Near 90-day resonance in the equatorial Indian Ocean: its structure as resolved by the multi-satellite sea level data and dynamics

Weiqing Han
Department of Atmospheric and Oceanic Science,
University of Colorado at Boulder

Coauthors:
J.P. McCreary, Y. Masumoto, J. Vialard and B. Duncan

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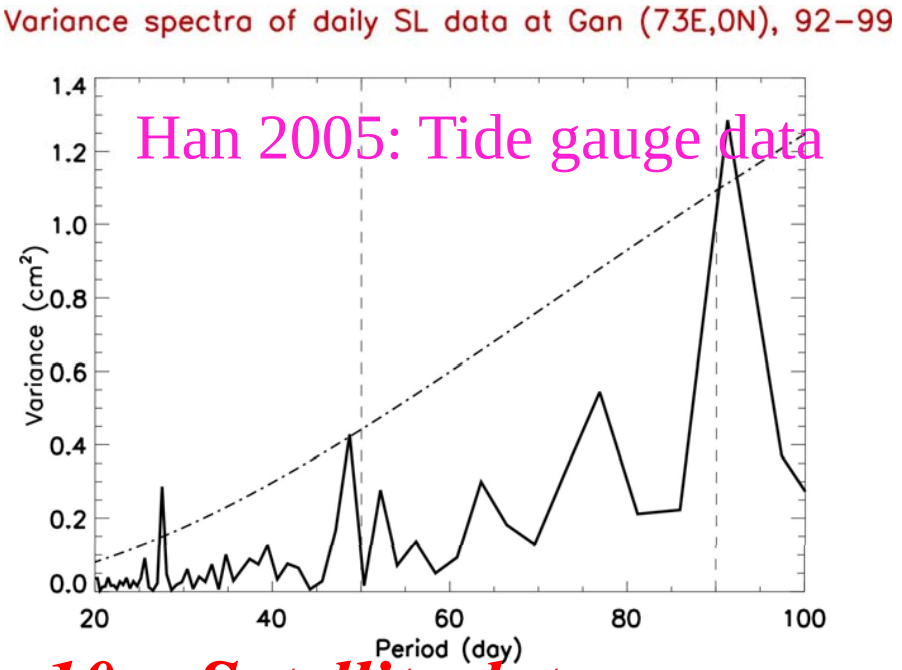
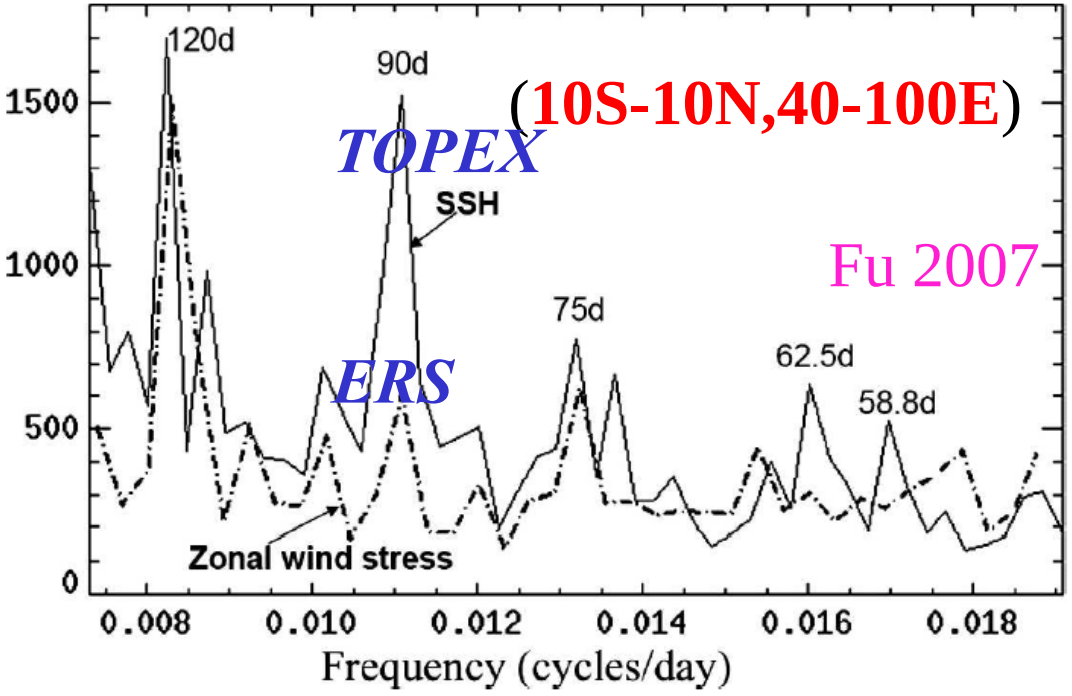
1. Background

- ***Observations:***

90d spectral peak of sea level



10yr Satellite data



Why does the equatorial Indian Ocean sea level variability prefer the 90-day period?

Theoretical studies: EQ basin resonance is possible when (Cane and Moore 1981, Gent 1981):

- $T = 4L/(mc_n)$, $m = 1,2\ldots$

  solution - infinity at $x_f = X_e - \frac{\pi C_n}{4\omega}(2m' + 1)$, $m' = 0, 1, \ldots$

Does EQ resonance exist in real ocean?

In the EQ Indian Ocean:

EQ L, C_2=167cm/s, ***m=2, T≈90d***

(Han 2005)

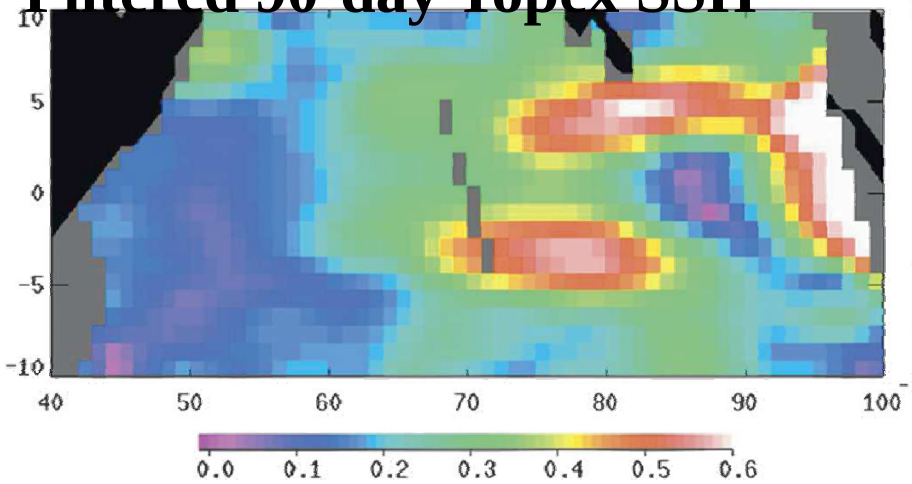
Issues:

Theoretical prediction: 90d – 2 equal maxima:

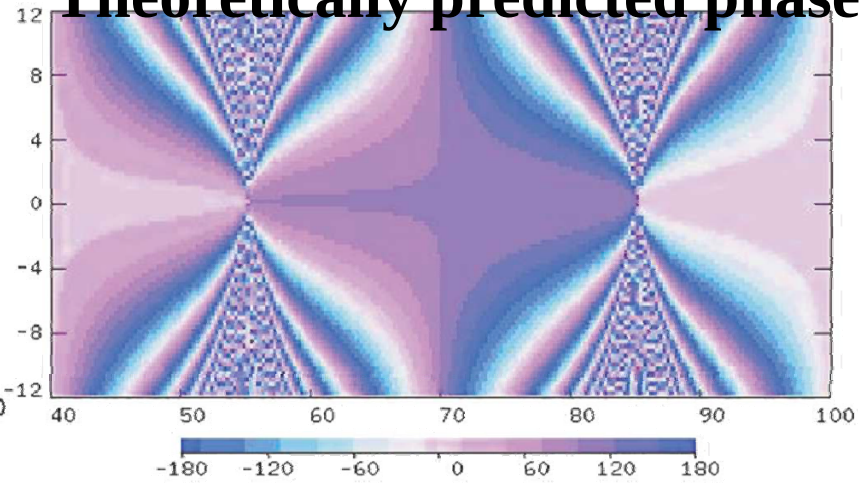
$$x_f = X_e - \frac{\pi C_n}{4\omega}(2m' + 1), \quad m' = 0, 1, ...$$

Eastern-basin concentration.

Filtered 90-day Topex SSH



Theoretically predicted phases



From Fu 2007

1. ***Why is there an eastern basin concentration?***
2. ***Is western boundary necessary for the 90-d peak?***

Goal:

- **Can the 90-day resonance be established in the equatorial Indian Ocean?**

- **Why is there an eastern-basin enhancement for the 90-day current and sea level, and is the western boundary necessary?**

2. Models and Experiments

a) A 1-D idealized Model and Experiments

Consists of Kelvin wave + (l=1) Rossby wave

Interior unbounded wind forced

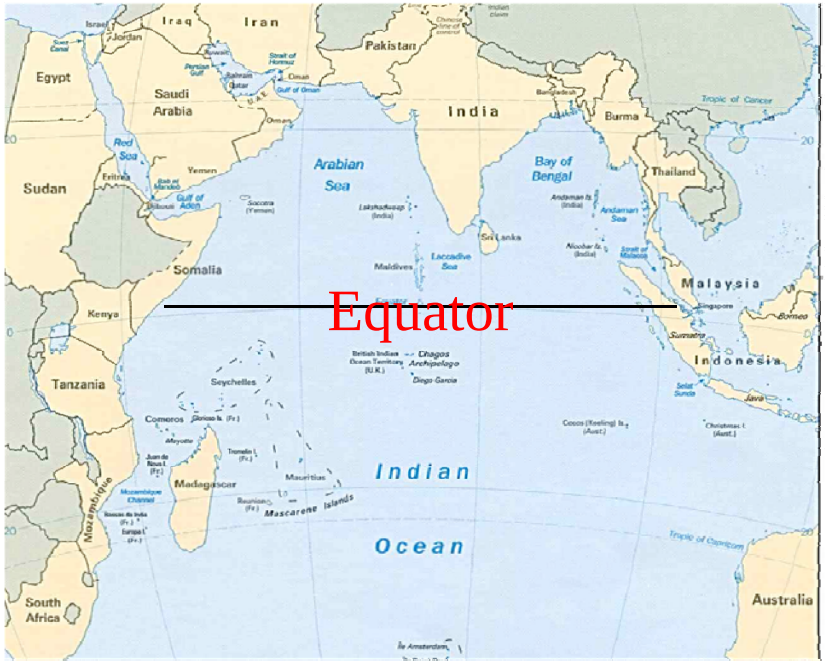
Reflected Kelvin at WB

Reflected Rossby at eastern boundary

$$q = (\tilde{q}_p + Ae^{ik_K x} + Be^{ik_R(x-L)})e^{-i\omega t},$$

b) The Linear Continuously Stratified (LCSM): idealized & real wind forcing

c) OGCM (HYCOM): real wind forcing



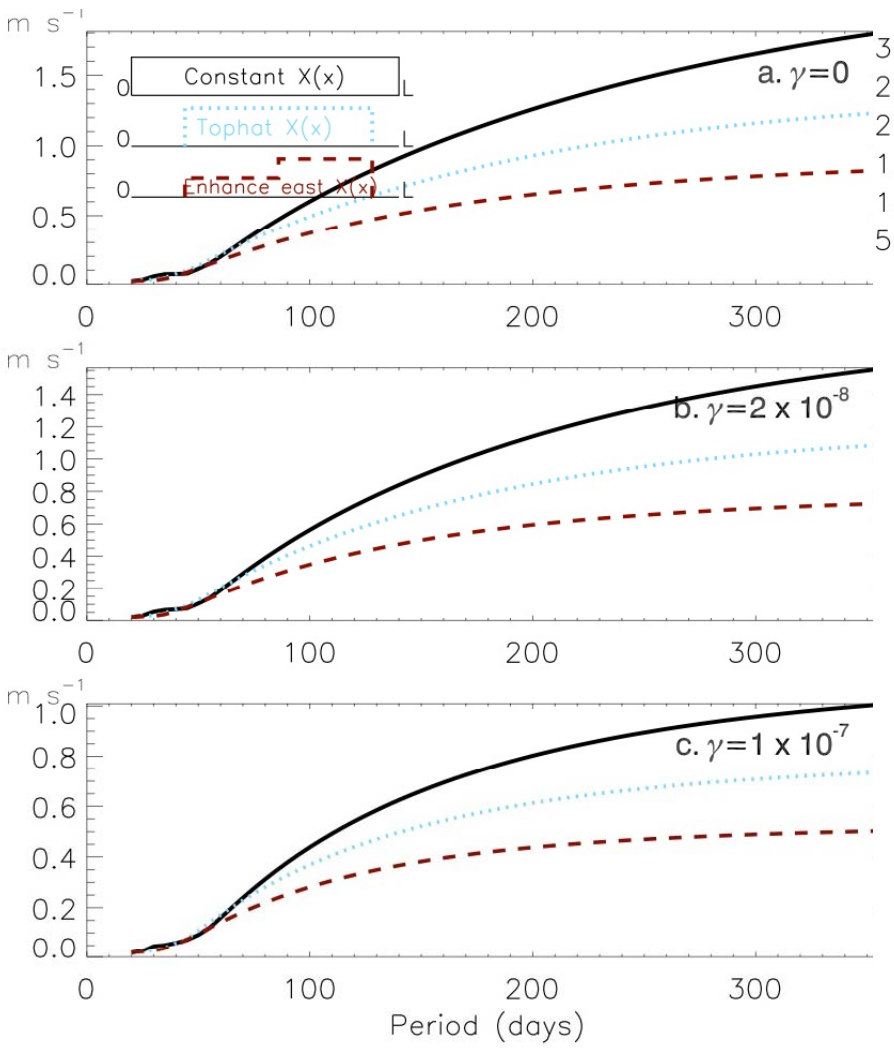
3. Solutions - 1-D model - Amplitudes

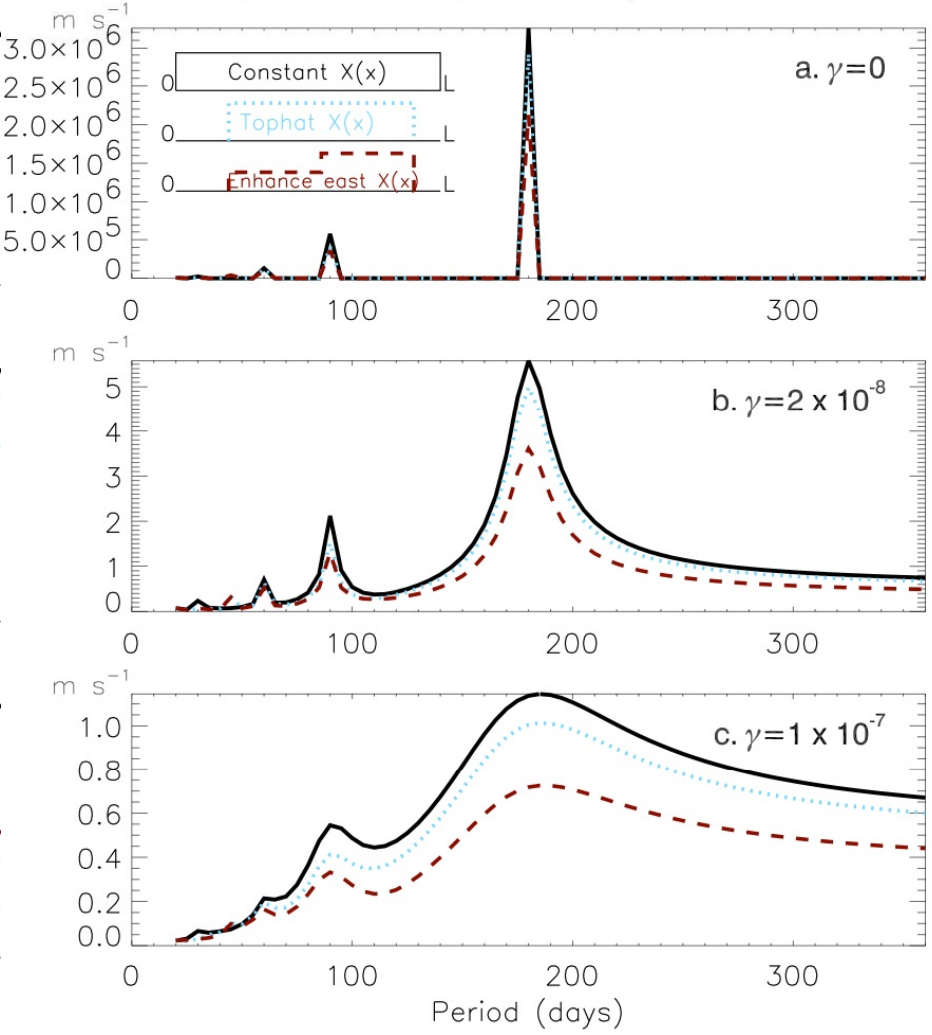
$$q = (\tilde{q}_p + Ae^{ik_K x} + Be^{ik_R(x-L)})e^{-i\omega t},$$

(No West Boundary)

$$q = (\tilde{q}_p + Ae^{ik_K x} + Be^{ik_R(x-L)})e^{-i\omega t},$$

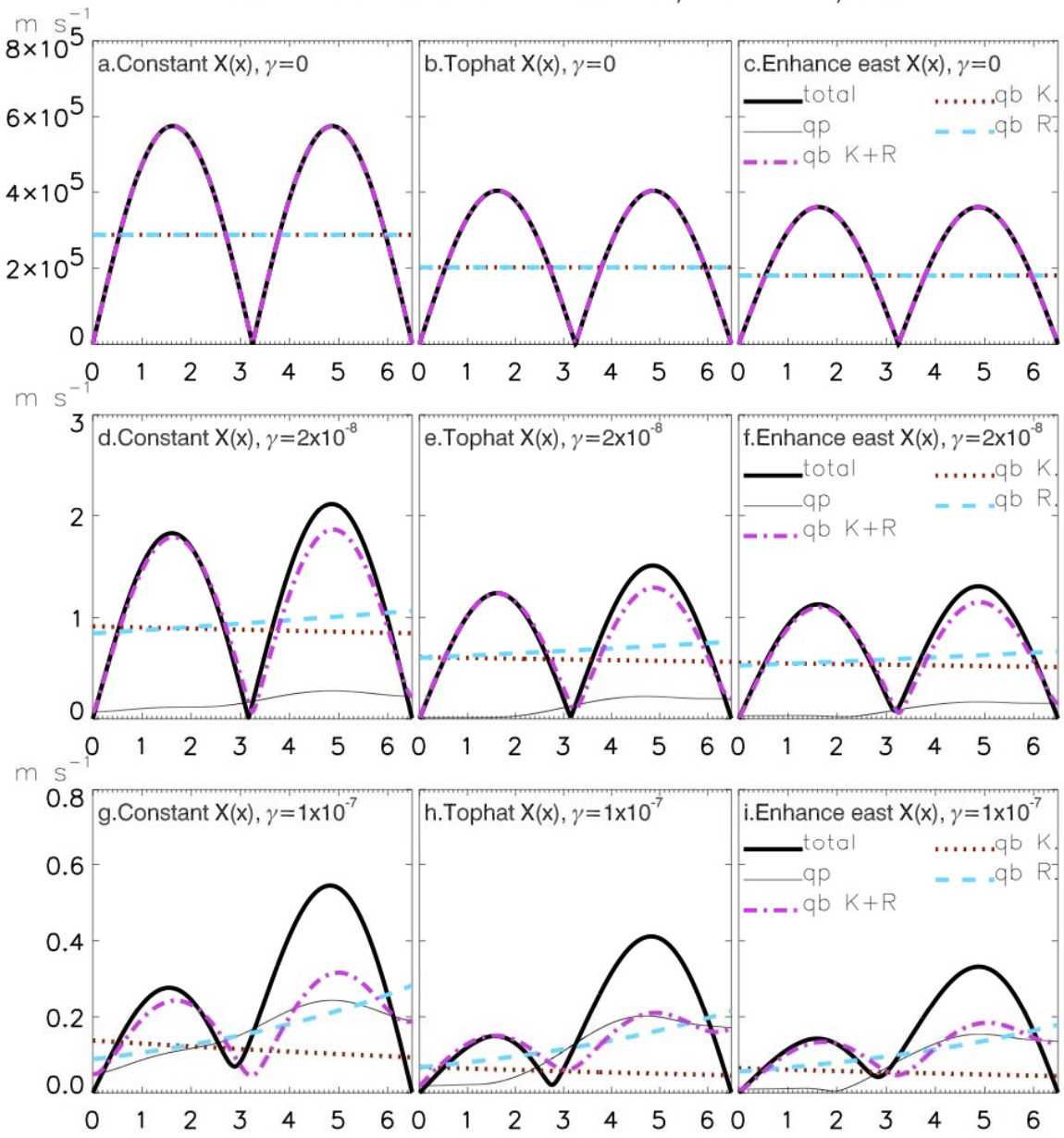
(total: with both boundaries)



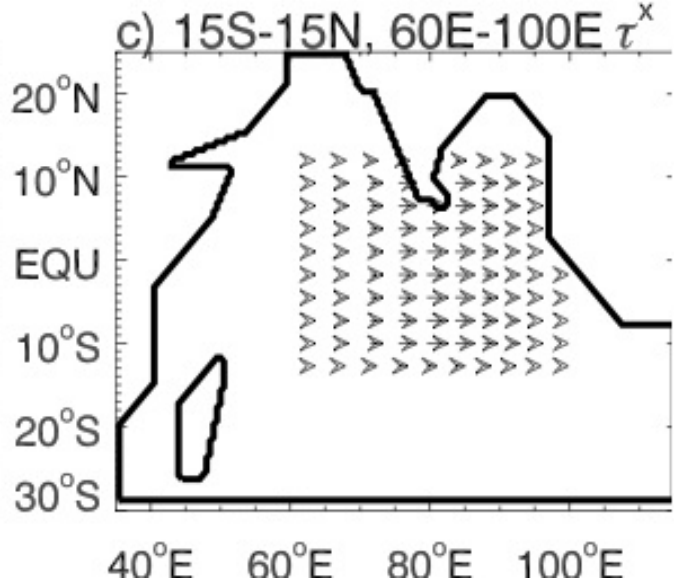


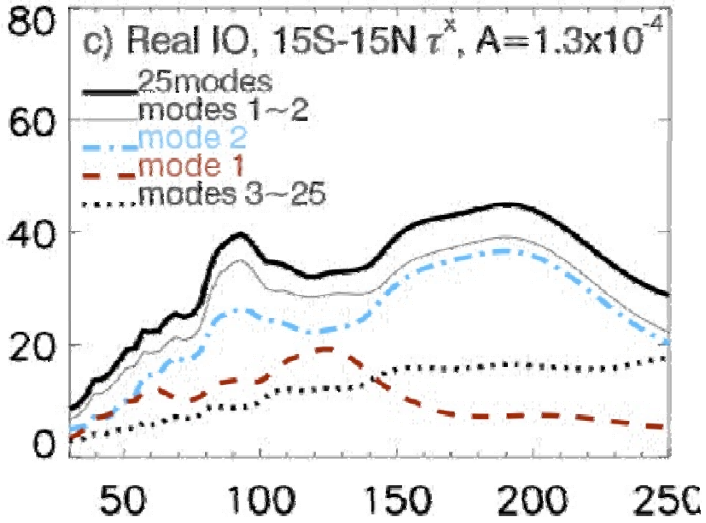
180-d: Jensen 1994; Han et al. 1999

1-D, Spatial Structure: mode 2, 90d



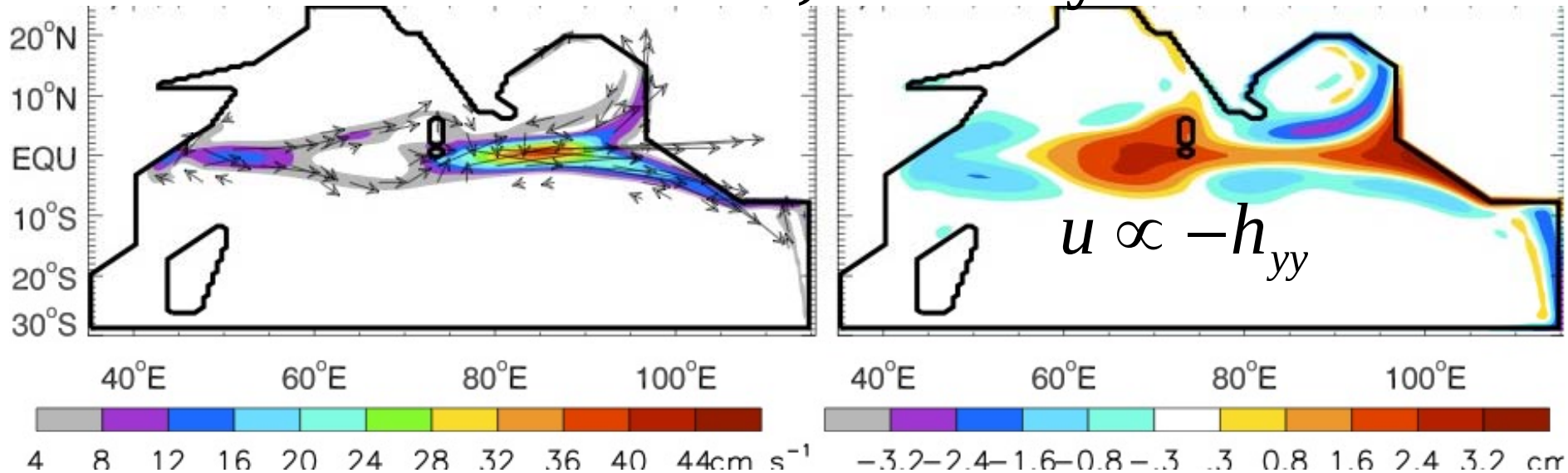
b) 2-D solution, LCSM



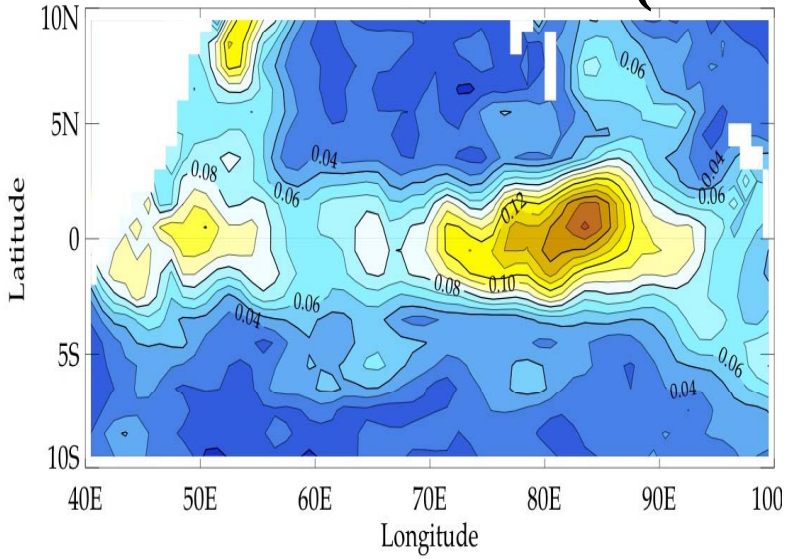


Periods

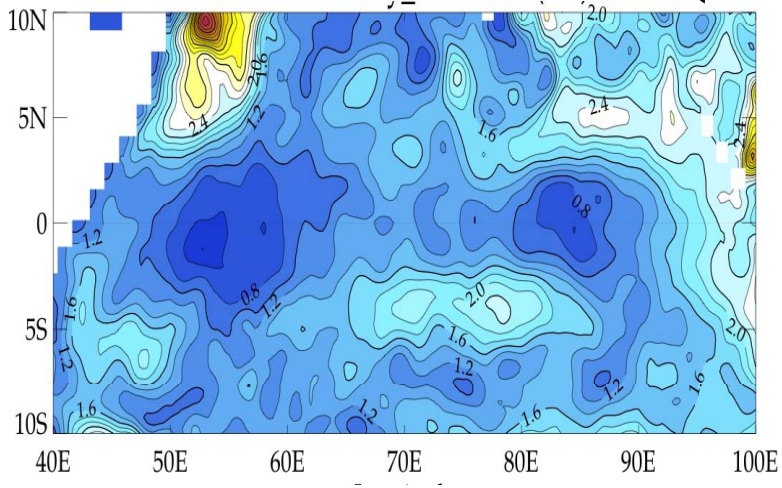
Surface current & Sea Level Anomaly (SLA)
n=2 mode, T=90day



STD: OSCAR 90d filtered U(94-08)

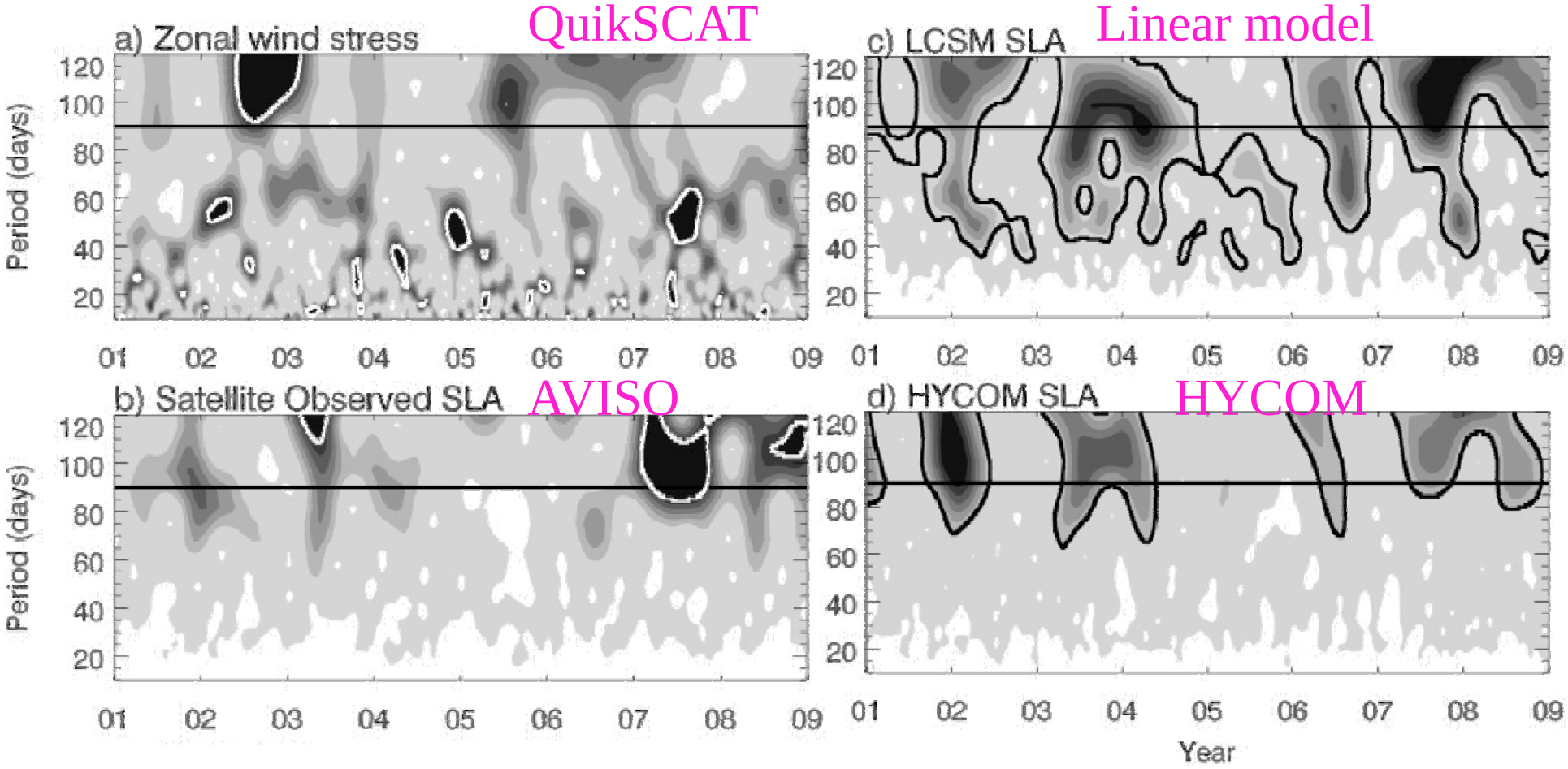


STD: AVISO 90d filtered SSH(93-08)



Wavelet: wind & observed/simulated SLA

(60E-95E, 5S-5N) average



Applications of this theoretical work:

Intraseasonal Rossby & Kelvin waves:

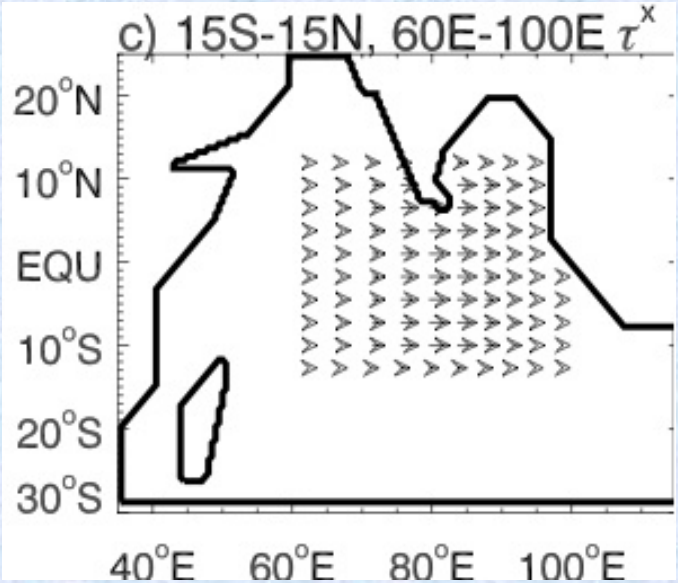
-Affect SST & gradients
-Initiating "large" Madden-Julian Oscillation (MJO) events; the 90-d resonance may have important implication on climate prediction

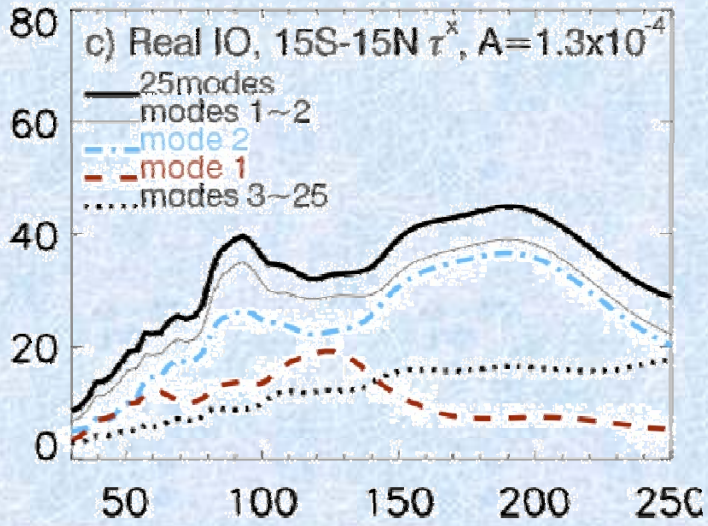
-(Webber et al. 2010; Webber et al. 2011a, 2011b).

4. Summary and Conclusions

- **The selective response of the equatorial Indian Ocean near the 90-day period results from basin resonance of the n=2 mode with the 90-day wind forcing; both the eastern and western boundaries are essential for the establishment of the resonance;**
- **Horizontal mixing & friction are important causes for the eastern basin enhancement of the 90-day resonance;**
- **The higher-resolution multi-satellite merged sea level data appear to resolve the 90-day resonance structure better than the lower resolution, single satellite data.**

b) 2-D solution, LCSM





2S-2N Average