High Frequency Variations in Evolution of Indian Ocean Dipole Events in 2003 and 2006

Suryachandra A. Rao and Toshio Yamagata[1]

Frontier Research Center for Global Change/JAMSTEC, Japan

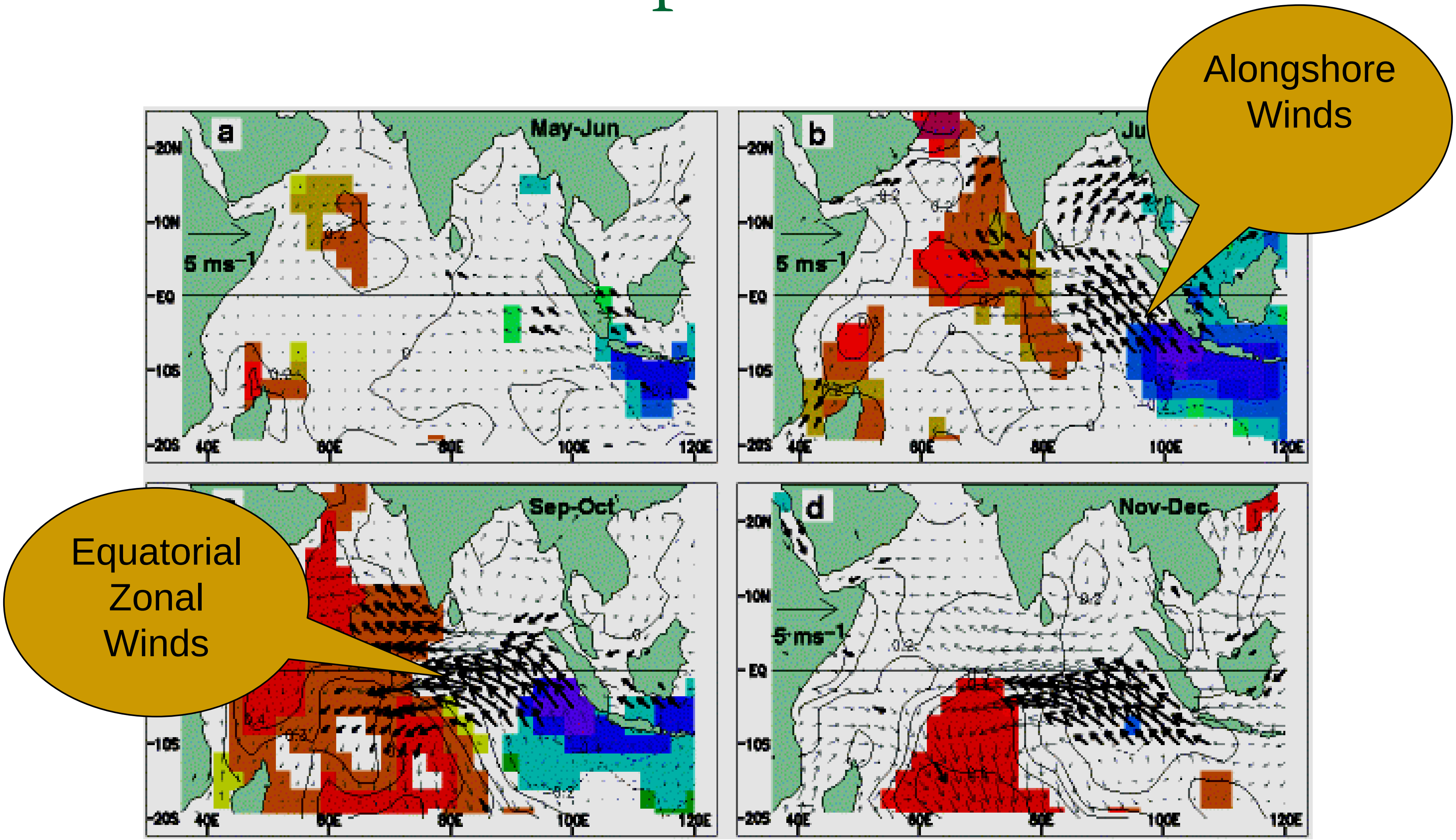
[1]also at The University of Tokyo, Tokyo, Japan

Symposium on the Predictability of the Climate Variations in the Indo-Pacific Sectors

Outline

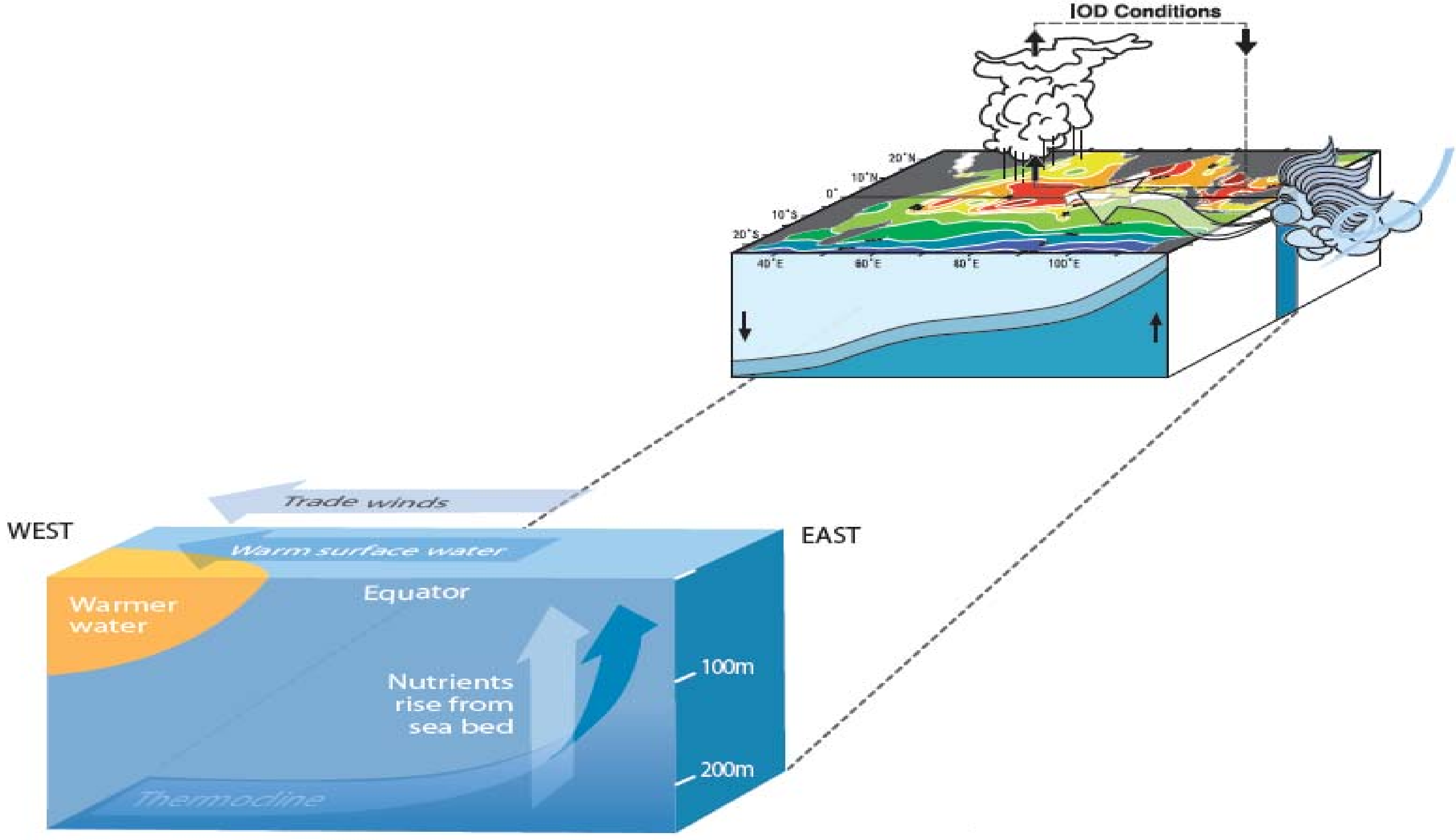
- High frequency variations in
  1. evolutions of 2003 and 2006 IOD events.
  2. IOD and El Niño in 2006
  3. IOD and Monsoon in 2006
- Conclusions

Indian Ocean Dipole

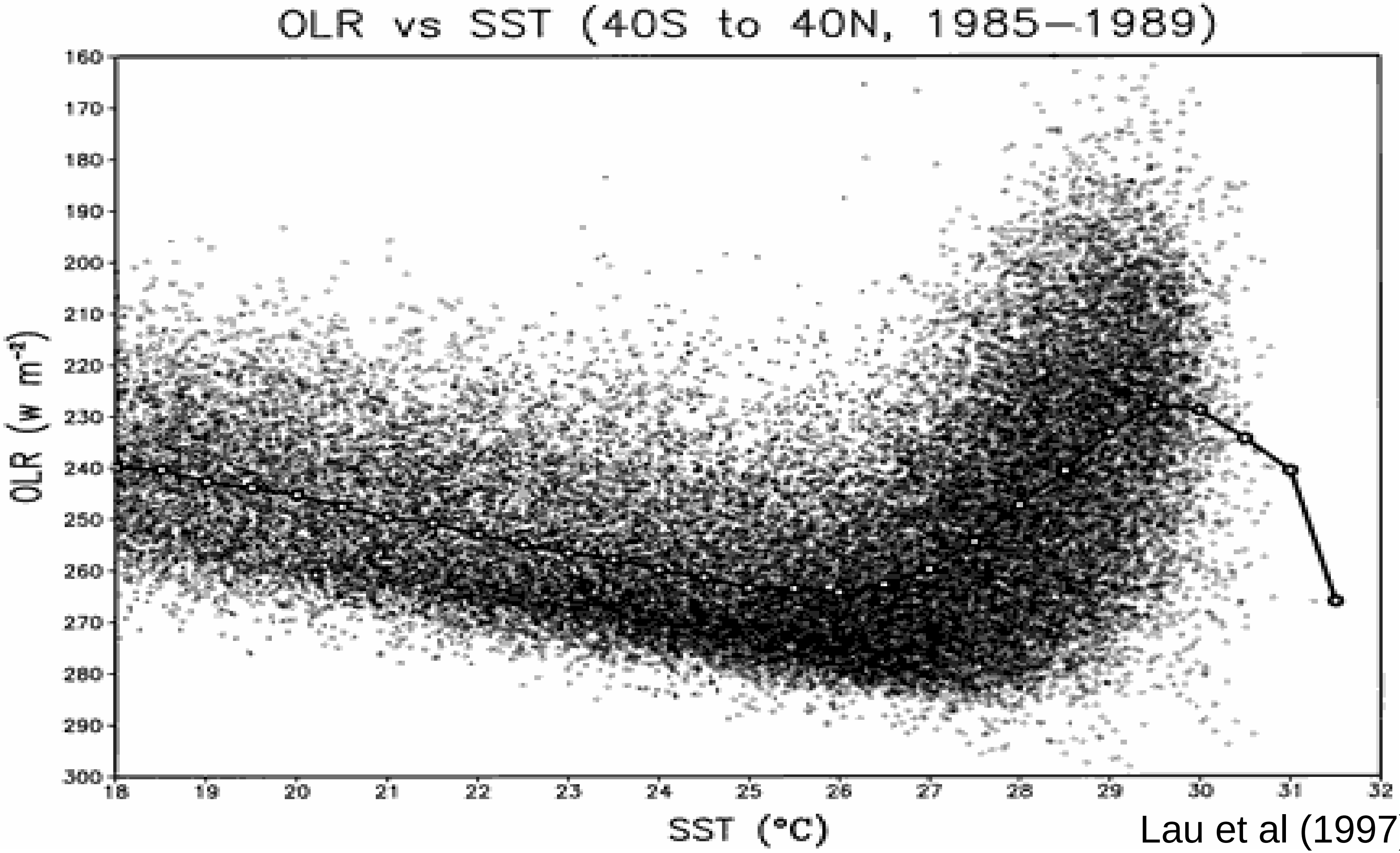


(Saji et al., 1999)

Role of equatorial Zonal winds and along shore winds

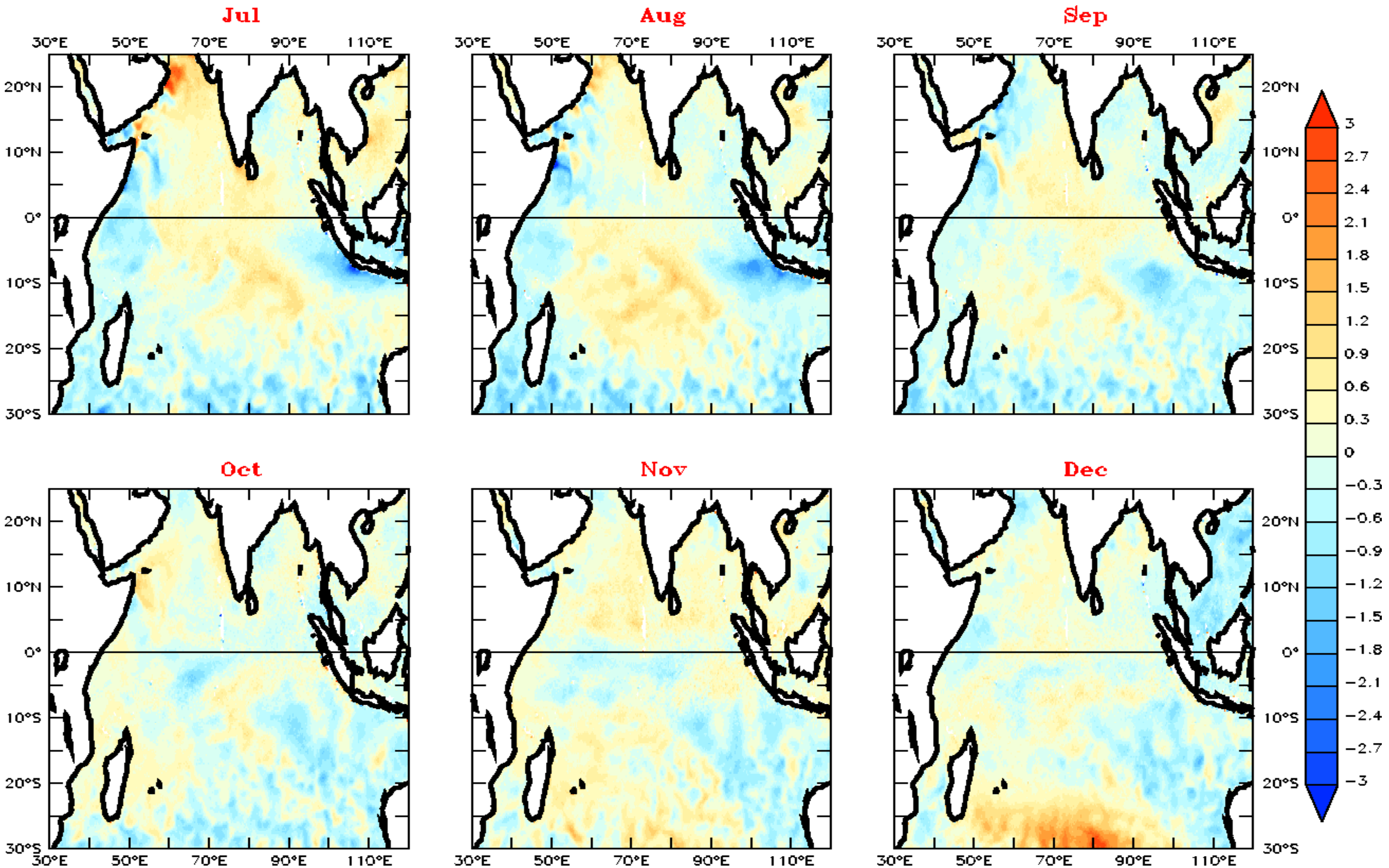


Threshold SST for maintenance of large-scale convection

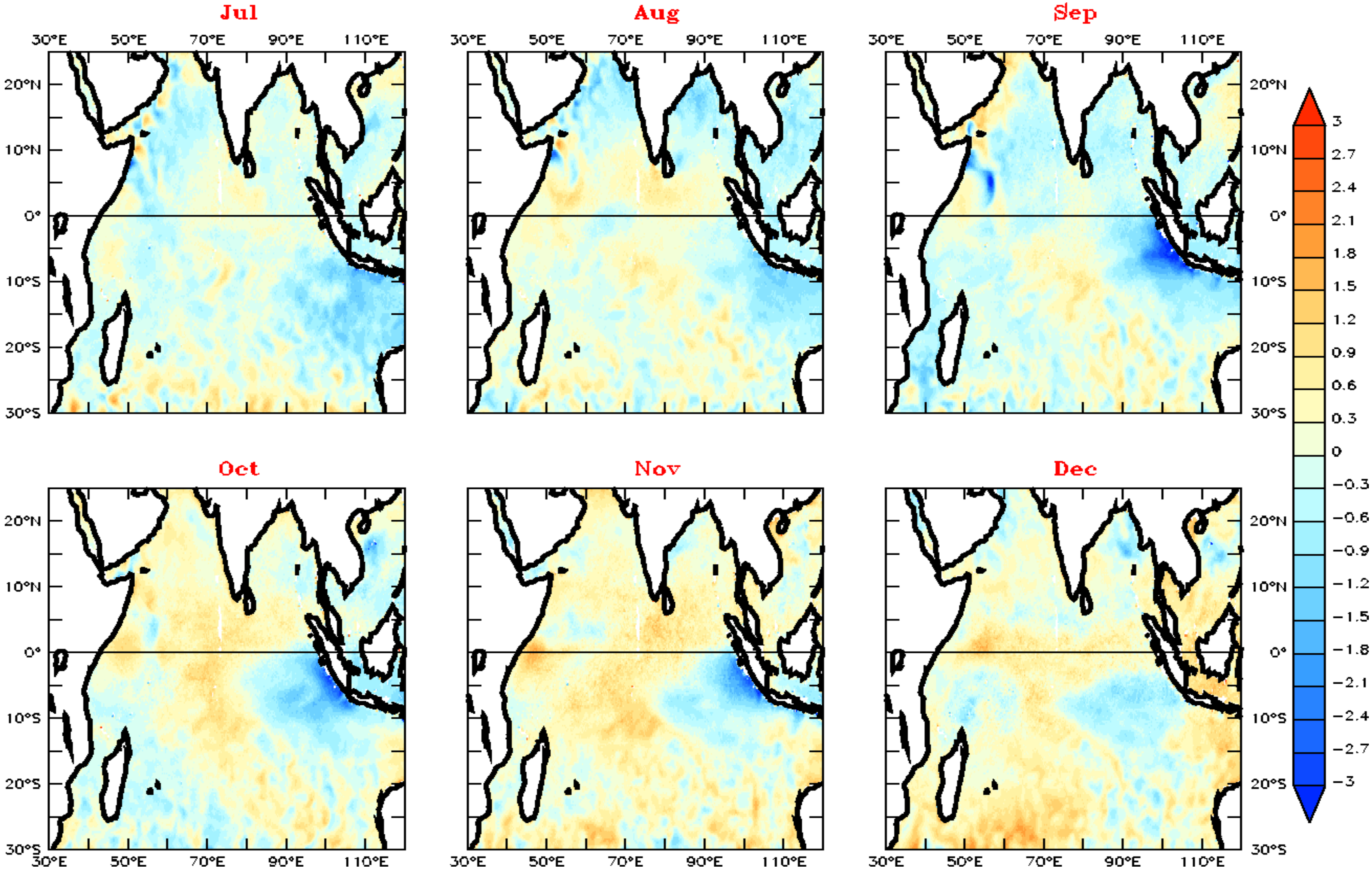


Lau et al (1997)

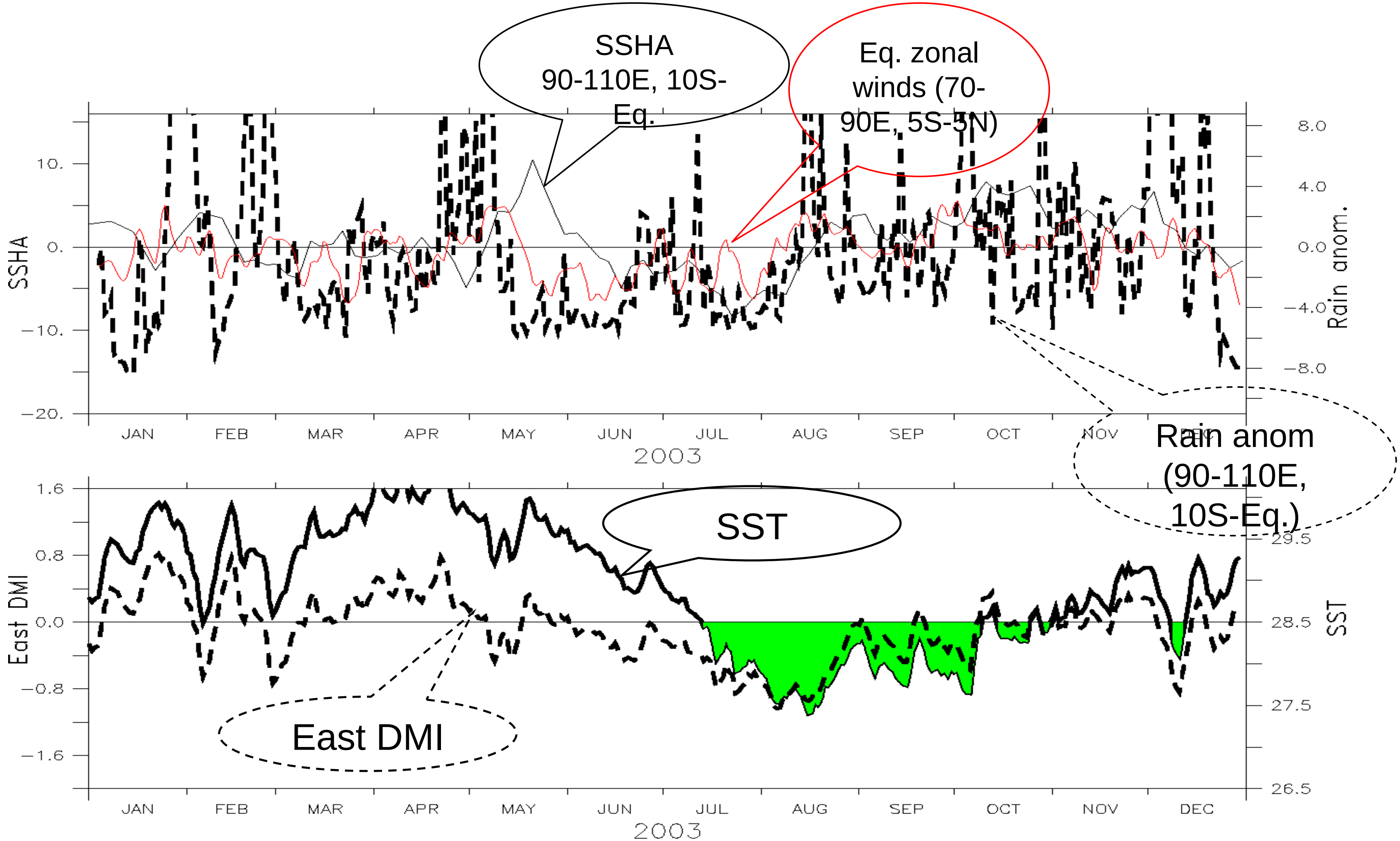
Evolution of 2003 IOD event SSTA



Evolution of 2006 IOD event SSTA



Evolution of 2003 IOD event (DMI, SST, SSH and rainfall anomalies in east and equatorial zonal wind anomalies)



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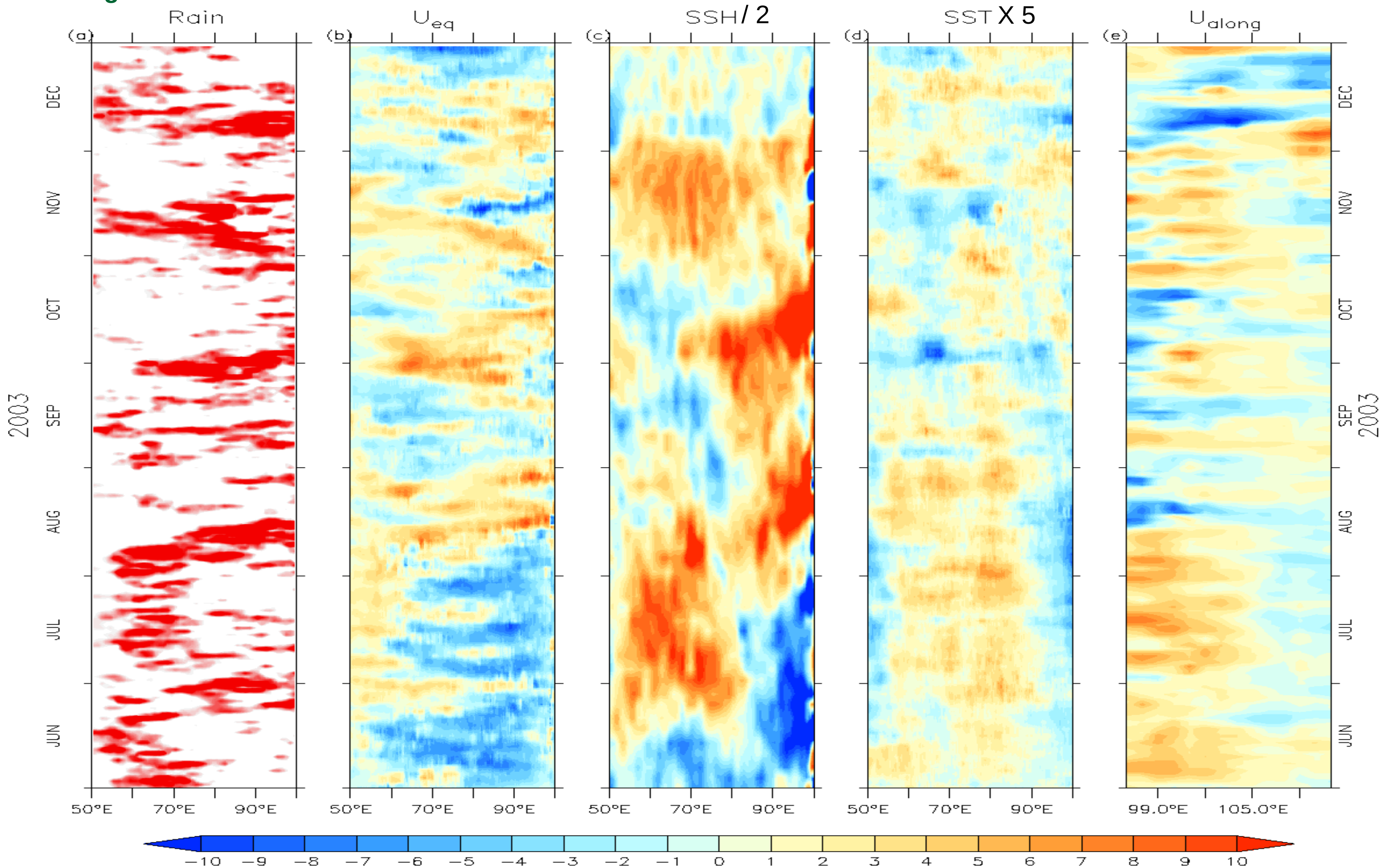
Evolution of 2003 IOD event (anomalies of Rainfall, Ueq, SSH, SST and $U_{along\text{-}shore}$)



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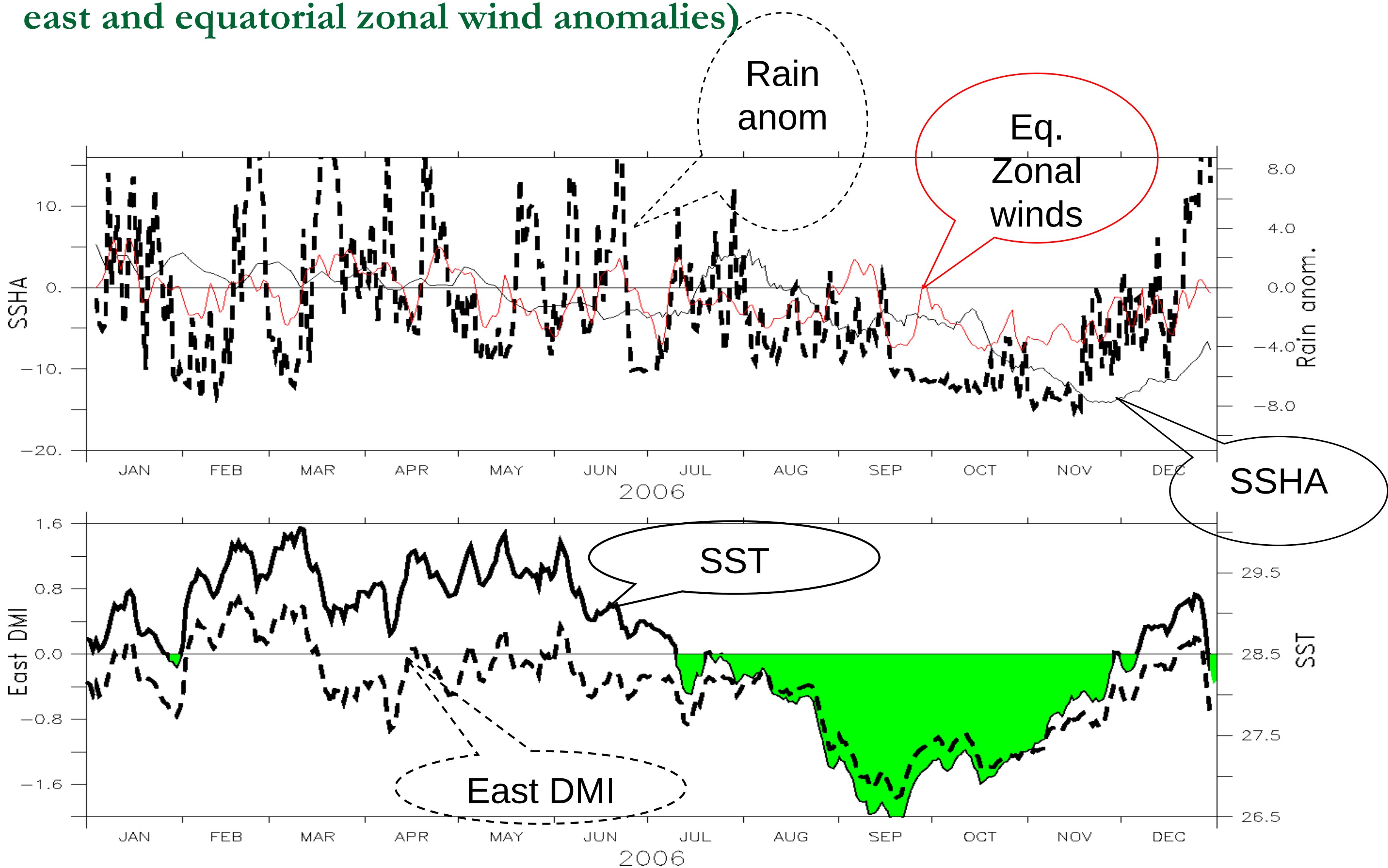
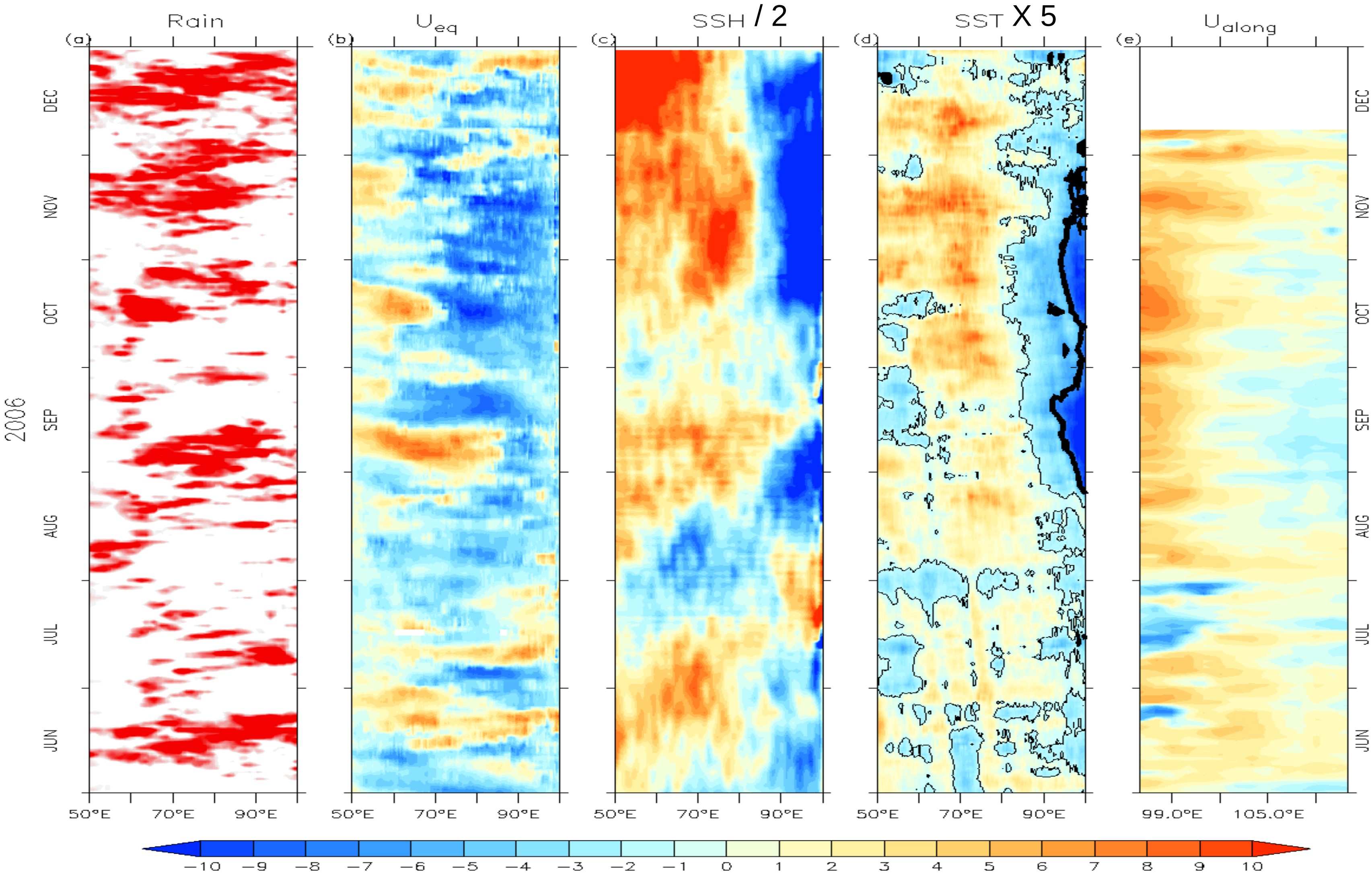
Evolution of 2006 IOD event (DMI, SST, SSHA and rainfall anomalies in east and equatorial zonal wind anomalies)



Evolution of 2006 IOD event (anomalies of Rainfall, Ueq, SSH, SST and Ualong-shore)



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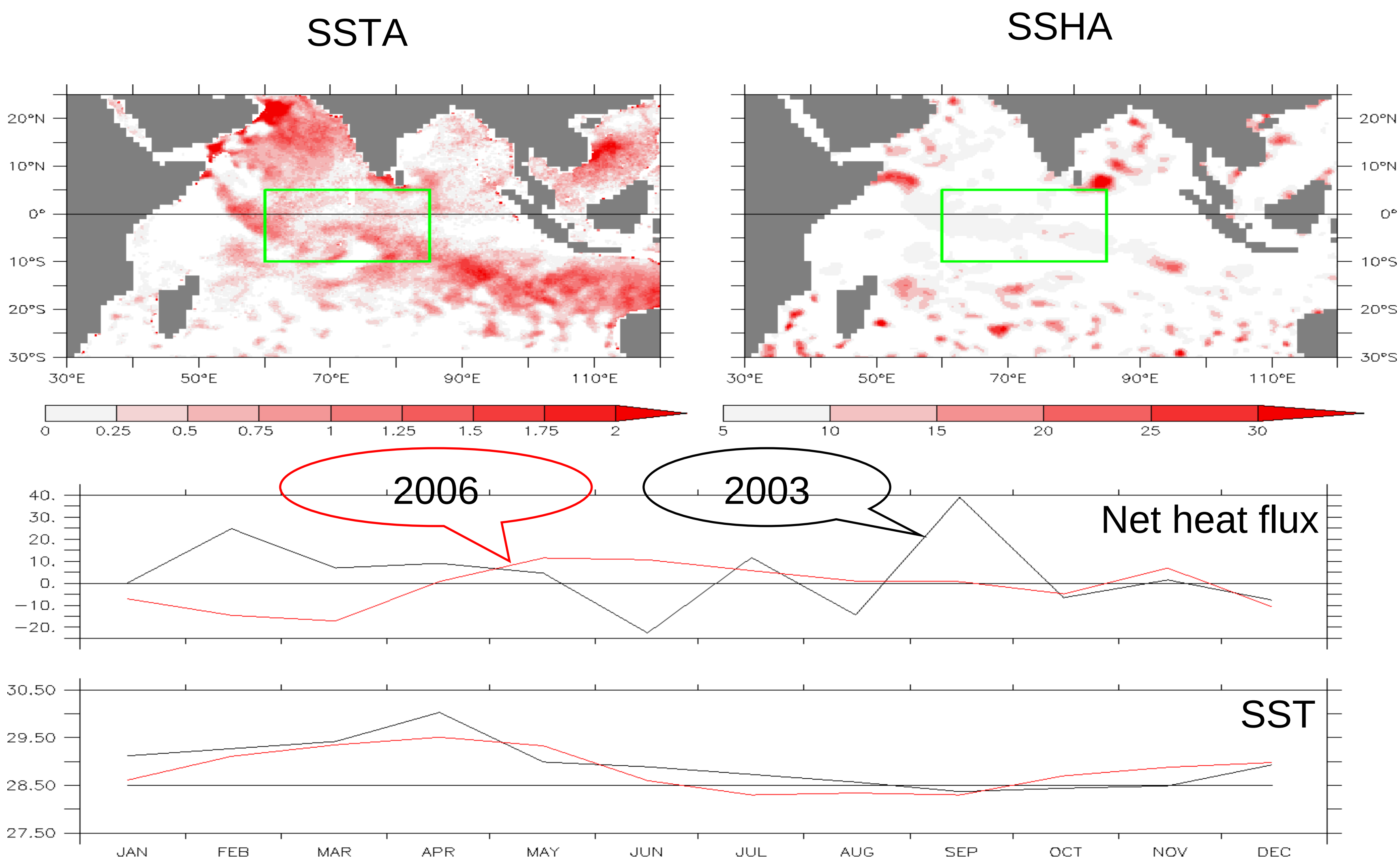
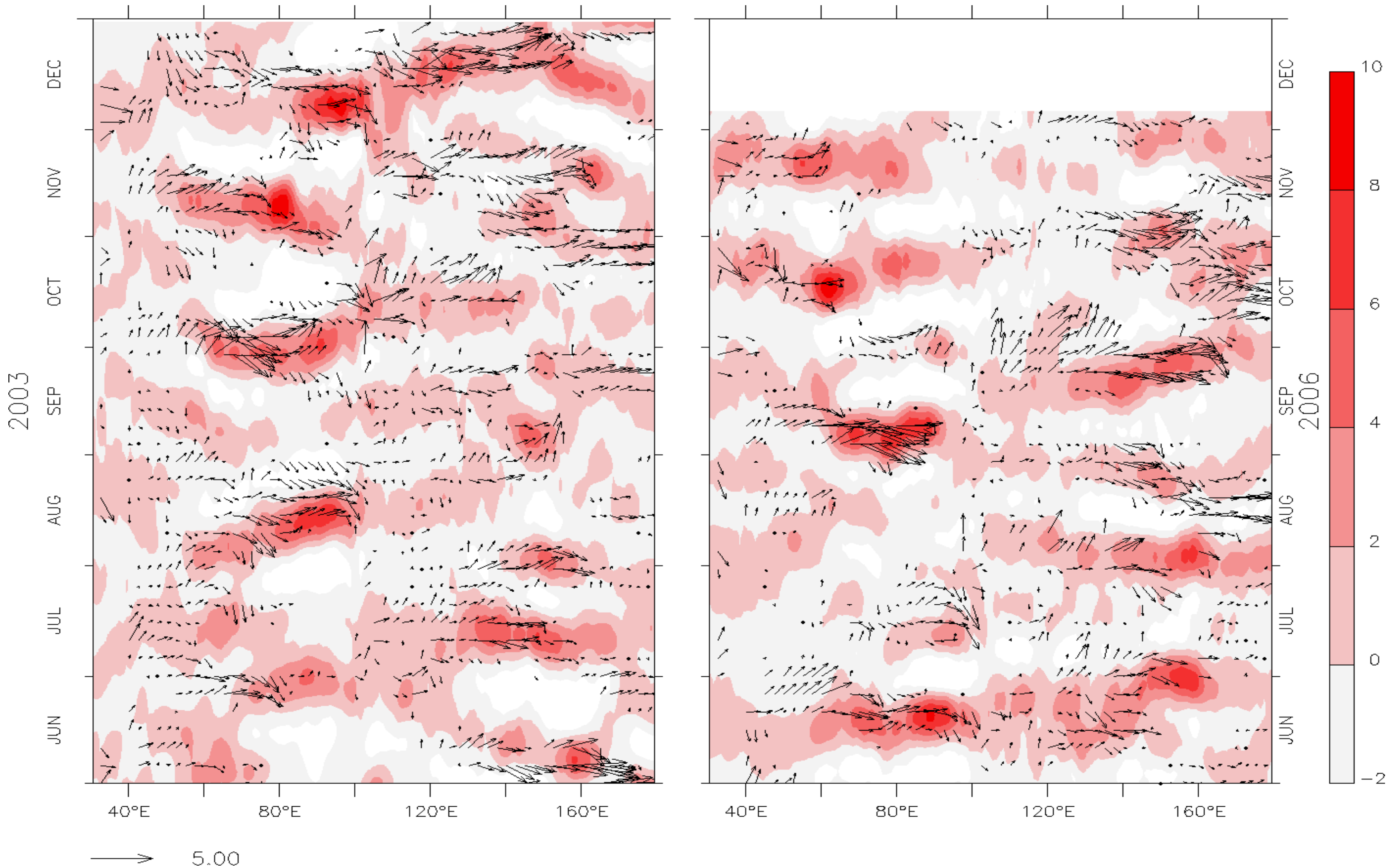
Differences in SSTA and SSHA between 2003 and 2006 July.



Filtered (20-60 days) OLR and wind anomalies averaged between 10°S-10°N in 2003.



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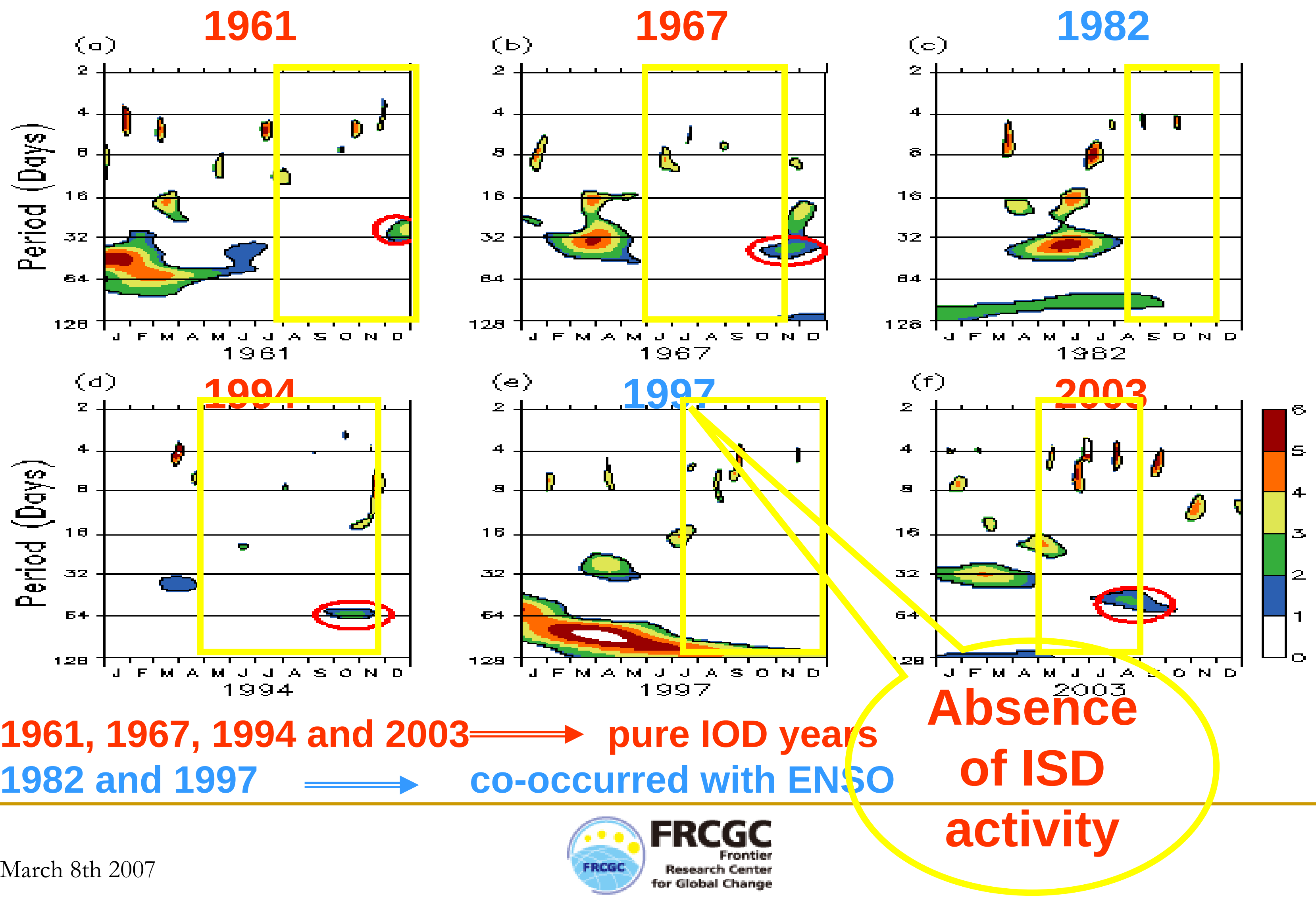
Equatorial Zonal wind (70-90E and 5S-5N) wavelet spectrum (NCEP reanalysis)

(Rao and Yamagata, 2004)



1961, 1967, 1994 and 2003 → pure IOD years

1982 and 1997 → co-occurred with ENSO

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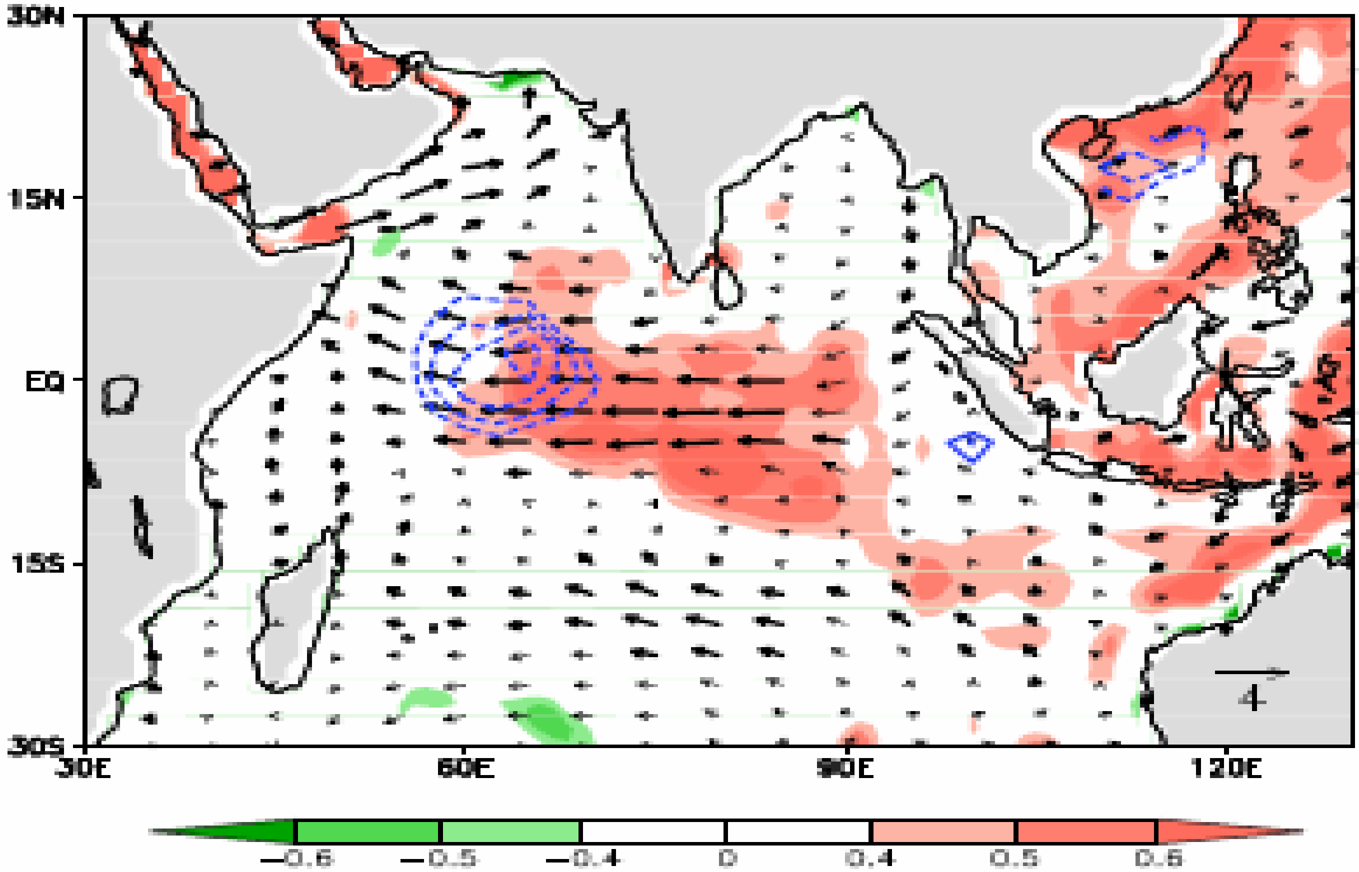
Linear Trend in SST, OLR and Winds
(Under global warming are the properties of IOD changing?)



(Ajaya Mohan, Rao and Yamagata, 2007)

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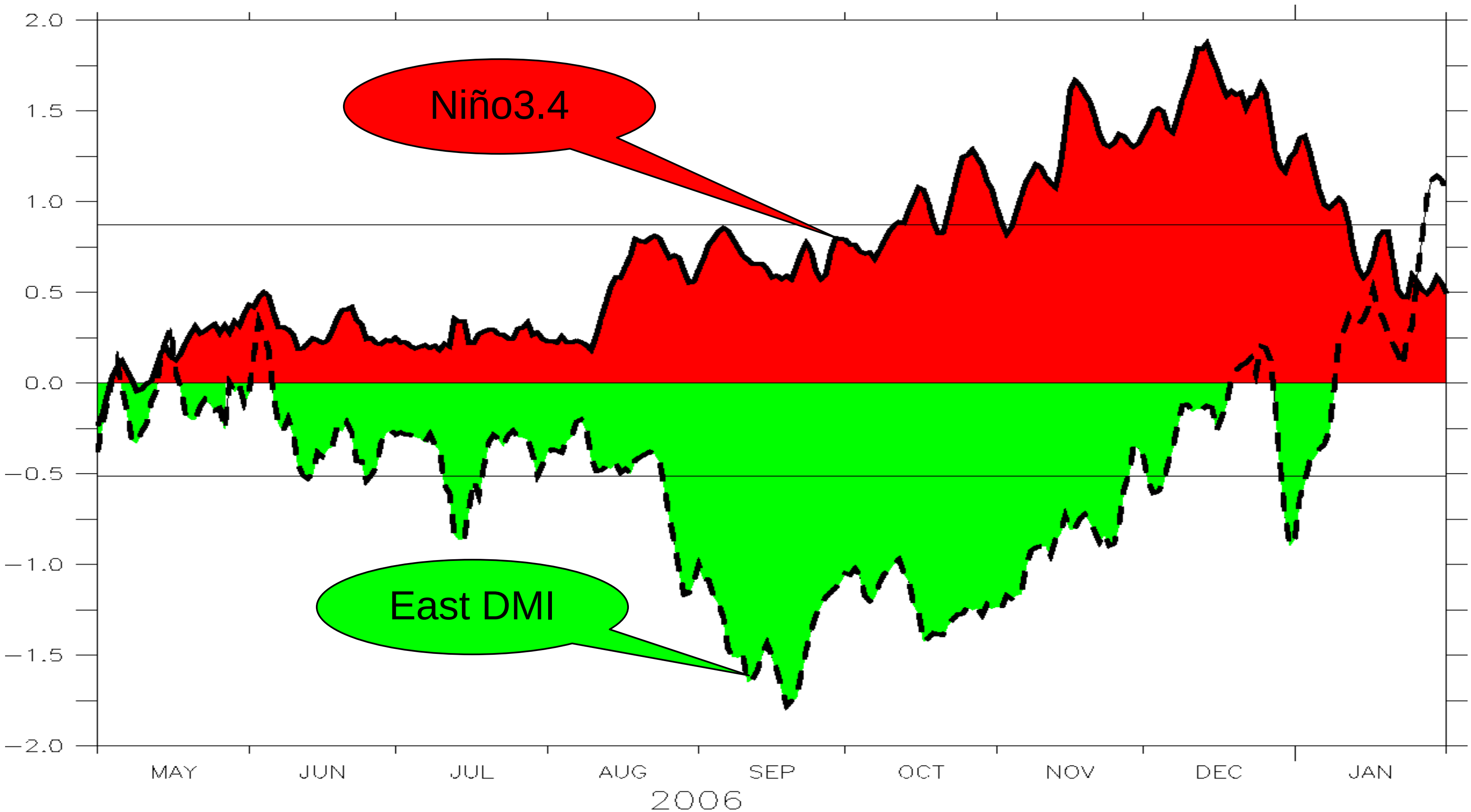
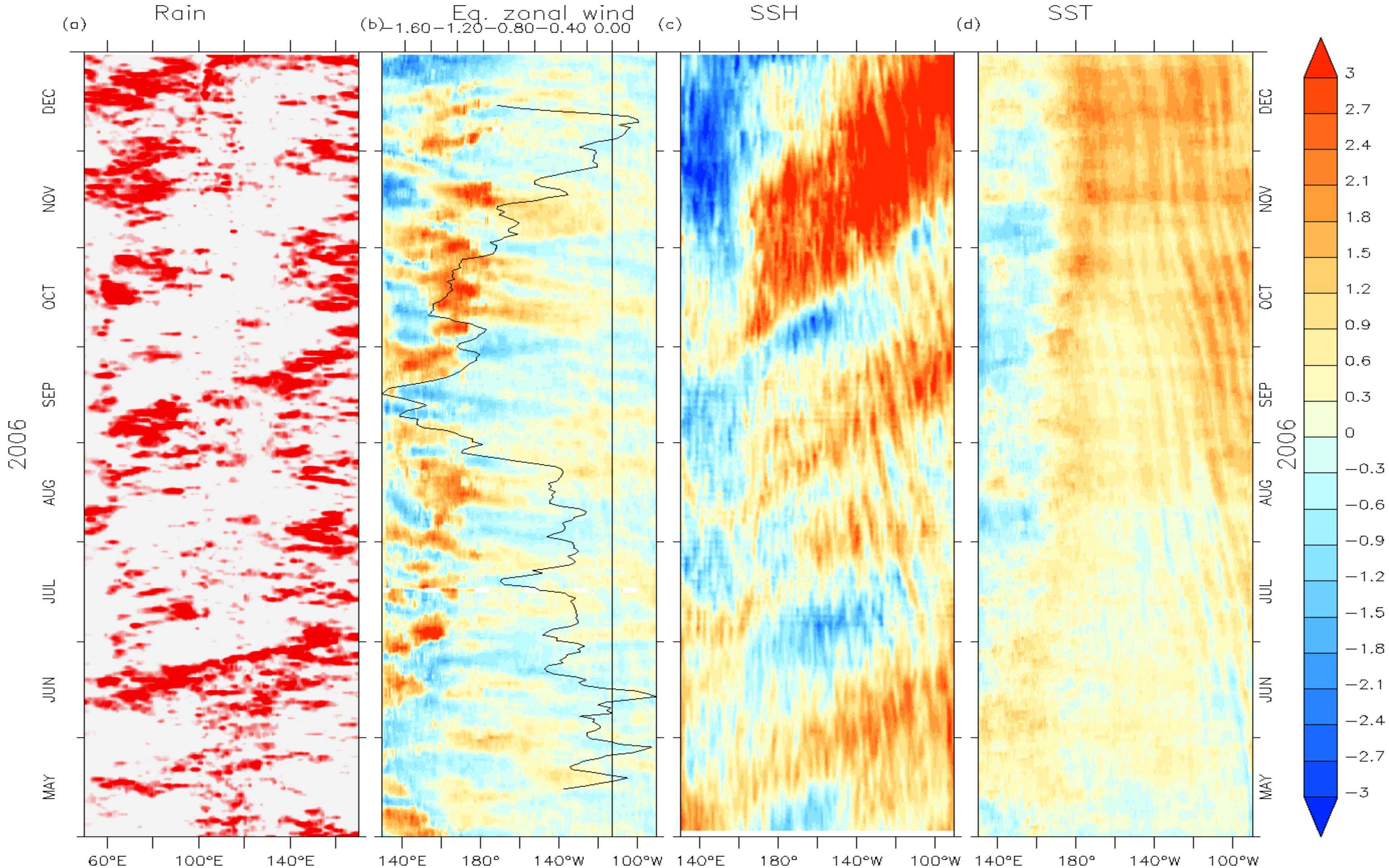
IOD and El Niño

Evolution of East DMI and Niño 3.4 in 2006



Evolution of 2006 El Niño event (anomalies of Rainfall, Ueq/east DMI, SSH, SST)



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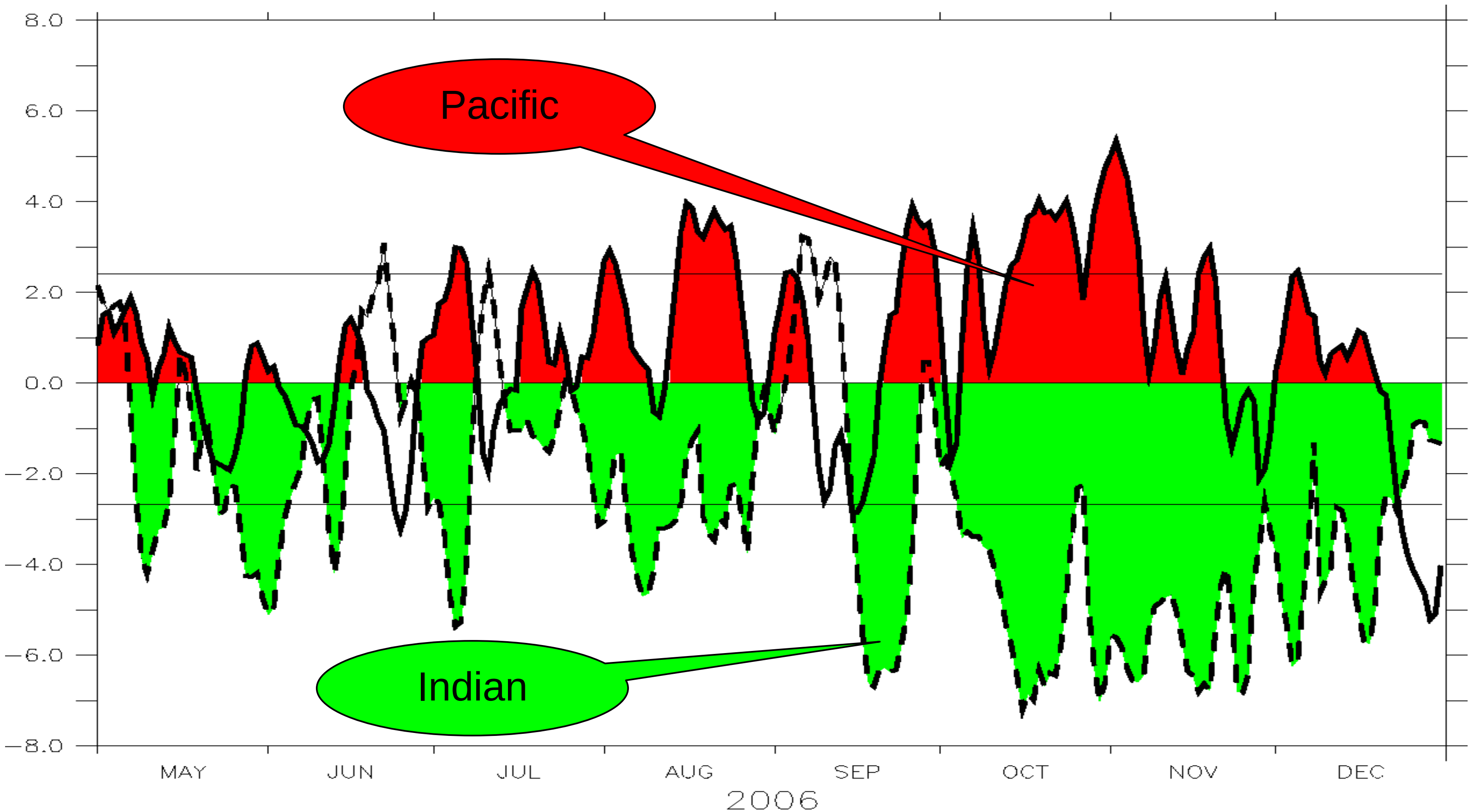
Equatorial Zonal winds in central Indian and western Pacific Oceans (130^{o}E-180^{o}E) in 2006



Impact of Indian Ocean Sea Surface Temperature on Developing El Niño

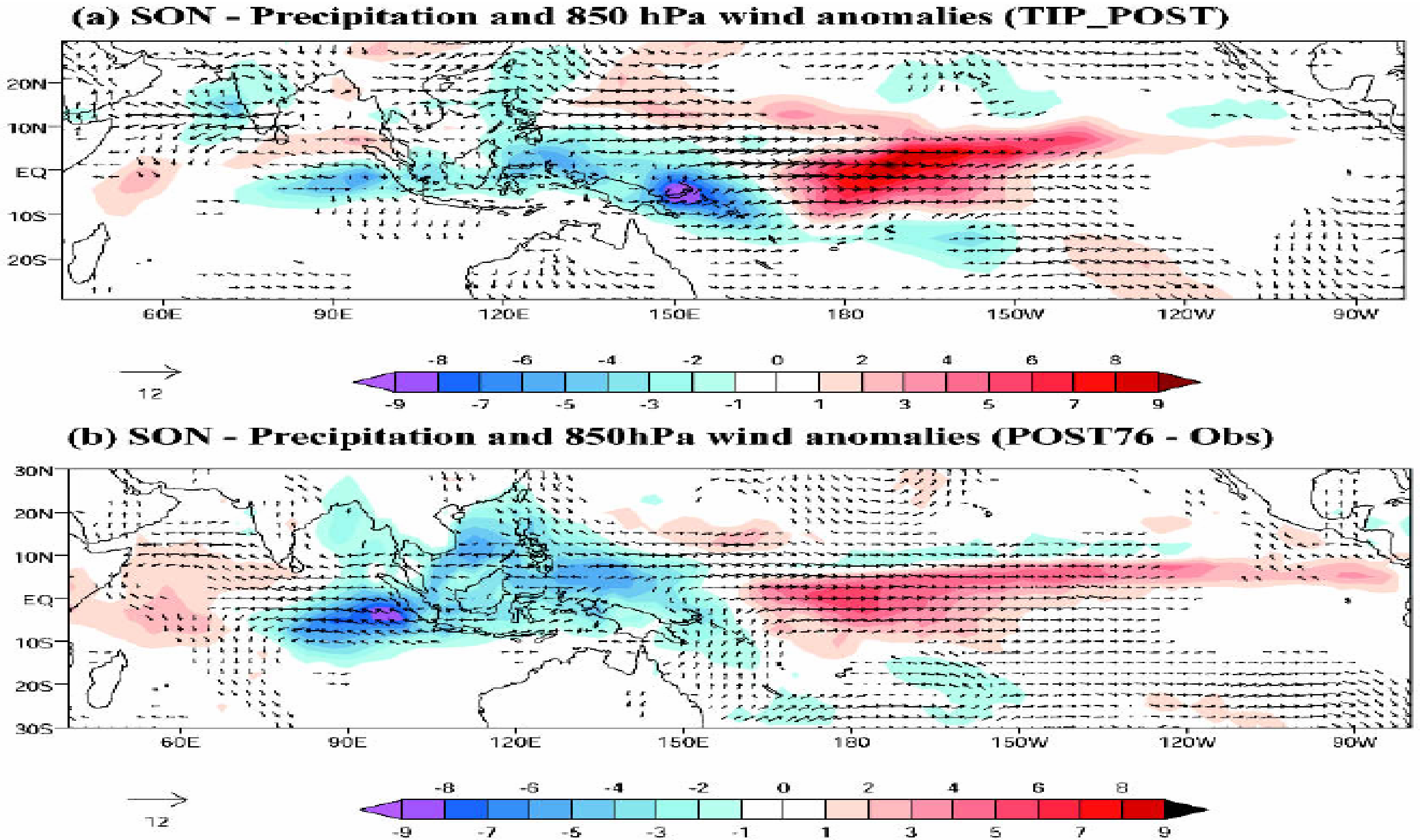
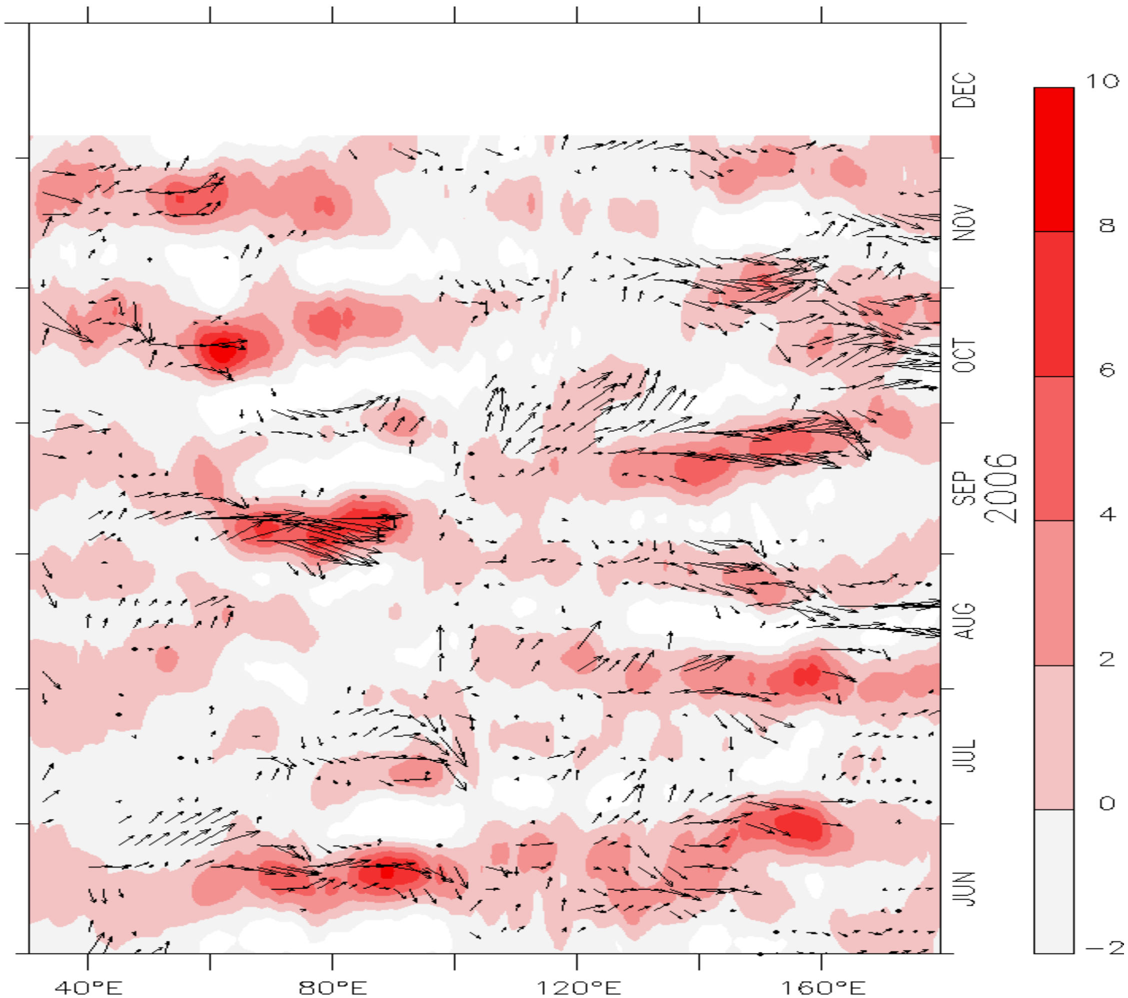


FIG. 6. (a) Anomalous precipitation (mm day^{-1}, shaded) and 850-hPa wind anomalies from the TIP_POST solutions; (b) same as (a) but from observations.

Annamalai et al., (2005)

Filtered (20-60 days) OLR and wind anomalies averaged between 10ºS-10ºN.



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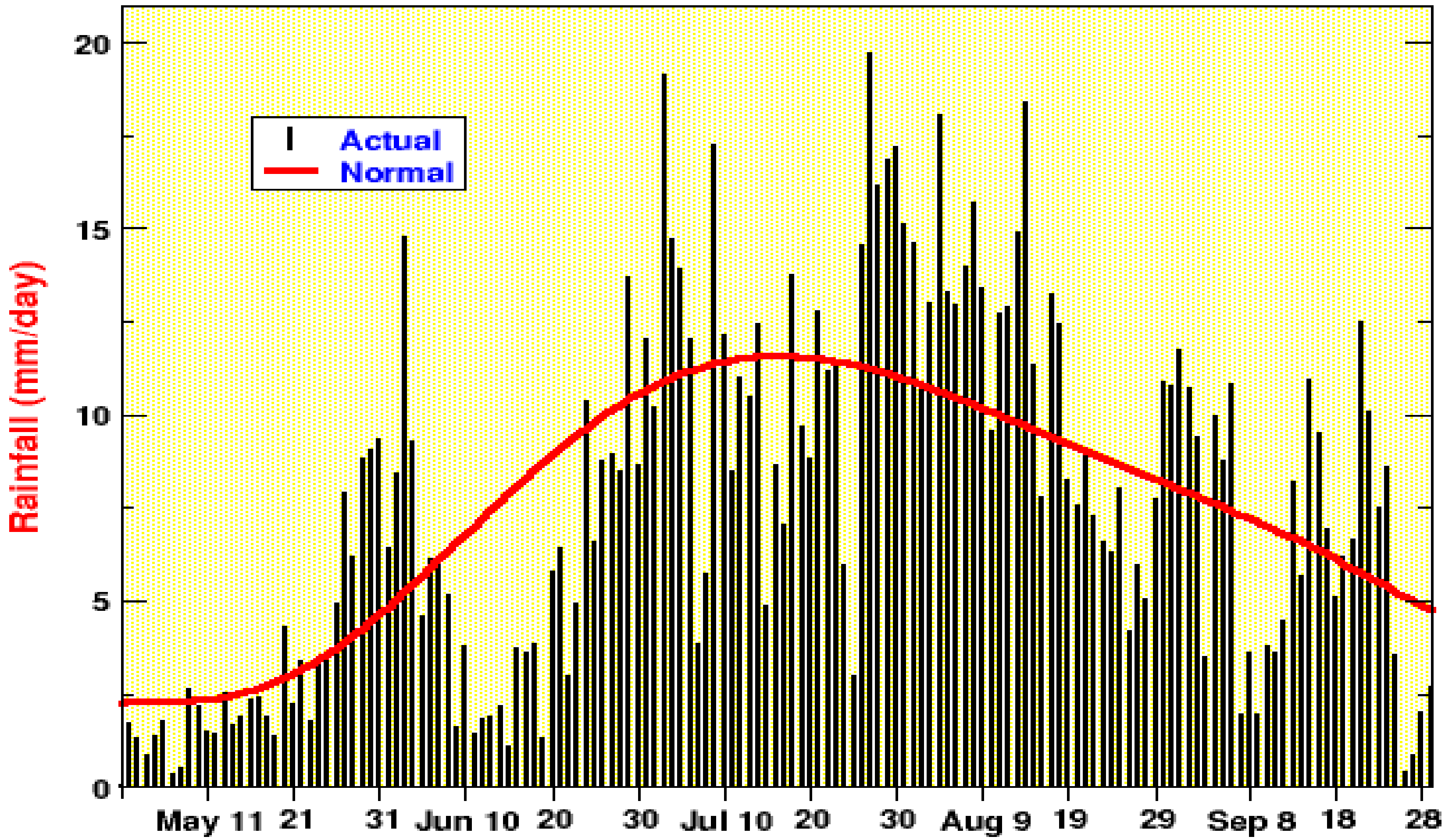
IOD and MONSOON

Indian Summer Monsoon in 2006



(Source: Monsoon Online, IITM)

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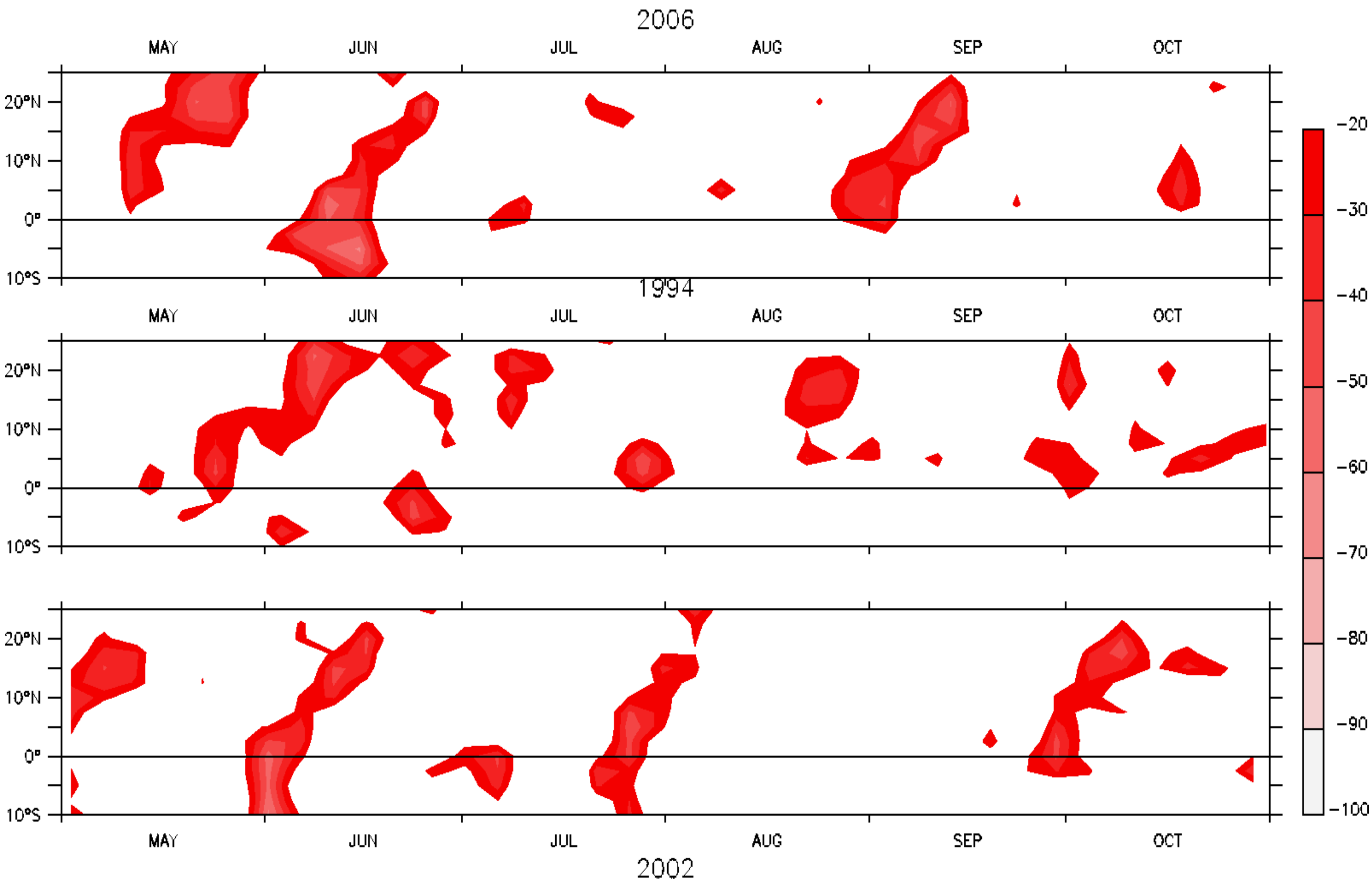
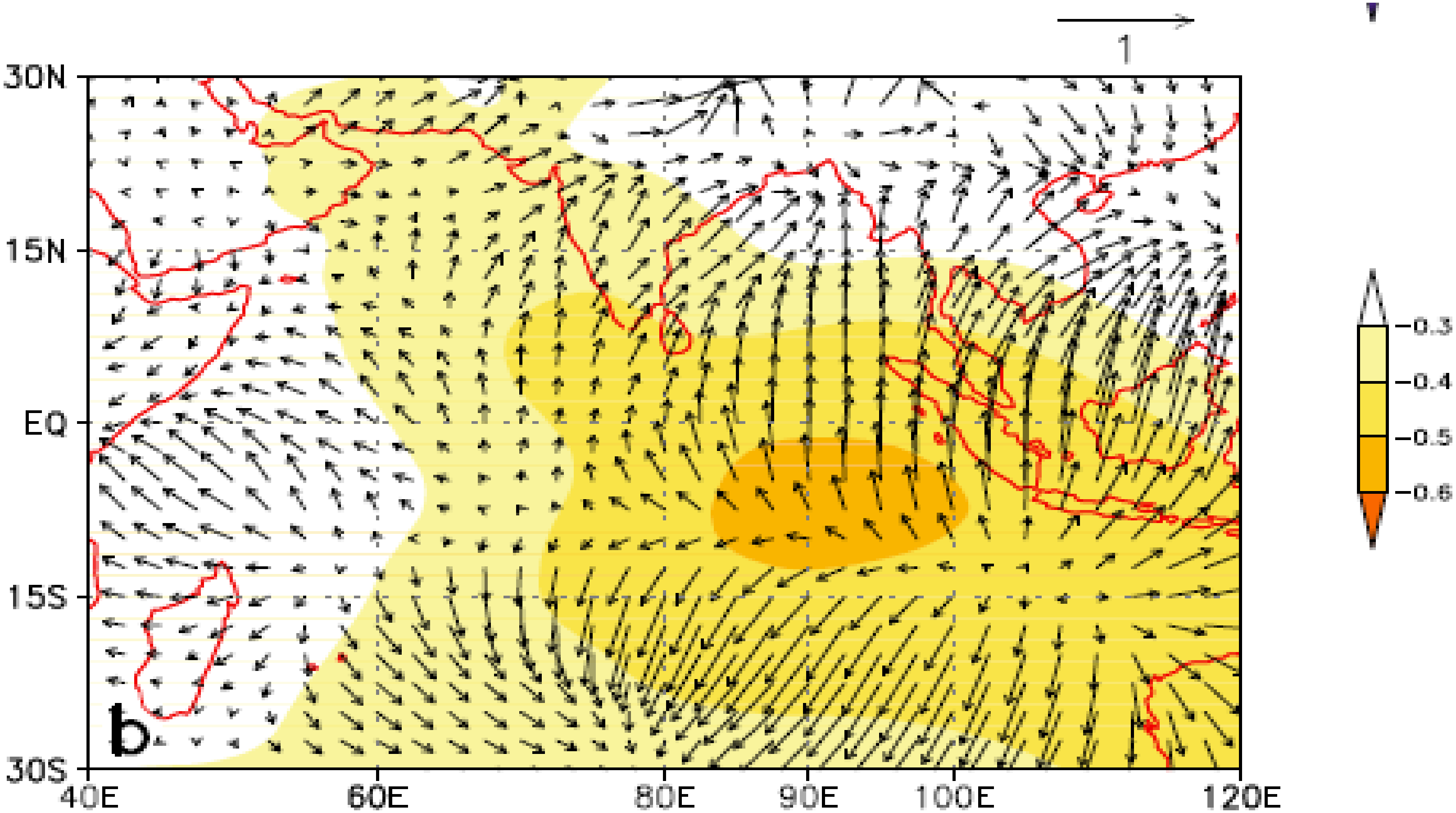
Northward propagating convective bands in 2006, 1994 and 2002. (OLRA)



Correlation of East Central India monsoon rainfall with velocity potential Shading) and Moisture Divergence



(Ajaya Mohan, Rao and Yamagata, 2007)

Conclusions

- Unusually strong early warming (in July) in central tropical Indian Ocean excited an MJO in the tropical Indian Ocean and ultimately terminated IOD in 2003 due to strong westerlies associated with this strong MJO.
- Eventhough, MJO was excited in Sep. 2006 it was unable to terminate IOD in 2006, due to strong cooling in the eastern Indian Ocean (SSTs well below 28.5^{o}C).
- MJOs generated in the tropical Indian Ocean in 2006 generated westerly wind bursts in western equatorial Pacific and eventually initiated 2006 El Niño event.
- In spite of strong El Niño conditions in the tropical Pacific, Indian Summer Monsoon rainfall was above normal in 2006 due to the strong Indian Ocean Dipole. Even in absence of northward propagating ISOs in July/August 2006 the monsoon rainfall was above normal.