Oceanic signature of intraseasonal variability in the Indian Ocean

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Science talk

- **Sorry for not being able to join for my first AAMP meeting. Enjoy Macao and AAMP!**

- **Focus of that talk**
- **A quick review of some of my research, focussed on studying the ocean response to atmospheric intraseasonal variability (ISV)**

Outline

- **Introduction and motivation**
- Dynamical response to atmospheric ISV in the Indian Ocean
- SST response to atmospheric ISV in the Indian Ocean
- A few perspectives

Atmospheric intraseasonal variability over the Indian Ocean

Atmospheric intraseasonal variability arises from coupling between deep atmospheric convection and atmospheric dynamics within the Indo-Pacific warm pool

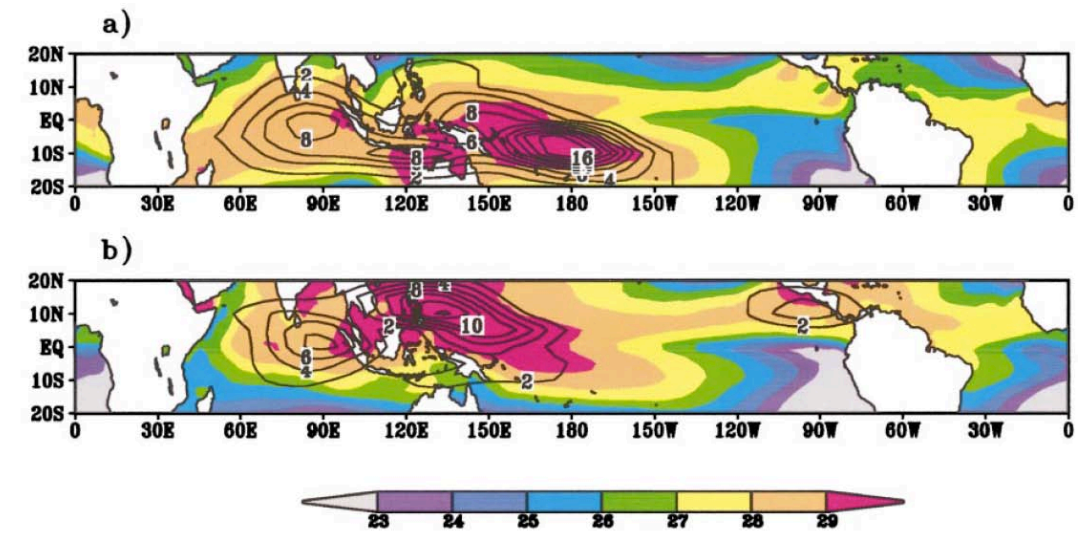

FIG. 6. Variance of P^* (mm² day⁻², contour) and mean SST (°C, color) averaged over (a) Dec–Mar and (b) Jun–Sep.

MJO seasonal variations :

- **Summer (active/break monsoon phases) over Northern Indian Ocean**
- **Winter ISV to the south hemisphere**
- **Equatorial wind variability all year long**

SST response to atmospheric intraseasonal variability

MJO induces surface momentum and heat flux variations
=> Ocean SST response

Motivation: possible feedback of MJO SST signal to the atmosphere (e.g. Waliser et al. 1999; Inness and Slingo 2003; Maloney and Sobel 2004; Woolnough et al. 2007)

SST response to atmospheric intraseasonal variability

Processes and amplitude of MJO-induced SST variations:

Early studies (e.g. Krishnamurti et al. 1988; Hendon and Glick 1997; Shinoda et al. 1998): air-sea fluxes seem to dominate a SST response ~ 0.2°C

These studies were using infrared-based SST estimates. Microwave SST measurements later revealed much larger SST signals, in particular in the Indian Ocean (e.g. Harrison and Vecchi 2001; Duvel et al. 2004)

Do we need to revise previous studies to account for this larger SST variations detected by microwave sensors?

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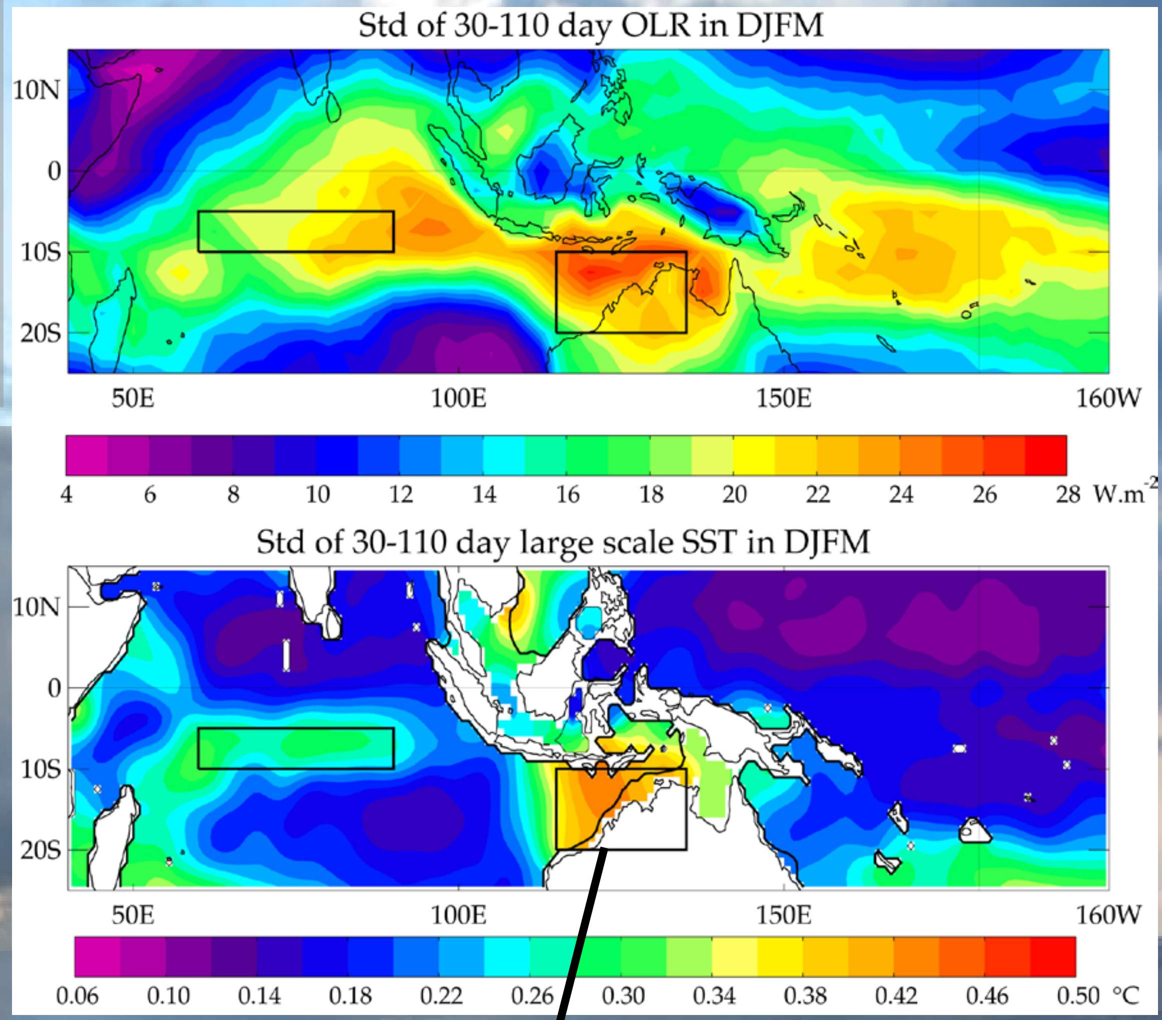
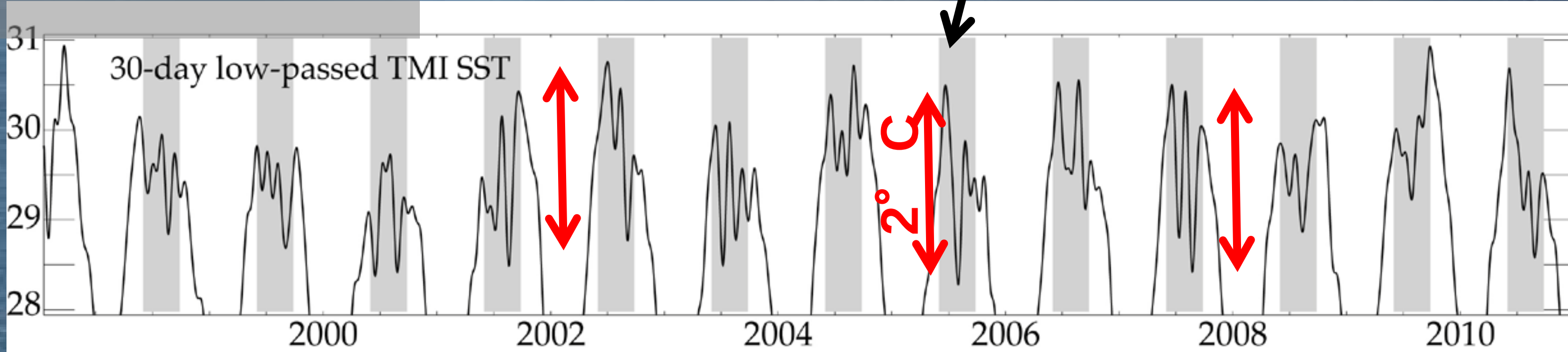
The MJO and its oceanic signature during boreal Winter

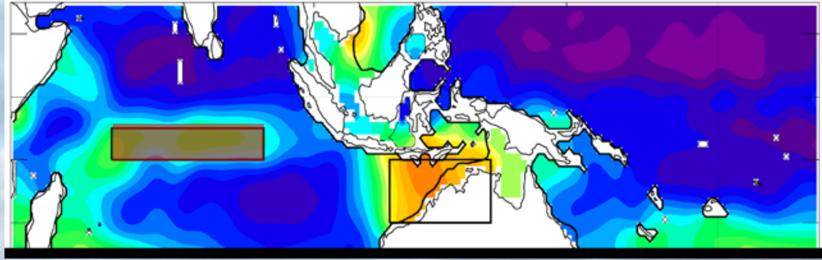
Two regions of strong SST signature : thermocline ridge and North-Western Australian Basin

Potential feedback of the SST signal on the MJO (e.g. Woolnough et al. 2007)





Thermocline ridge



Many studies

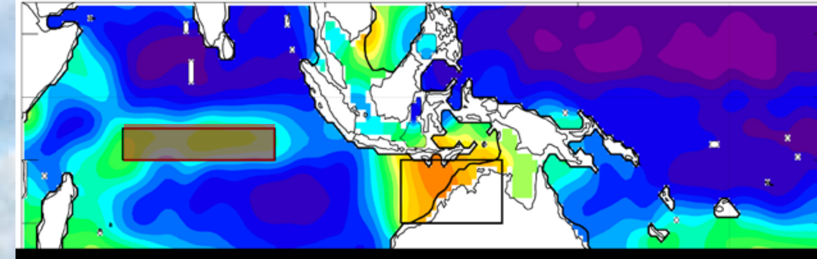
(Harrison and Vecchi 2001, Duvel et al. 2004, Saji et al. 2006, Duvel and Vialard 2007, Han et al. 2007, Vinayachandran and Saji 2008, Vialard et al. 2008)

$$\frac{\partial T}{\partial t} = \underbrace{\frac{Q_0}{\rho c_p h}}_{(a)} \underbrace{- \frac{F_{-h}}{\rho c_p h} - w_e \frac{(T - T_{-h})}{h}}_{(b)} \underbrace{- u\frac{\partial T}{\partial x} - v\frac{\partial T}{\partial y}}_{(c)}$$

Atmospheric heat fluxes **or** Mixing, entrainment **?**

Debate amongst previous studies: some say that atmospheric air-sea fluxes dominate, while some other propose that vertical mixing and entrainment plays a strong role because of shallow thermocline in that region.

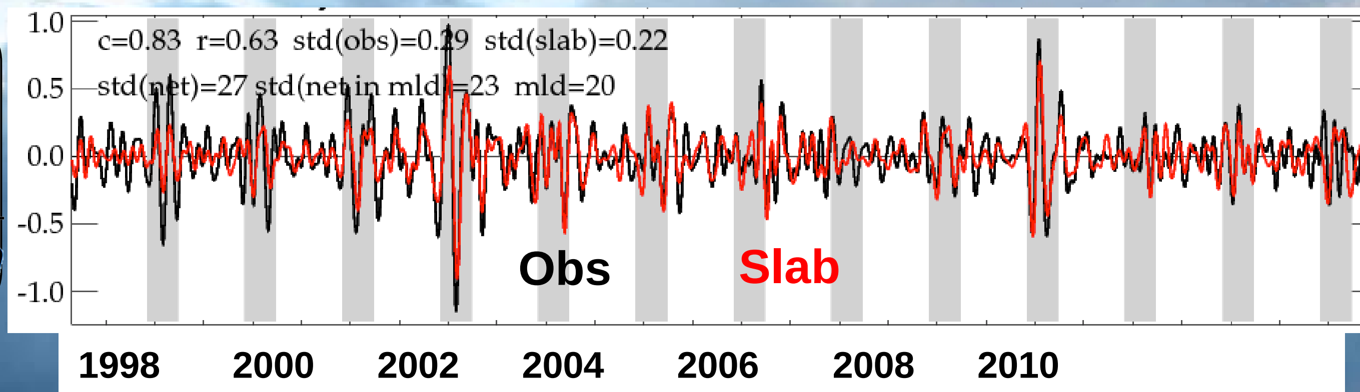
Thermocline ridge (Winter)



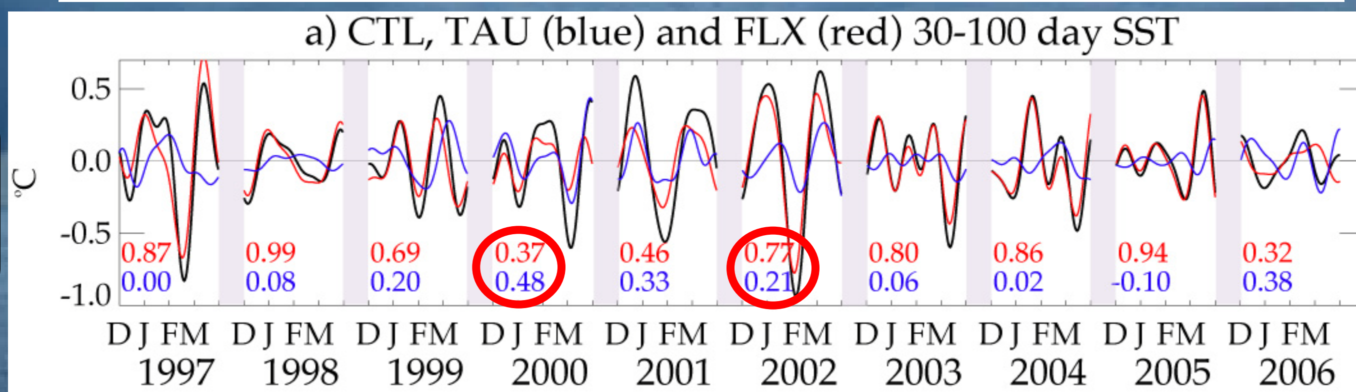
(Jayakumar et al. 2011)

Slab ocean

$$\frac{\partial T}{\partial t} = \frac{Q_0}{\rho c_p h}$$



OGCM MOM 1997-2006



Heat Fluxes

63%

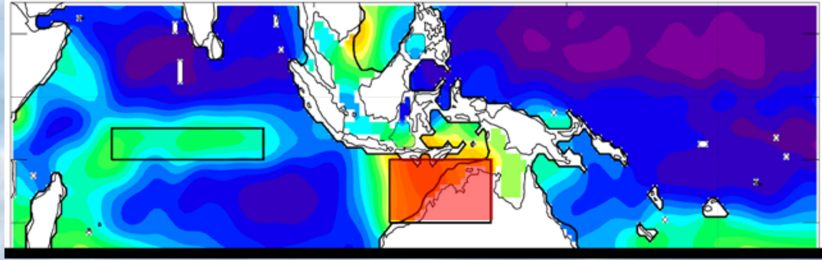
70%

20%

Vert. processes

Large year to year variations of the role of vertical processes explain discrepancy between previous case studies (e.g. vert. processes are small on average but larger than fluxes in 2000)

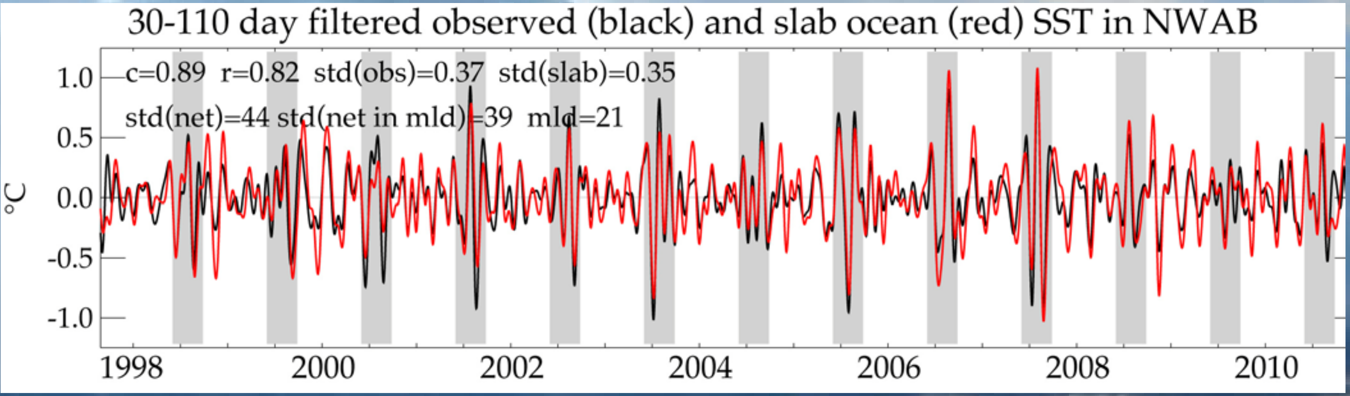
North-Western Autralian Basin (Winter)



(Vialard et al. Clim dyn online)

Slab ocean

$$\frac{\partial T}{\partial t} = \frac{Q_0}{\rho c_p h}$$



Heat Fluxes

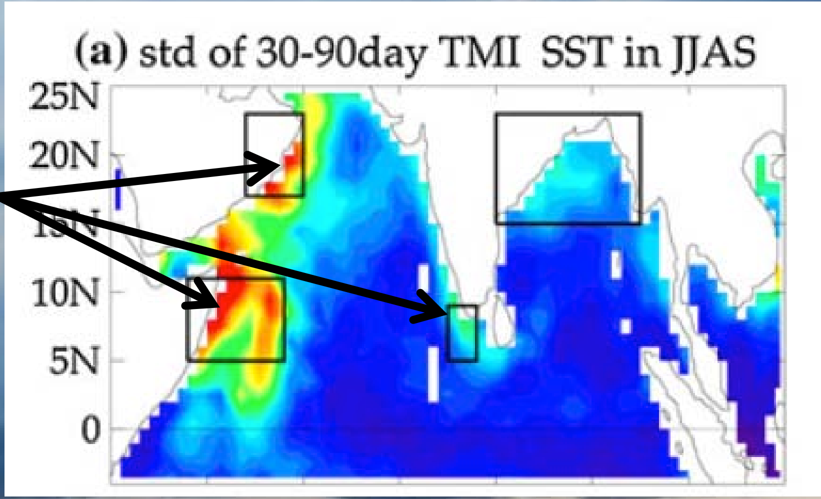
82%

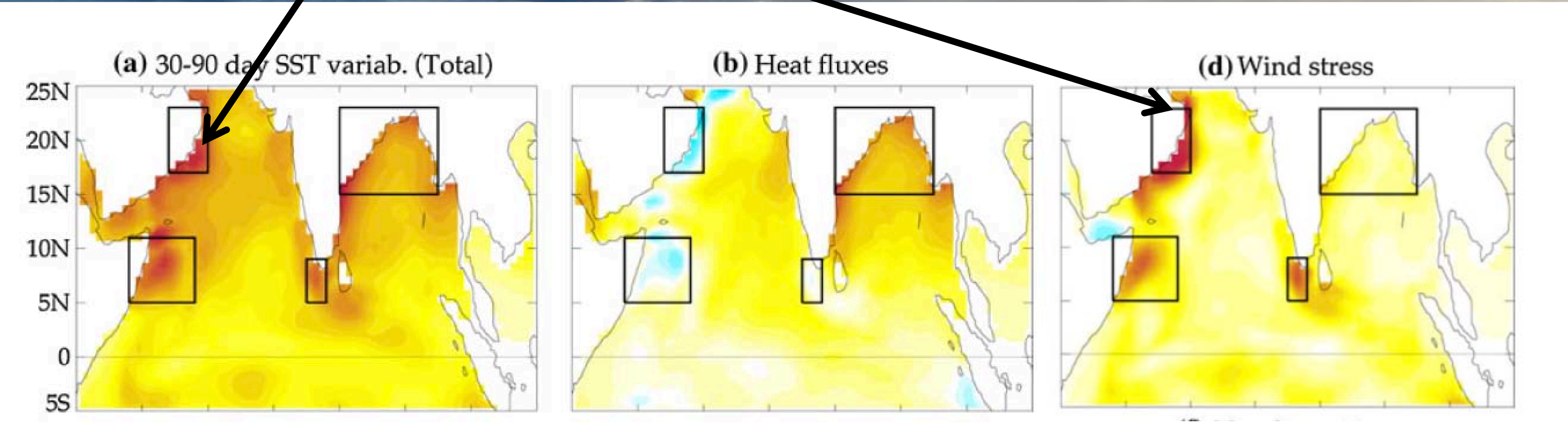
While thermocline ridge region has been thoroughly studied, the NWAB region (that has larger SST signals) has not been very much investigated

Vialard et al. Clim dyn online => Heat fluxes dominate (~82%) the SST intraseasonal variations in this box (SST ISV very well reproduced by a slab ocean model with fixed mixed layer depth)

Northern Indian Ocean (Summer)

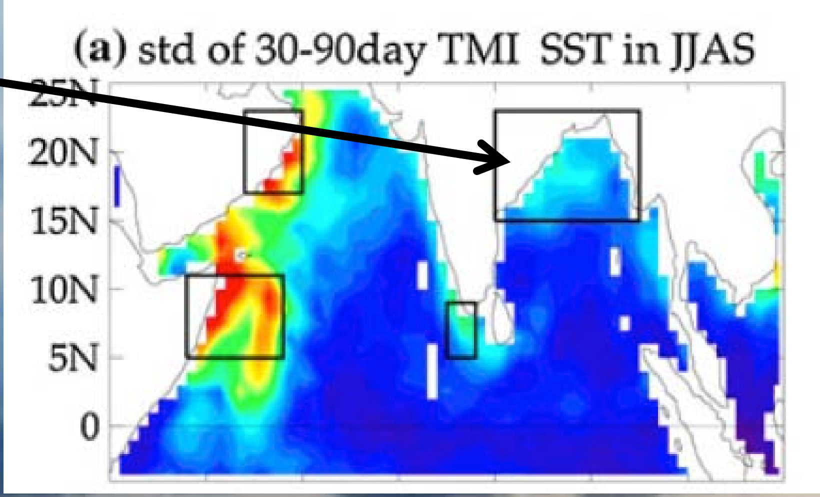
(Vialard et al. Clim dyn 2012)
Previously unreported large-scale SST fluctuations or Arabian-Sea upwelling systems in response to wind-stress fluctuations (vertical oceanic processes)

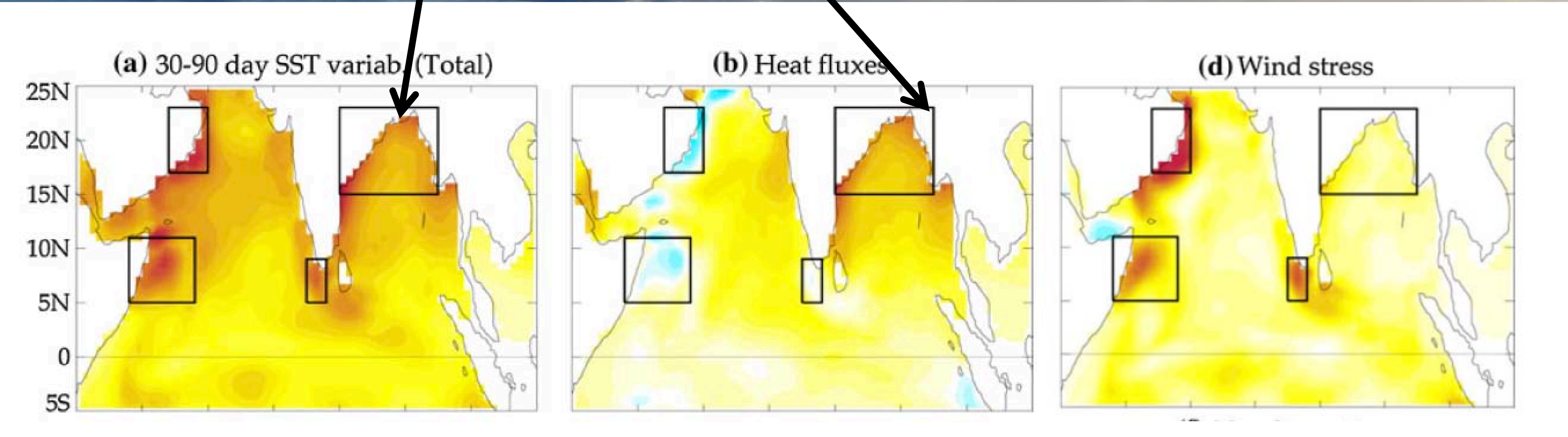




Northern Indian Ocean (Summer)

(Vialard et al. Clim dyn 2012)
Bay of bengal SST variations dominated by air-sea fluxes, in agreement with previous studies





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- Dynamical response to atmospheric ISV in the Indian Ocean (briefly!)
- A few perspectives

Dynamical response to atmospheric ISV over the Indian Ocean

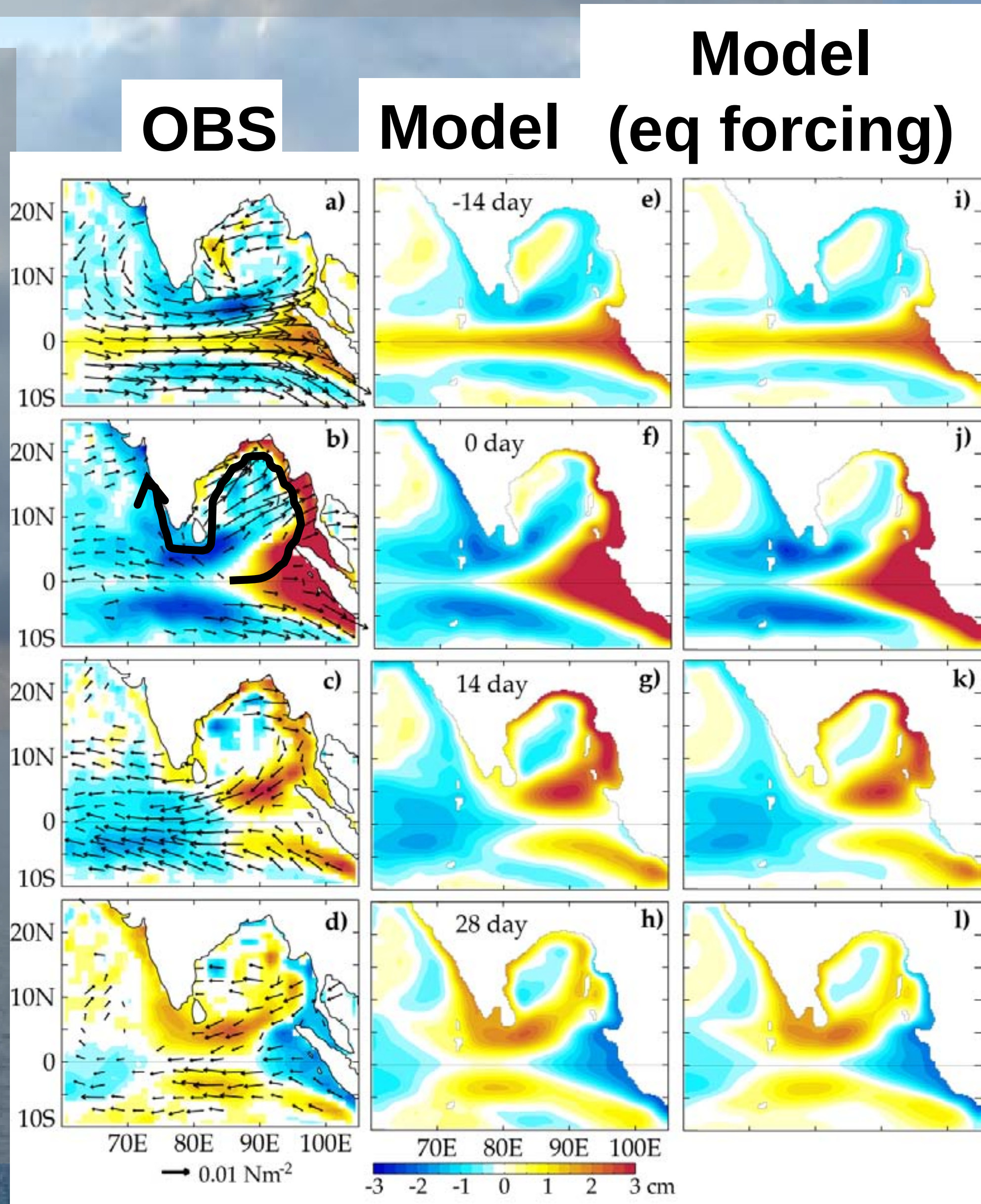
Equatorial wind ISV all year

⇒ Basin scale sea level resp. (equatorial R and K waves; K waves propagates into northern Indian Ocean as coastal wave)

⇒ Mostly driven by equatorial winds

⇒ Local wind forcing plays larger role in summer when atmos. ISV shifts to Northern Hemisphere

(Vialard et al. 2009, Suresh et al. submitted)



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Perspectives

- Do coupled models (e.g. CMIP-5) produce correct SST intraseasonal variability in the NWAB?
- Feedbacks on the atmosphere?
- Local meteorology (N. Australia, Indonesia) ?
- On the MJO propagation over the maritime continent?