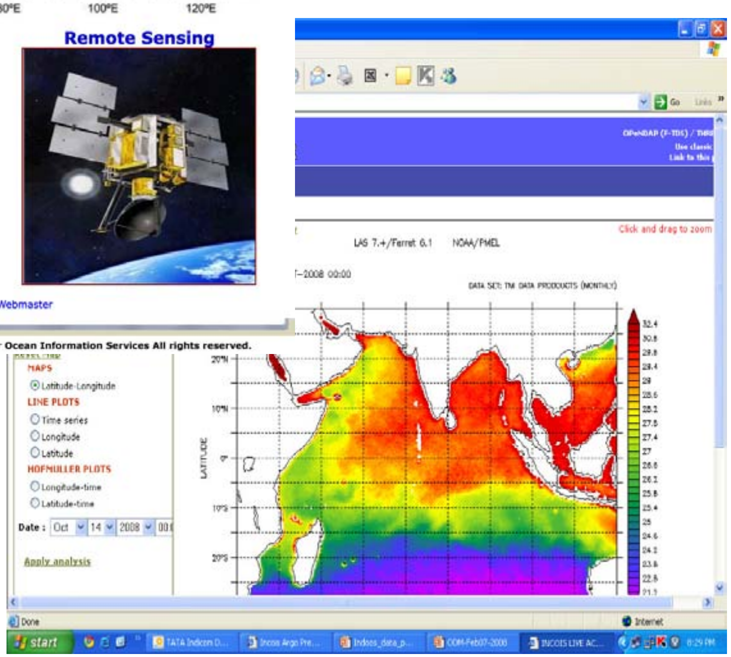
- Others (30)
- AUS (140)
- CANADA (??)
- FRA (27)
- IND (75)
- JAP (35)
- UK (25)
- USA (352)
- CHN (??)

IndOOS Data Portal & RAMA Data sites

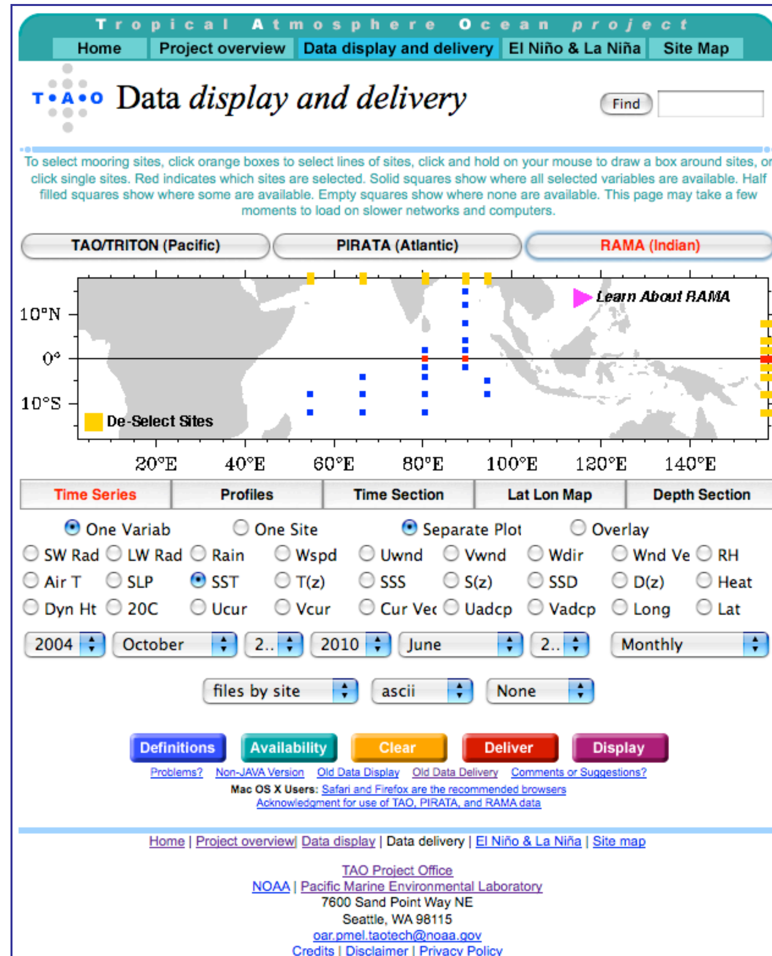


IndOOS data portal maintained by INCOIS, India

All the available data for IndOOS are listed with links to sources



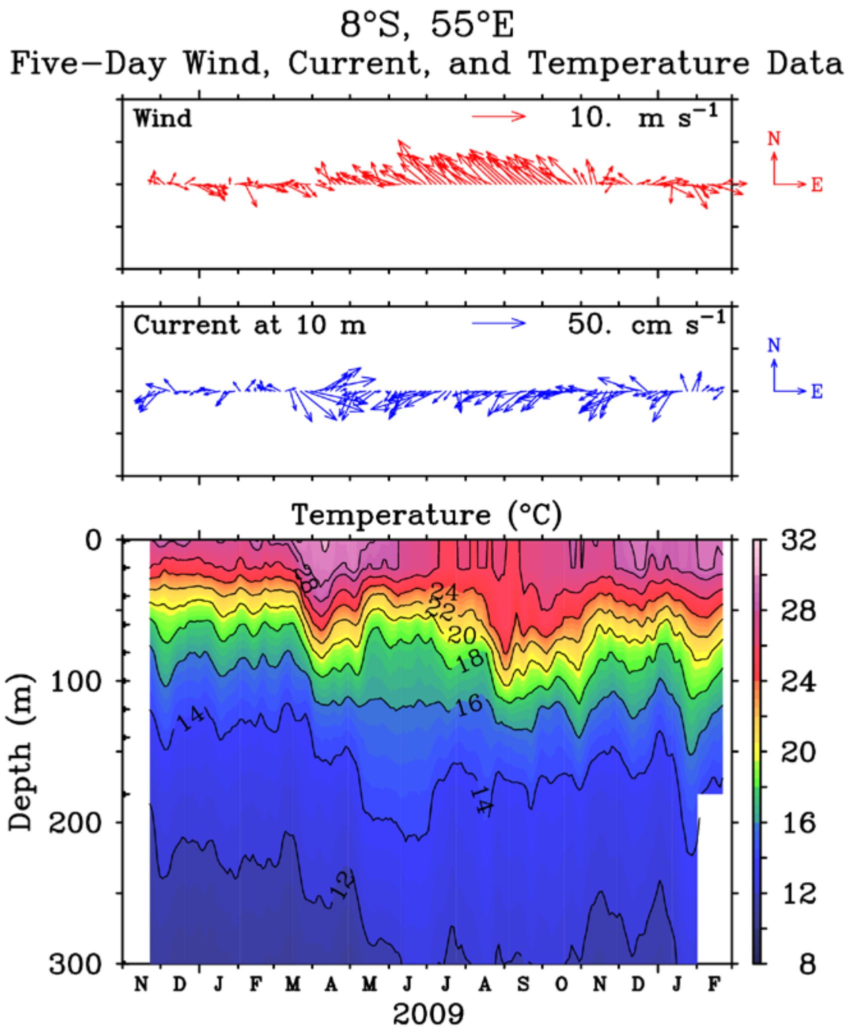
RAMA Data site maintained by PMEL



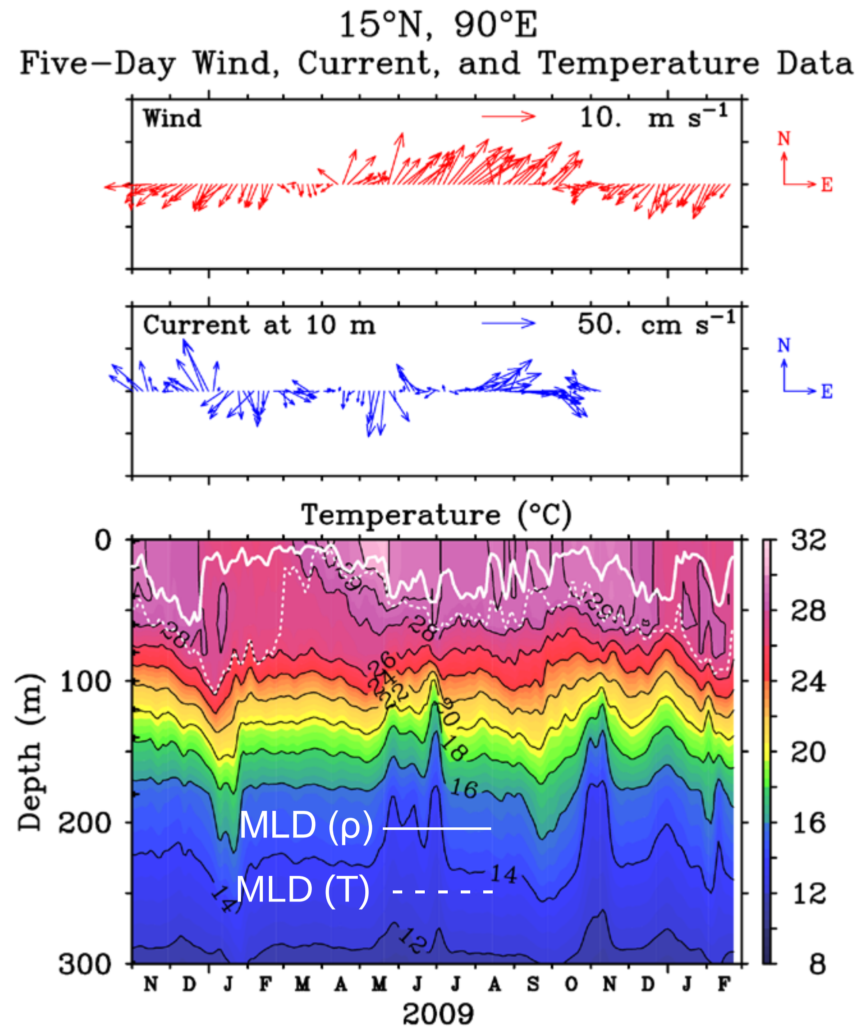
✓ http://www.incois.gov.in/Incois/iogoos/home_indoos.jsp

Two Examples of RAMA Data

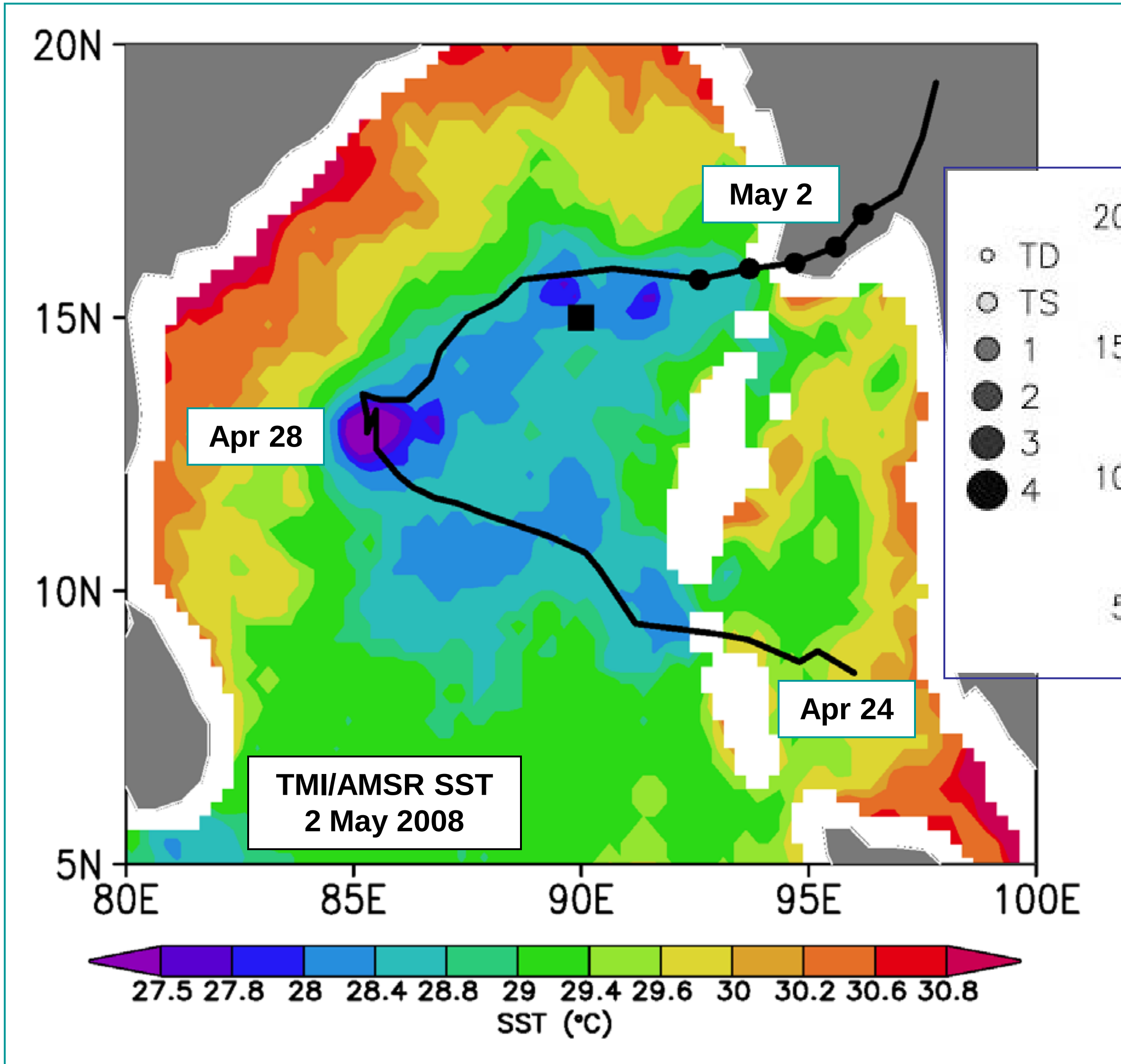
Thermocline Ridge in the southwestern tropical IO

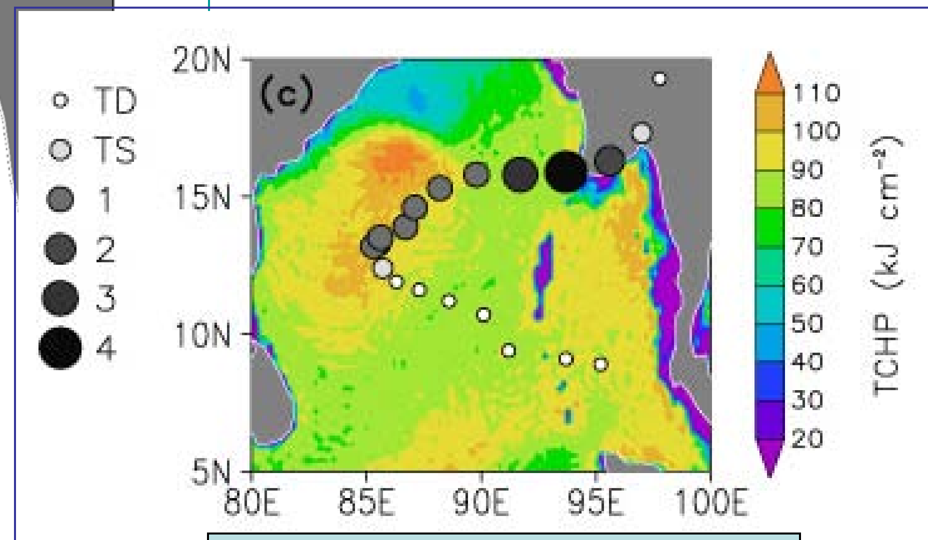


Bay of Bengal



Cyclone Nargis



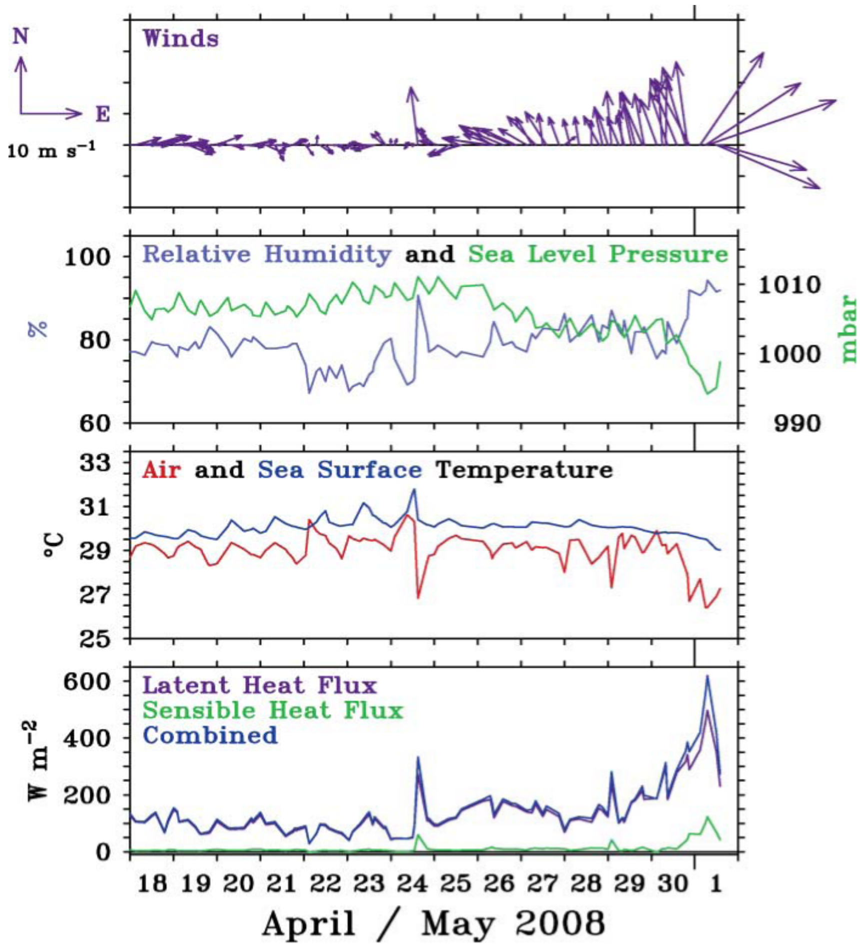


Tropical Cyclone Heat Potential (April Climatology)

TCHP: the amount of heat stored above the 26° C isotherm

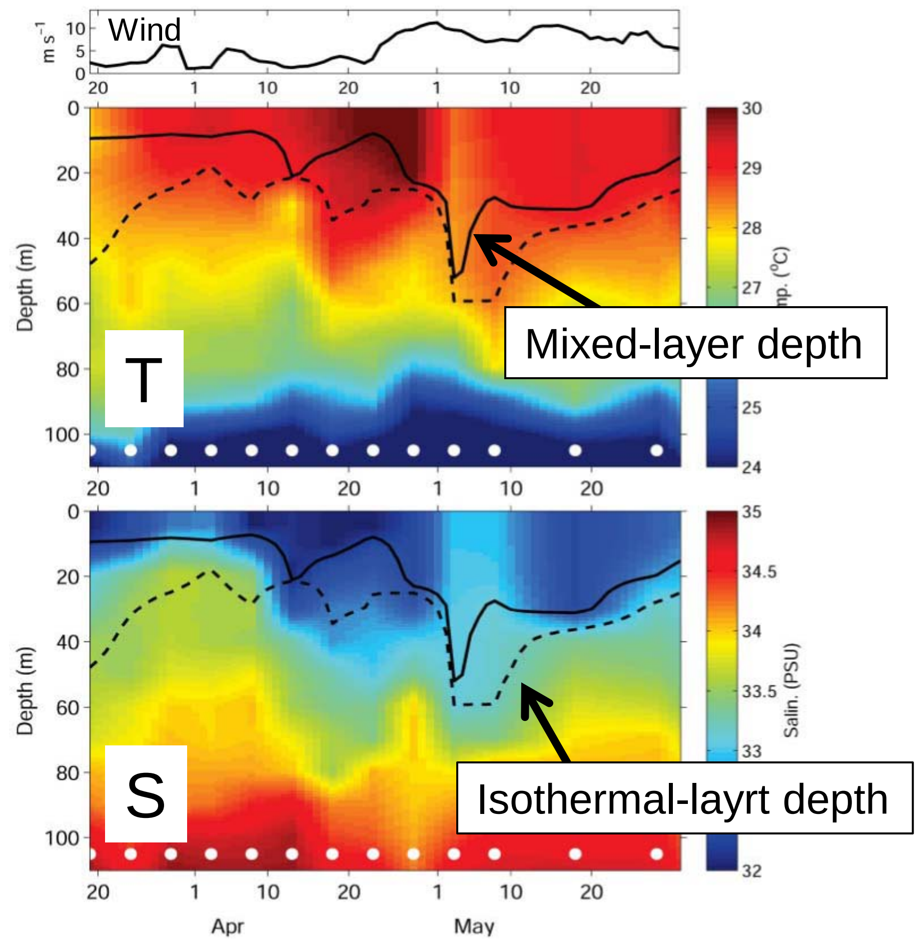
Variability associated with Cyclone Nargis

Surface meteorological data & estimated surface fluxes from the buoy at 90E, 15N



ATLAS buoy measures large variability in the surface fluxes

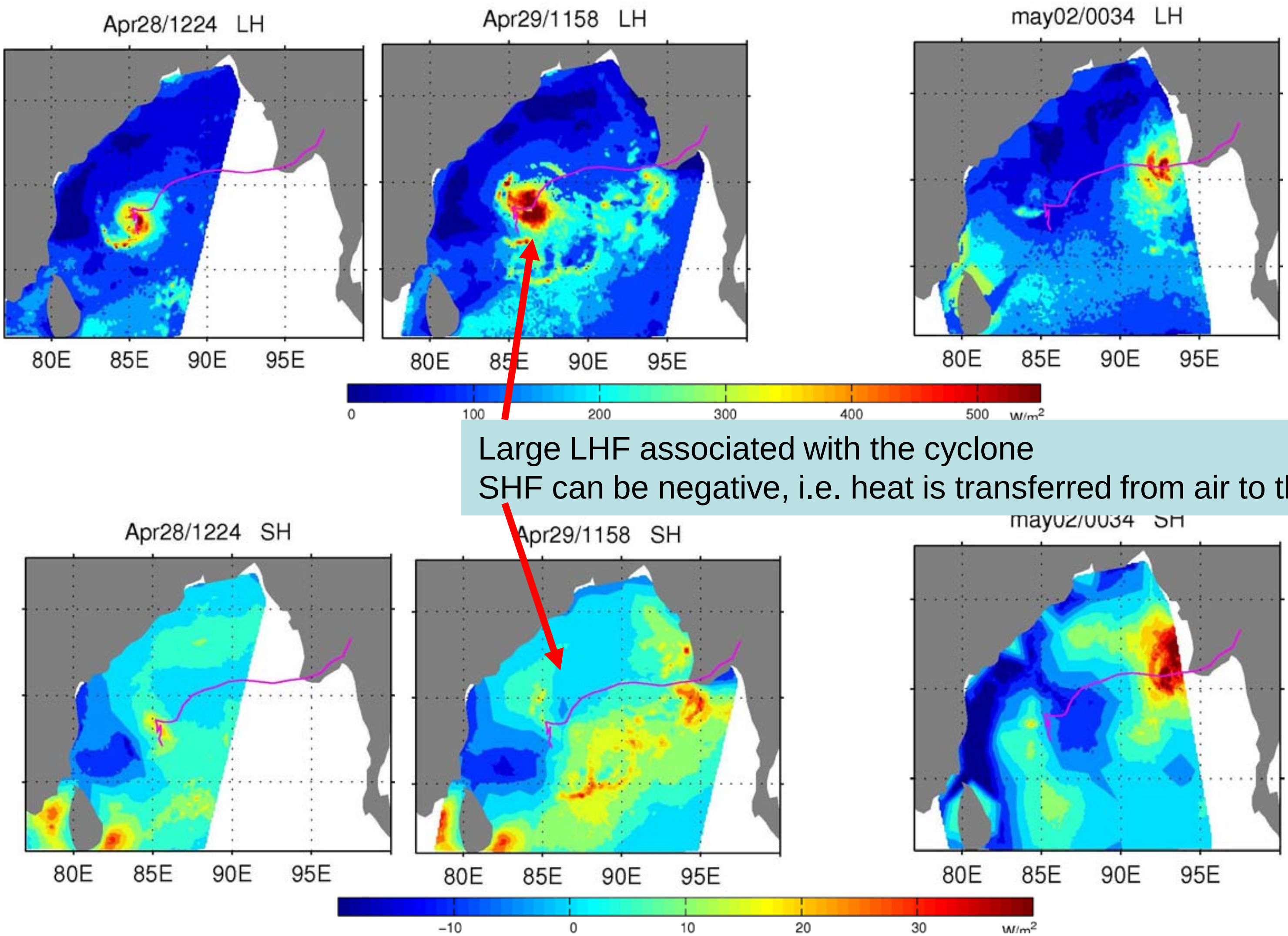
3-day averaged QSCAT wind (upper), Argo T (middle) & S (lower) profiles



Argo buoys capture large variability in the surface mixed-layer T, S

(McPhaden et al. 2009)

OAFlux estimation of Nargis latent and sensible heat fluxes

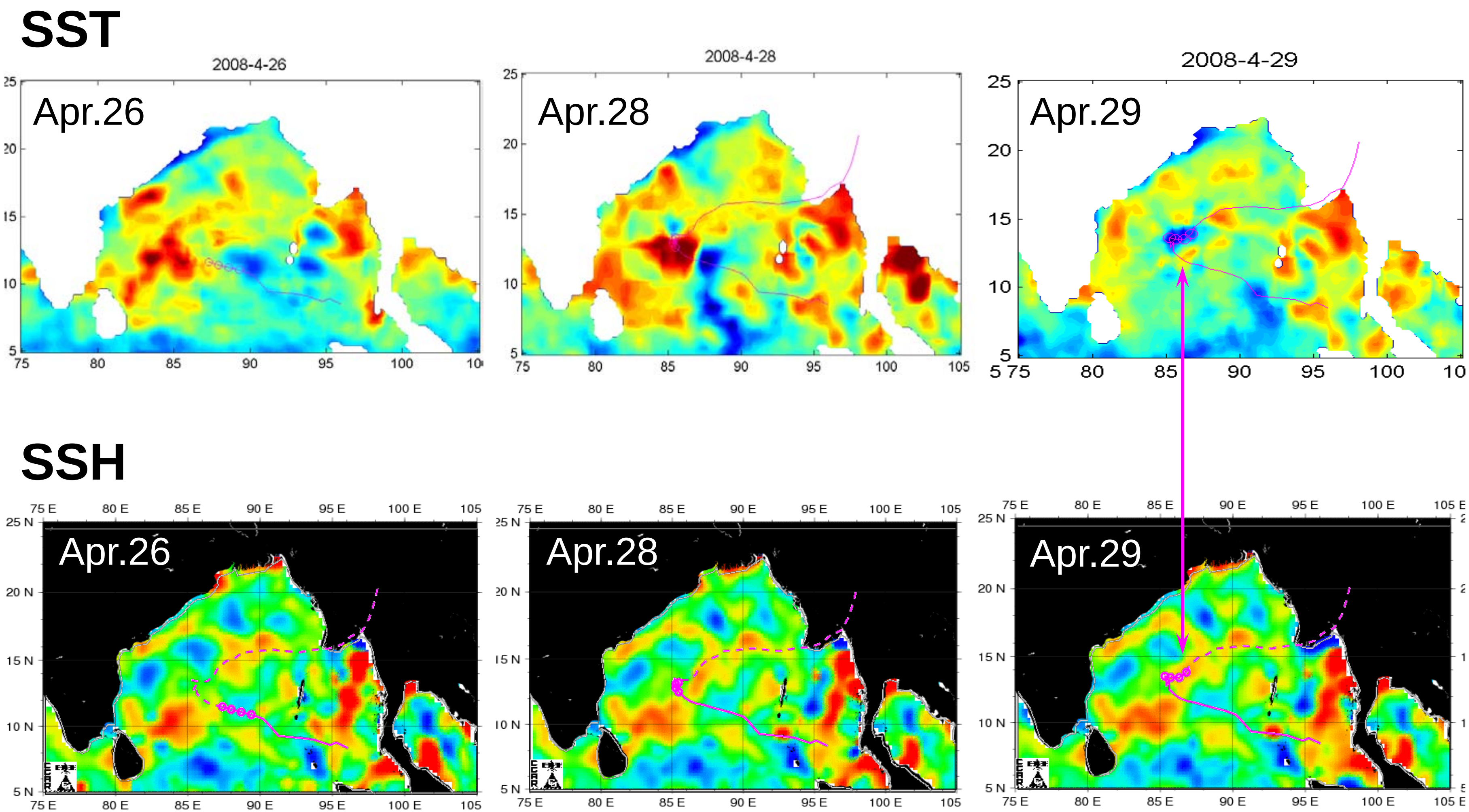


Large LHF associated with the cyclone
SHF can be negative, i.e. heat is transferred from air to the ocean

Based on QuikSCAT 12.5km swath

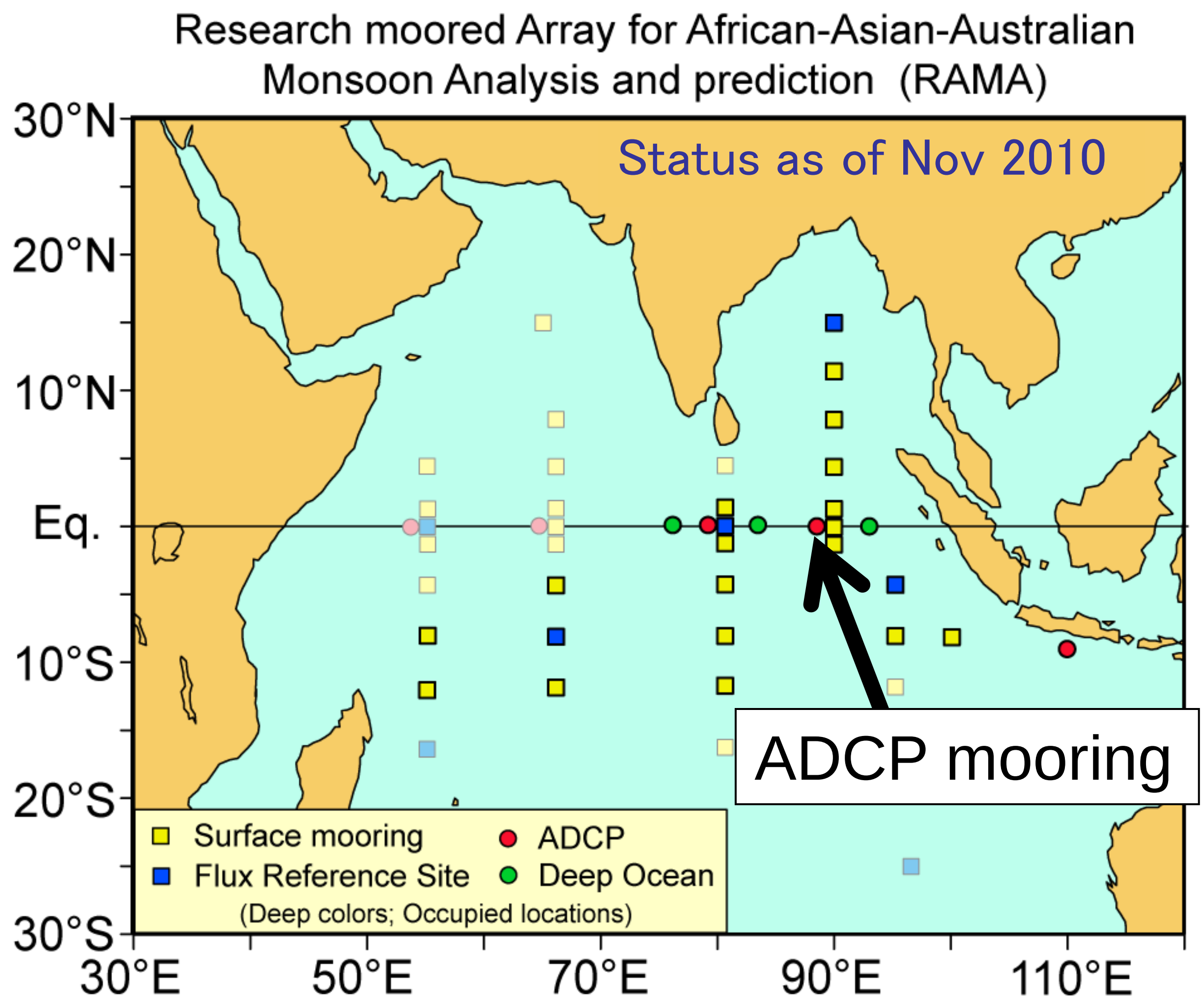
(Yu,2009; Lee 2009, personal communication)

Warm core ring signature in SST



(Yu,2009; Lee 2009, personal communication)

Mooring Array: Present Status

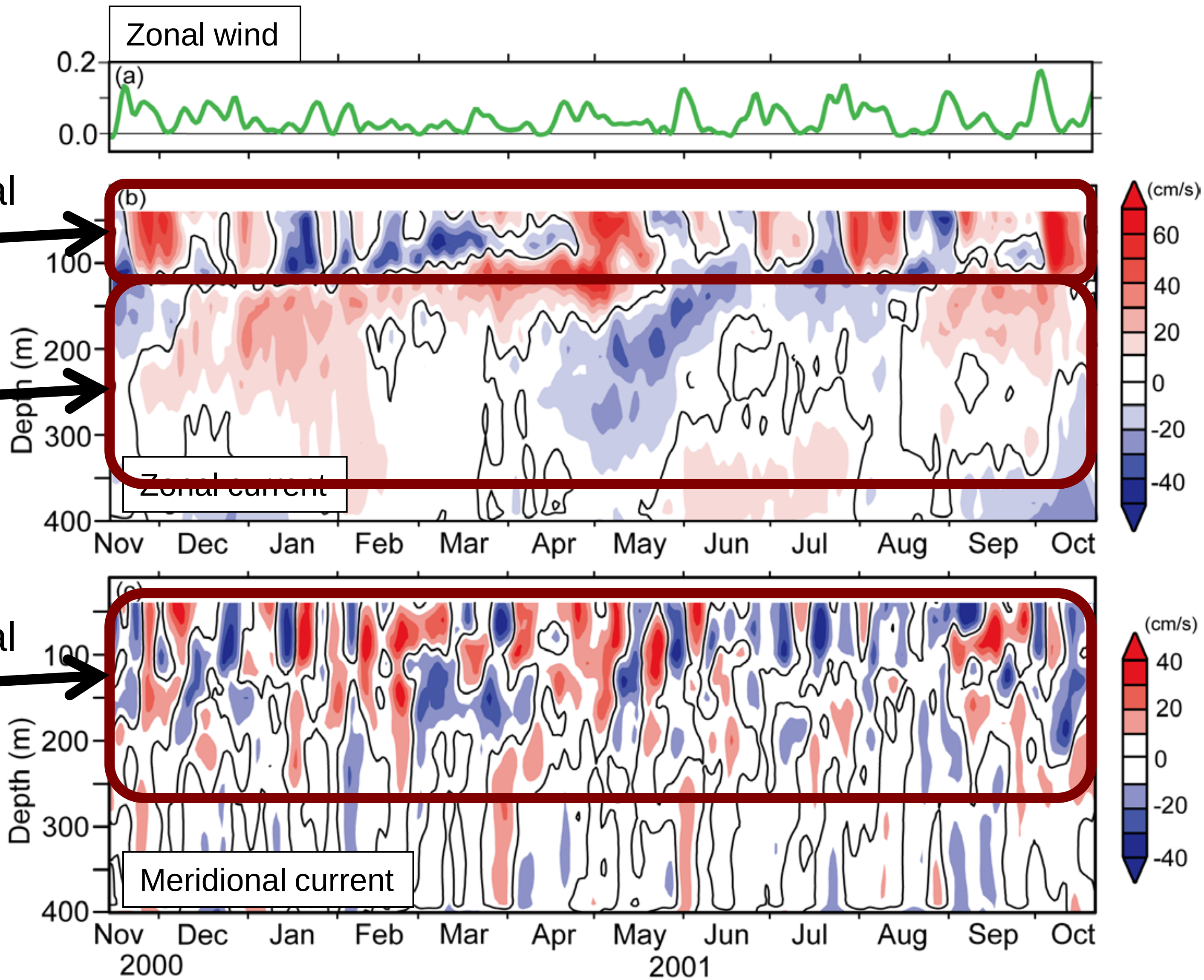


Current variability at 90E on the equator

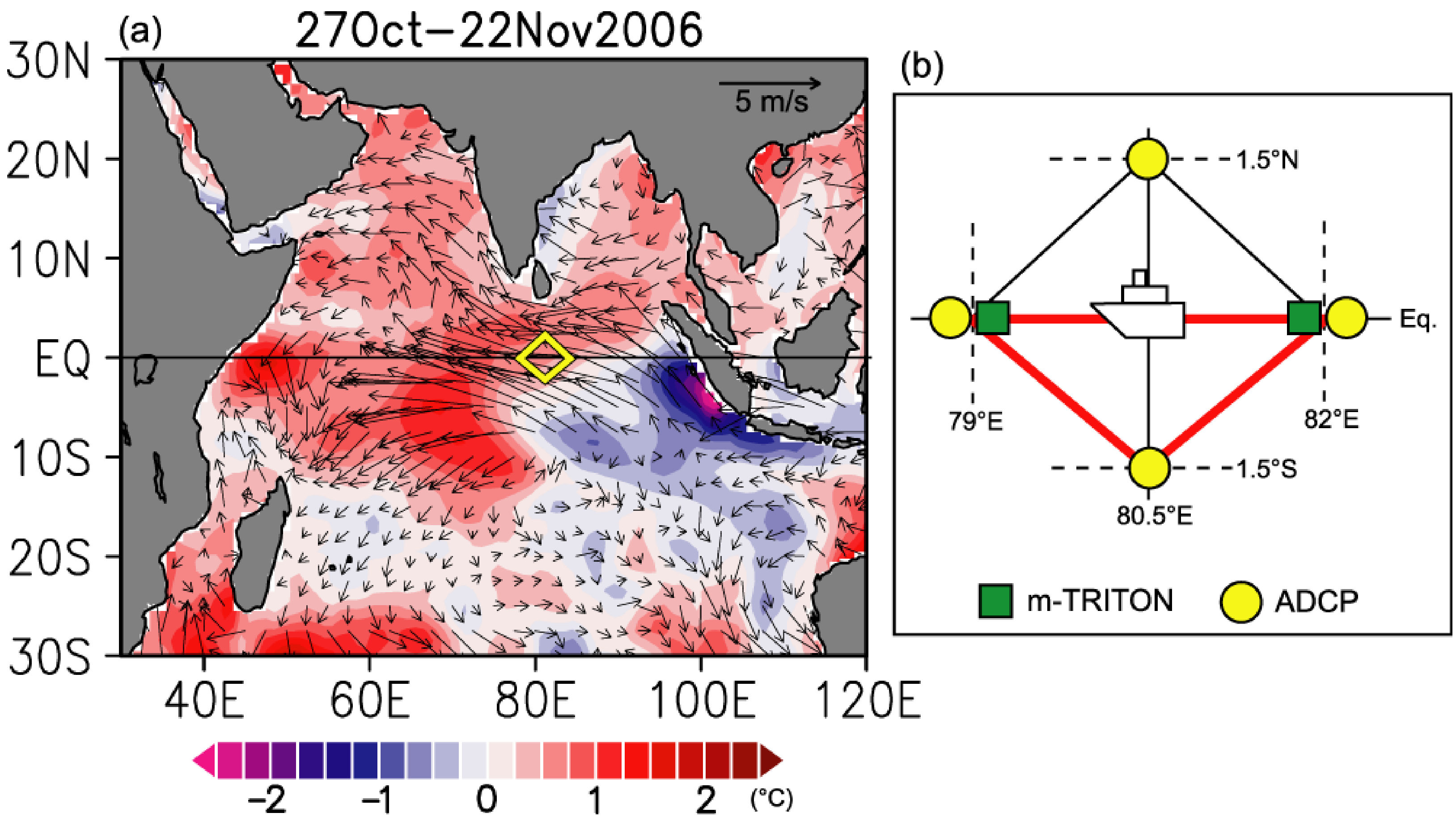
Intraseasonal variations (30-60 days)

Semiannual signal

Intraseasonal variations (10-20 days)



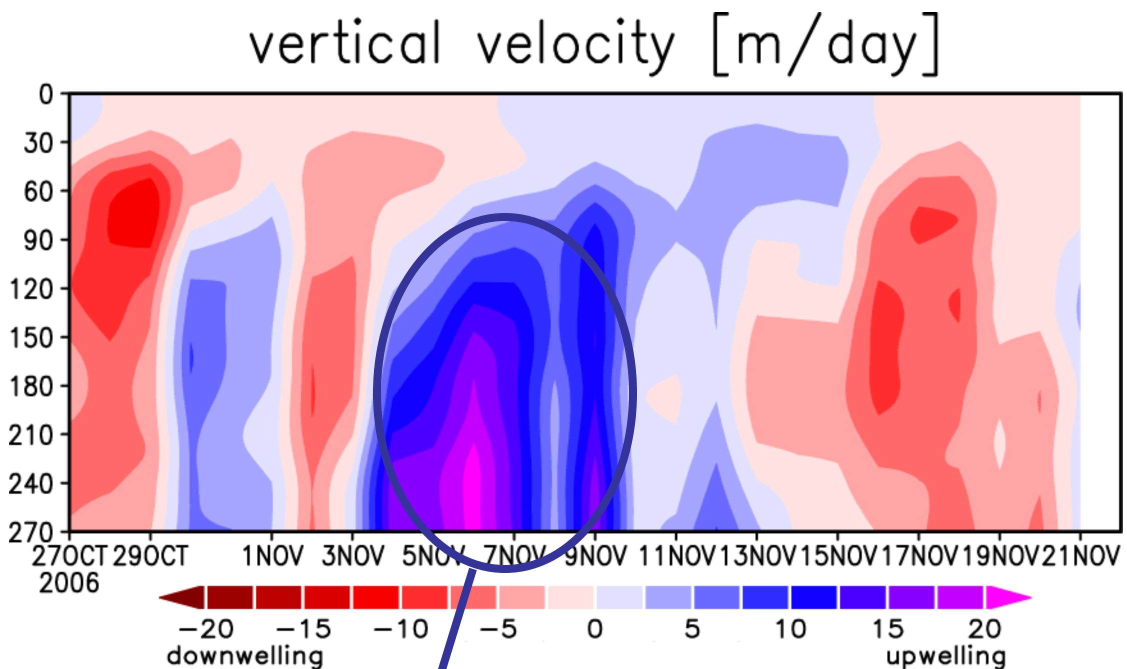
MISMO Observations and Large-scale Background Conditions

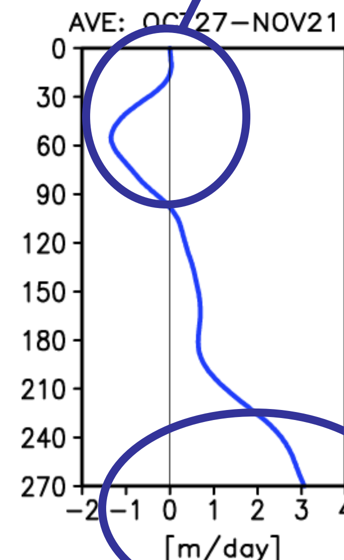


MISMO observations were conducted during the height of 2006 IOD event.

Vertical Profile of w

Downwelling in the top 100m depth

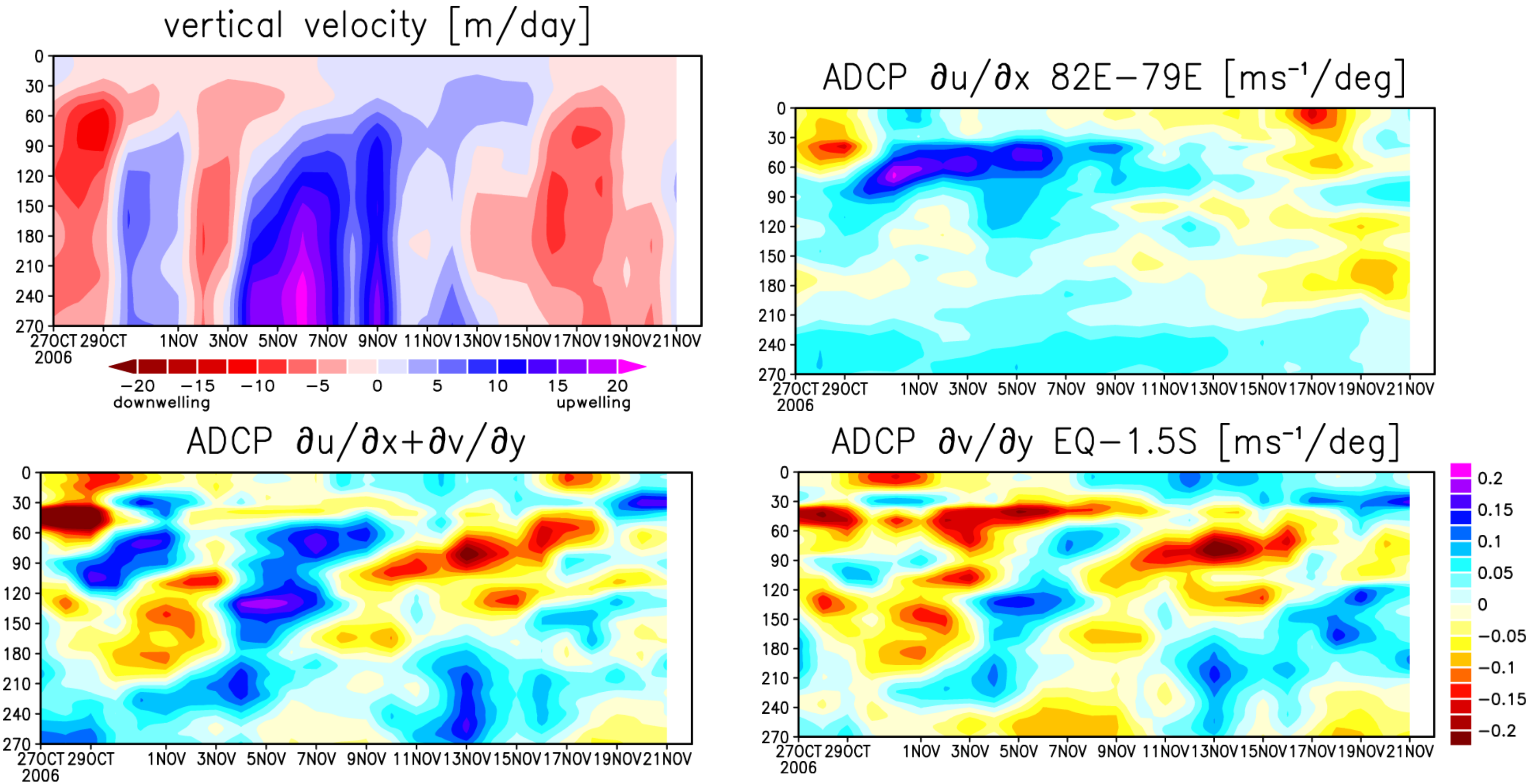




Strong upwelling/downwelling of 10 m/day occurred sporadically at intraseasonal time scale

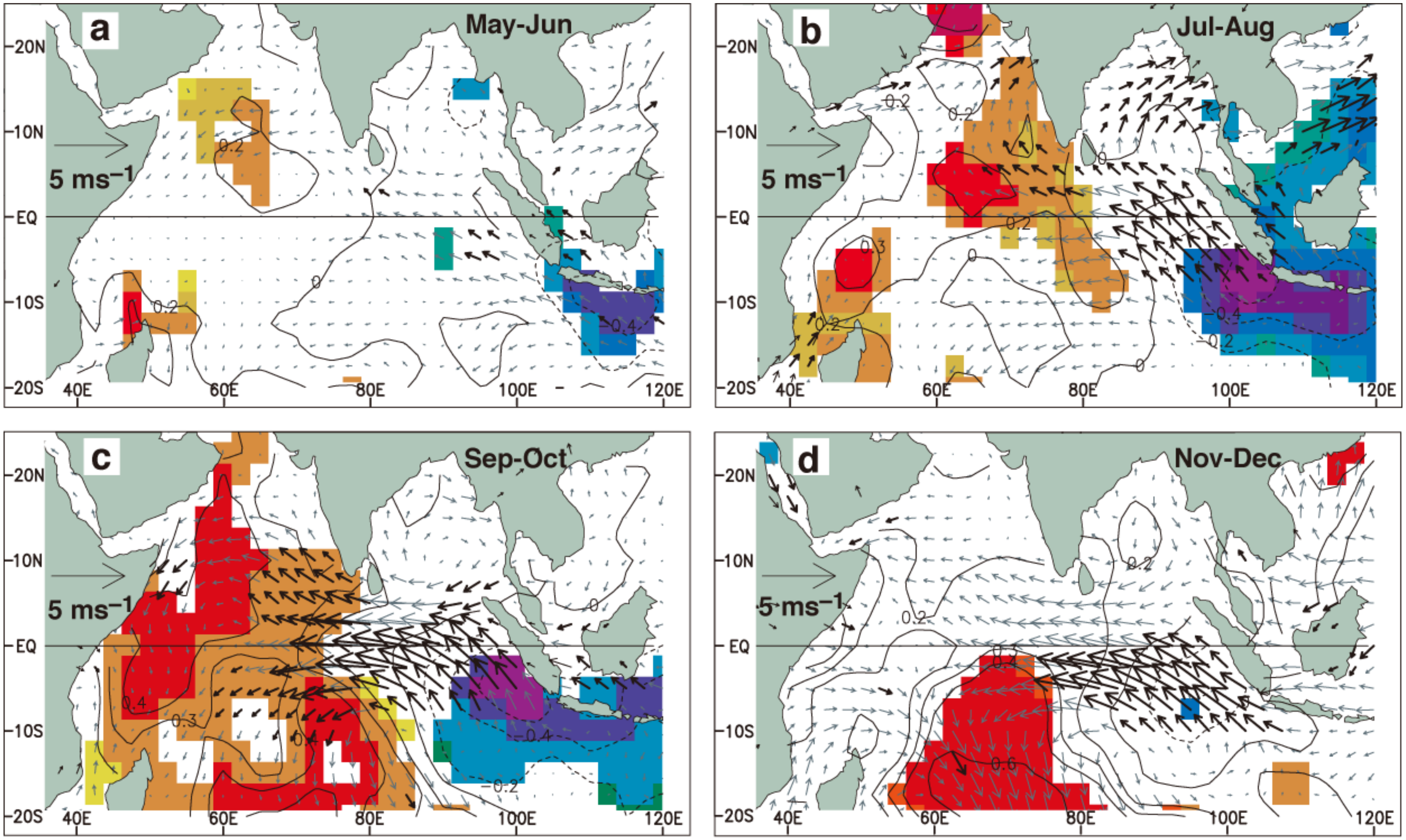
Mean value of ~ 2 m/day is about the same magnitude with previous studies in the Pacific Ocean

Causes of strong upwelling



• Large amplitude vertical motion is associated with the subsurface meridional current divergence at the intraseasonal time scale

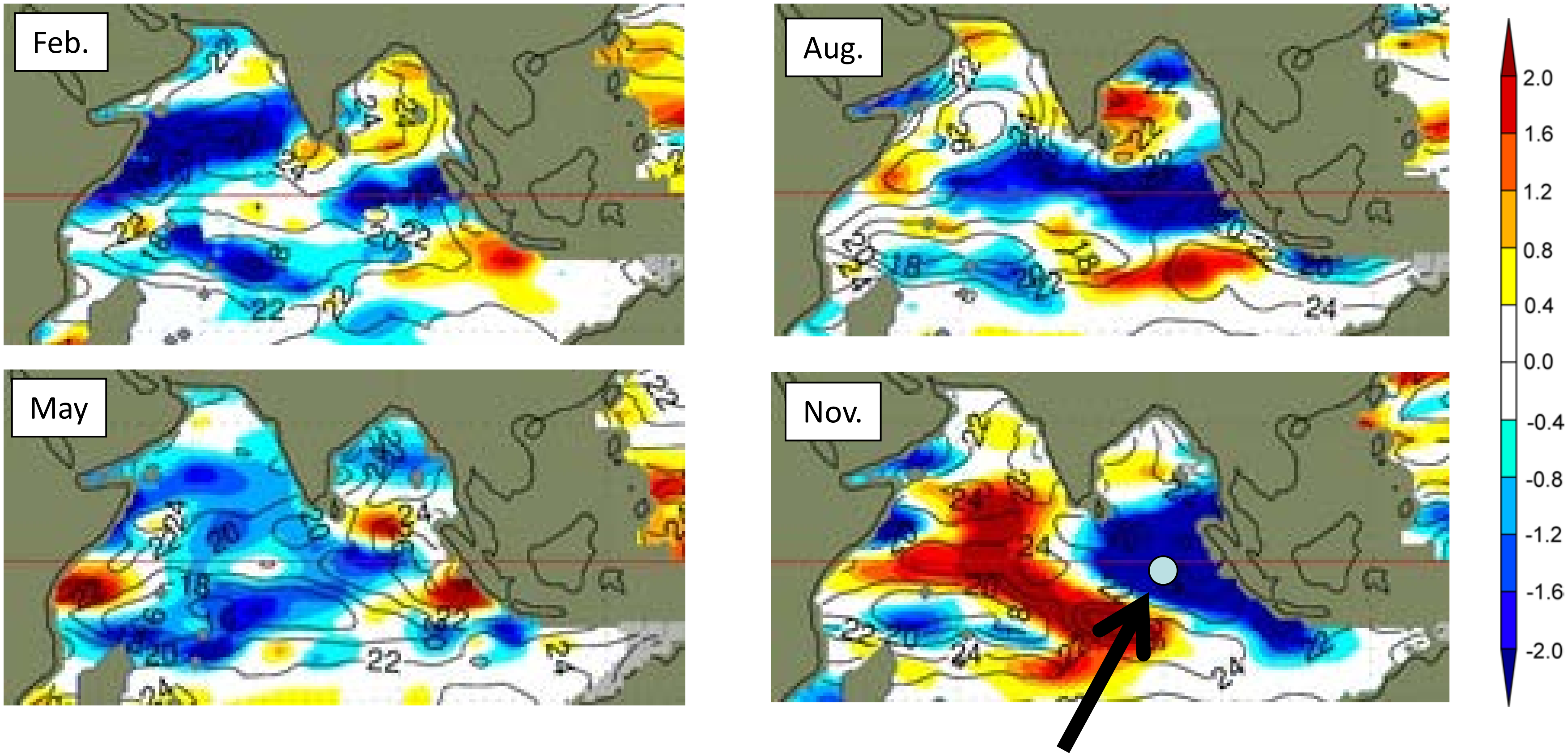
Evolution of IOD



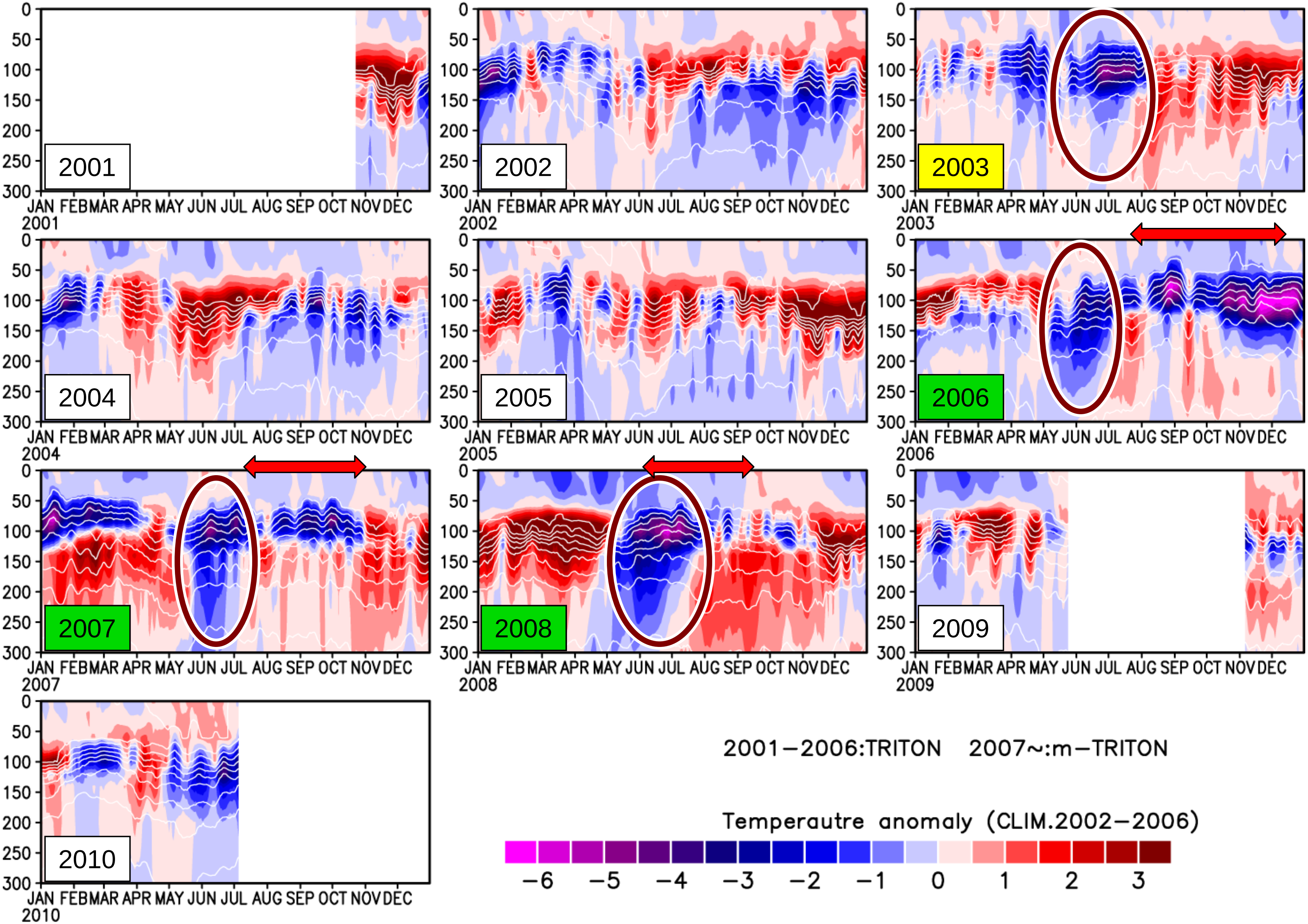
(Saji et al., 1999)

Argo detecting 2006 IOD evolution

(Monthly mean temperature anomaly at 100m depth)

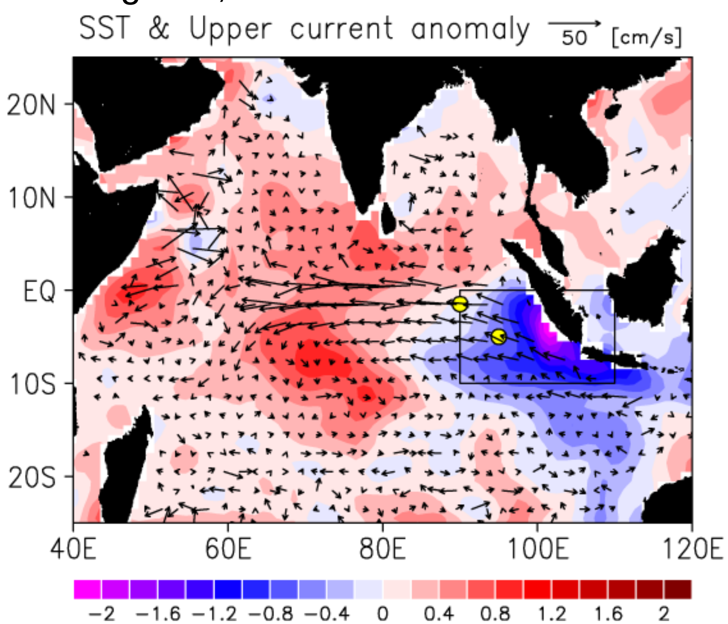


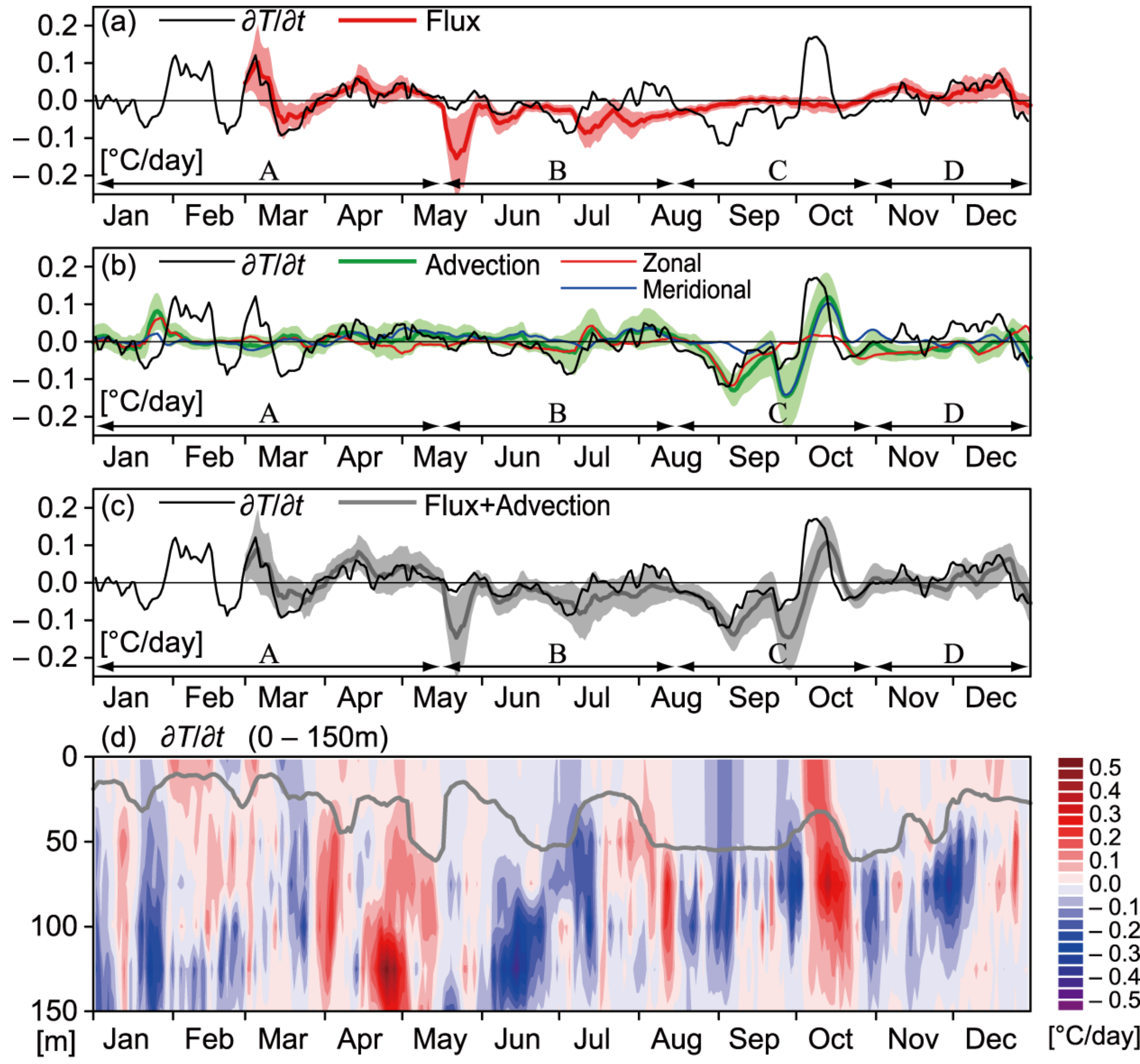
TRITON & m-TRITON (1.5S, 90E) TEMPERATURE



Heat Budget Analysis at the eastern pole of IOD

Aug-Nov, 2006

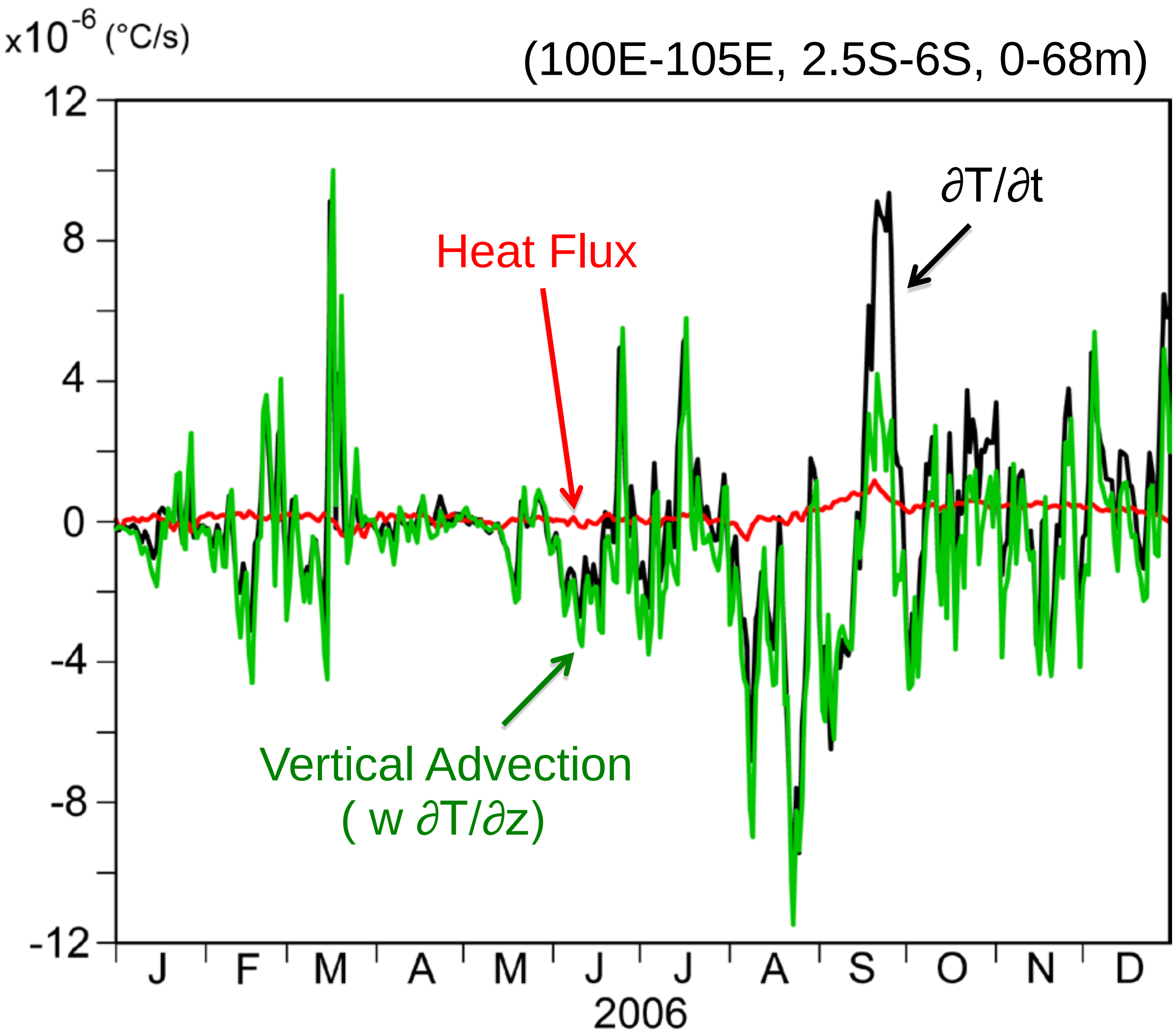


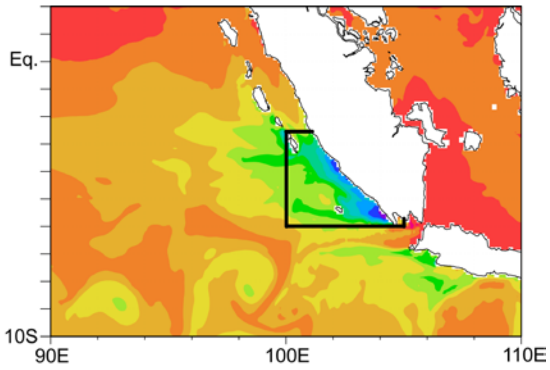


Horii et al., 2009, Mixed layer temperature balance in the eastern Indian Ocean during the 2006 Indian Ocean Dipole, J. Geophys. Res., 114, C07011, doi:10.1029/2008JC005180.

Heat Budget Analysis at upwelling region off Sumatra

< Analysis of eddy-resolving OGCM output >





- Large negative $\partial T/\partial t$ in Aug. with strong intraseasonal variability
- No contribution from heat flux
- Mostly explained by vertical advection

Summary

- IndOOS is expanding

  RAMA: 27 sites of 46 sites occupied; 4 flux reference sites
  (increase 5 sites, including 1 flux site, in past year)

- Data flowing via the web and via the GTS

- Exciting science emerging

  - Heat content and barrier layer in the Bay of Bengal could be important factor for cyclone activity and ocean responses to it

  - Strong upwelling associated with the Mixed Rossby-gravity waves in the equatorial Indian Ocean

  - IOD variations; importance of the intraseasonal variability and horizontal advection