Low-frequency sea level variability in the southern Indian Ocean

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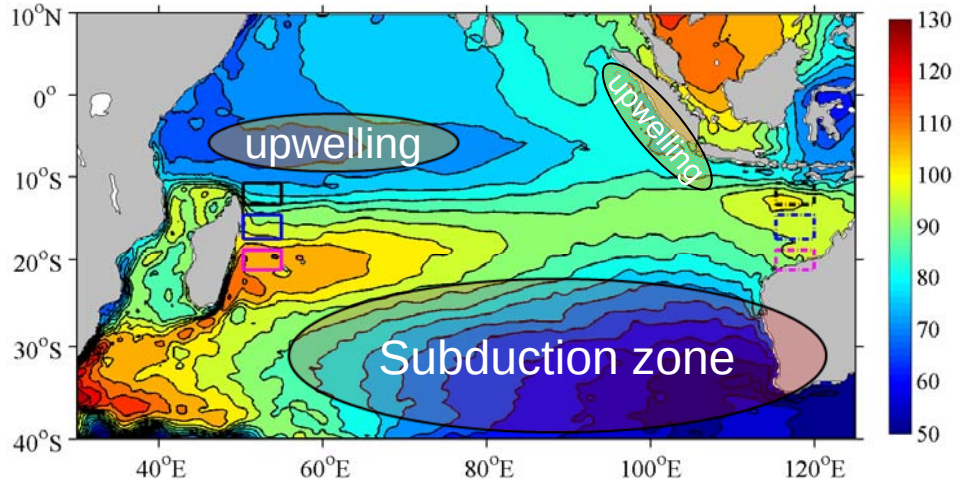
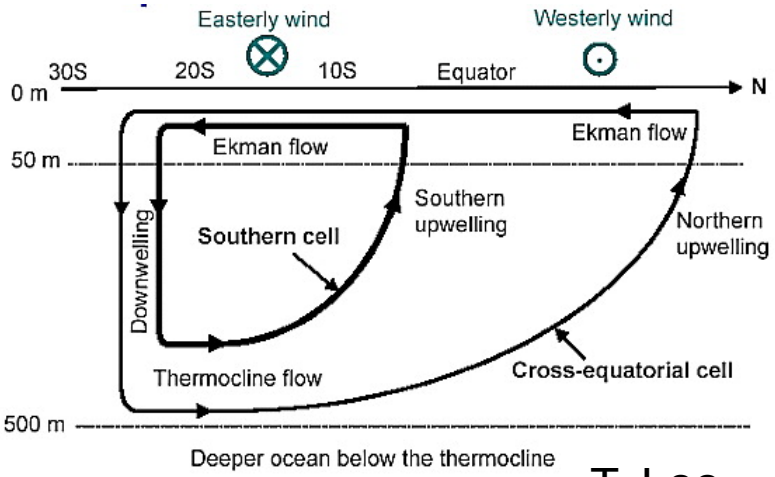
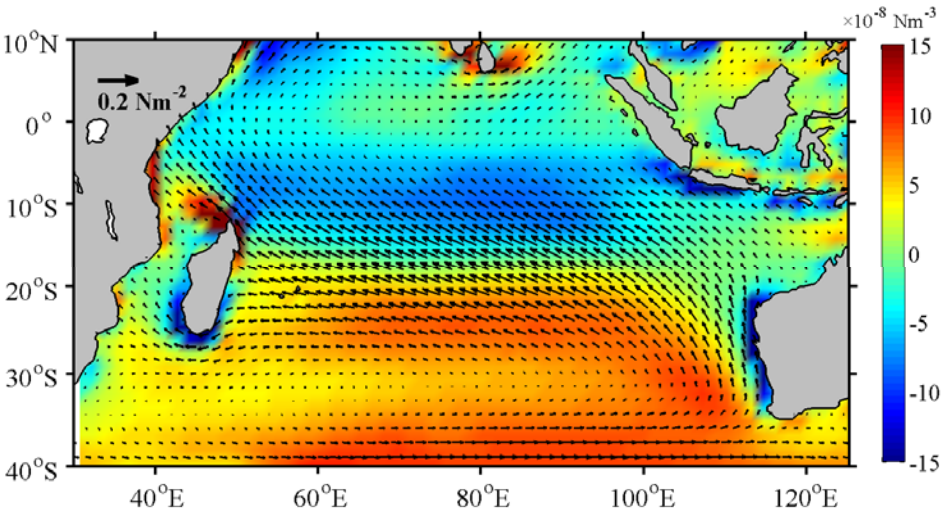
Mean circulation in the southern Indian Ocean



Rio dynamic topography

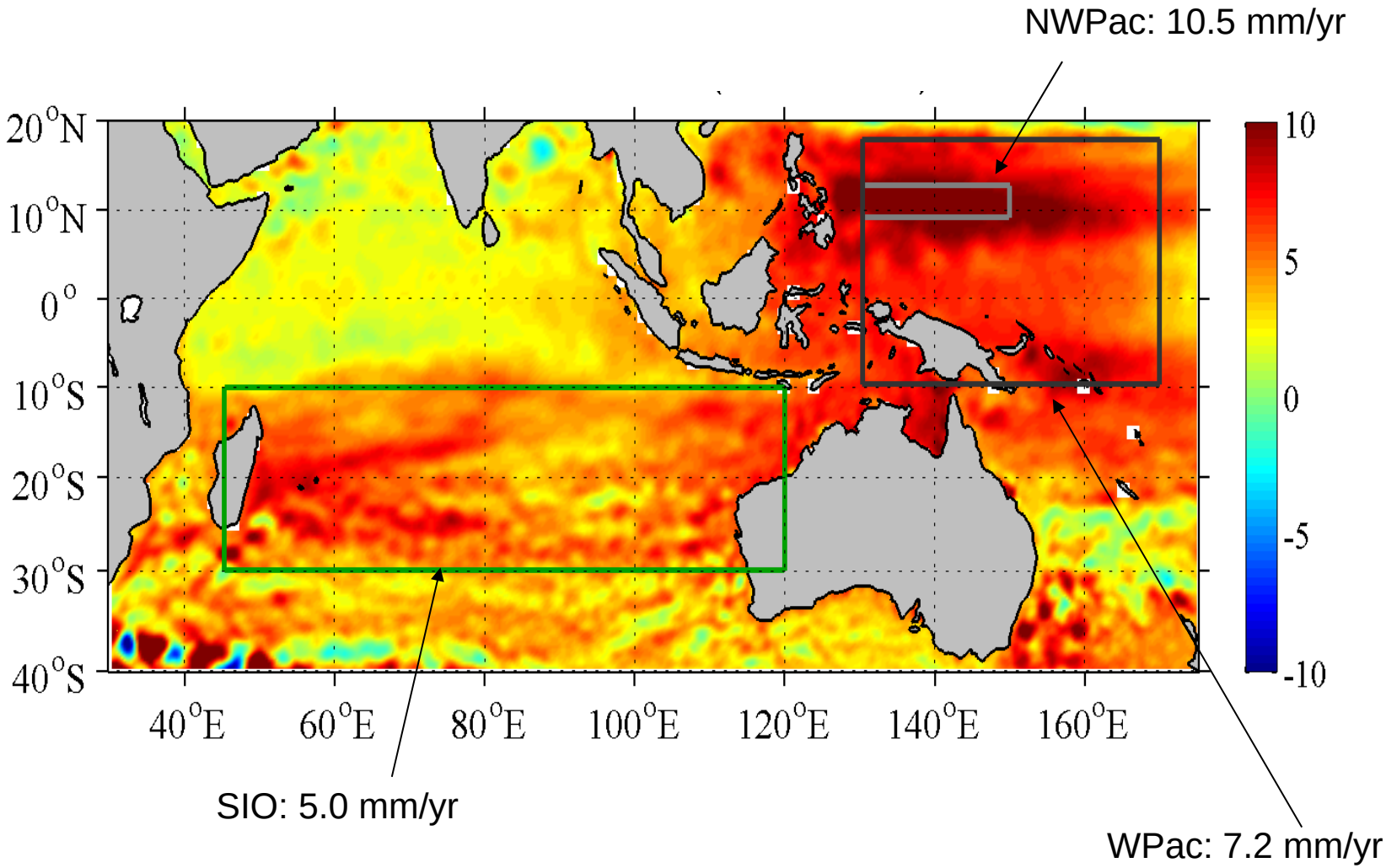


T. Lee



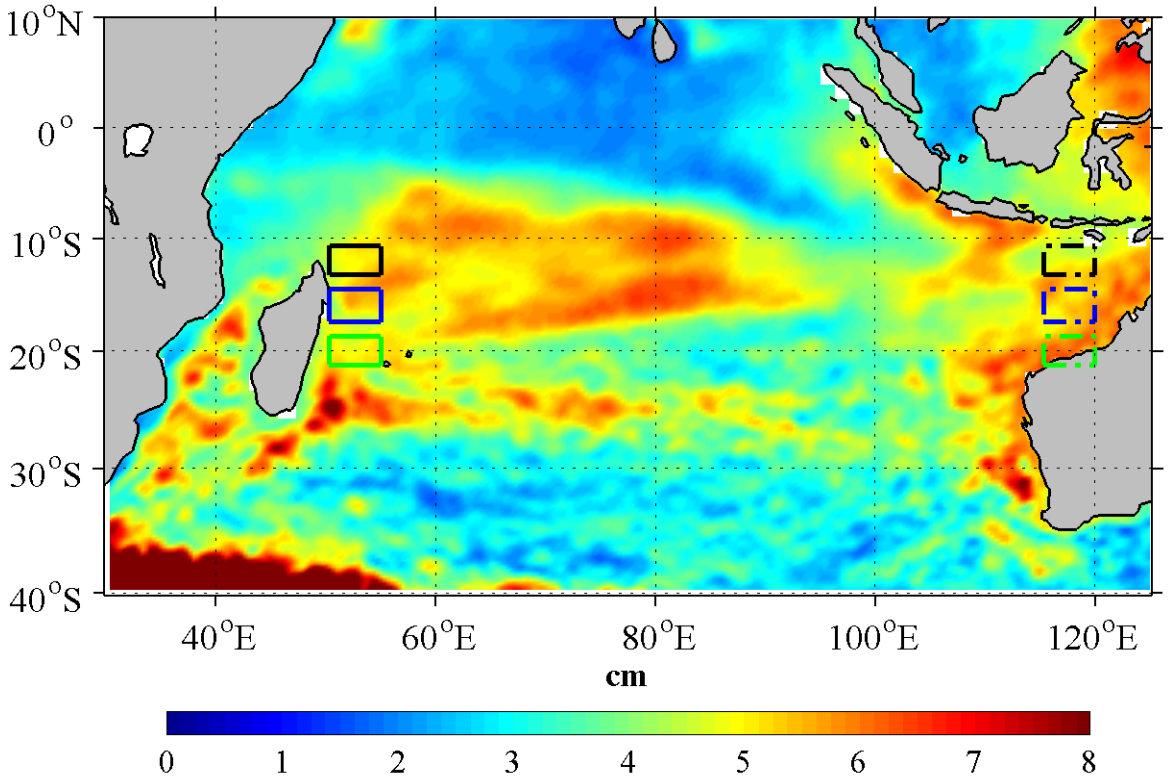
ECMWF interim wind stress and curl

Altimeter sea level trend (1993-2010)



Motivation of the study

- **The relative importance of local wind forcing and remote forcing from Pacific to the sea level variability.**
- **The relation of sea level difference between east (He) and west (Hw) basin and the meridional transport in SIO.**



STD of sea level anomaly

Sea level anomalies in selected boxes

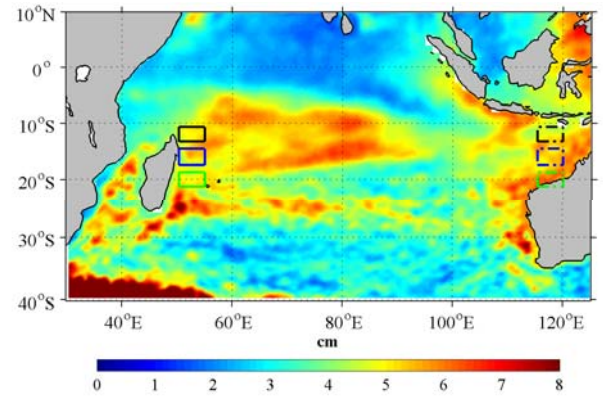
Pacific

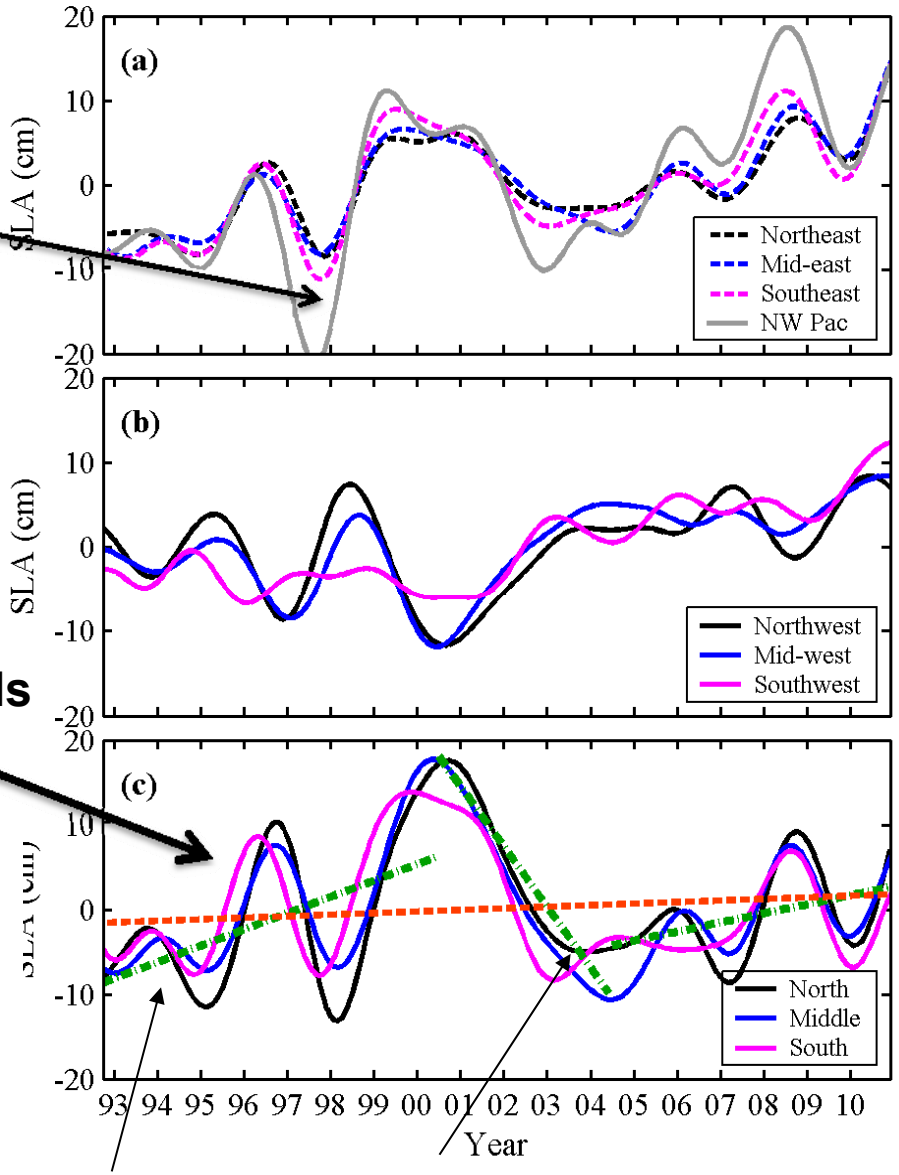
East IO

West IO

Strength of subtropical cells

East - West





9.3 mm/yr

-71.3 mm/yr

A linear Rossby Wave model

• Under the long-wave approximation, large-scale SSH changes are governed by linear vorticity dynamics (Qiu, 2002, JPO):

$$\frac{\partial h'}{\partial t} - c_R \frac{\partial h'}{\partial x} = -\frac{g' \nabla \times \tau}{\rho_o g f} - \epsilon h'$$

• Given the wind forcing and $H(x_e)$, SSH changes can be found by integrating the above equation along the Rossby wave characteristics：

$$h'(x,y,t) = h'(x_e, t + \frac{x - x_e}{C_R}) \exp[\frac{\varepsilon}{C_R}(x - x_e)]$$

SSH signal generated at eastern boundary

$$+ \frac{g'}{\rho_0 g f} \int_{x_e}^{x} \frac{1}{C_R} \nabla \times \tau(x', y, t + \frac{x - x'}{C_R}) \exp[\frac{\varepsilon}{C_R}(x - x')] dx'$$

Wind-driven

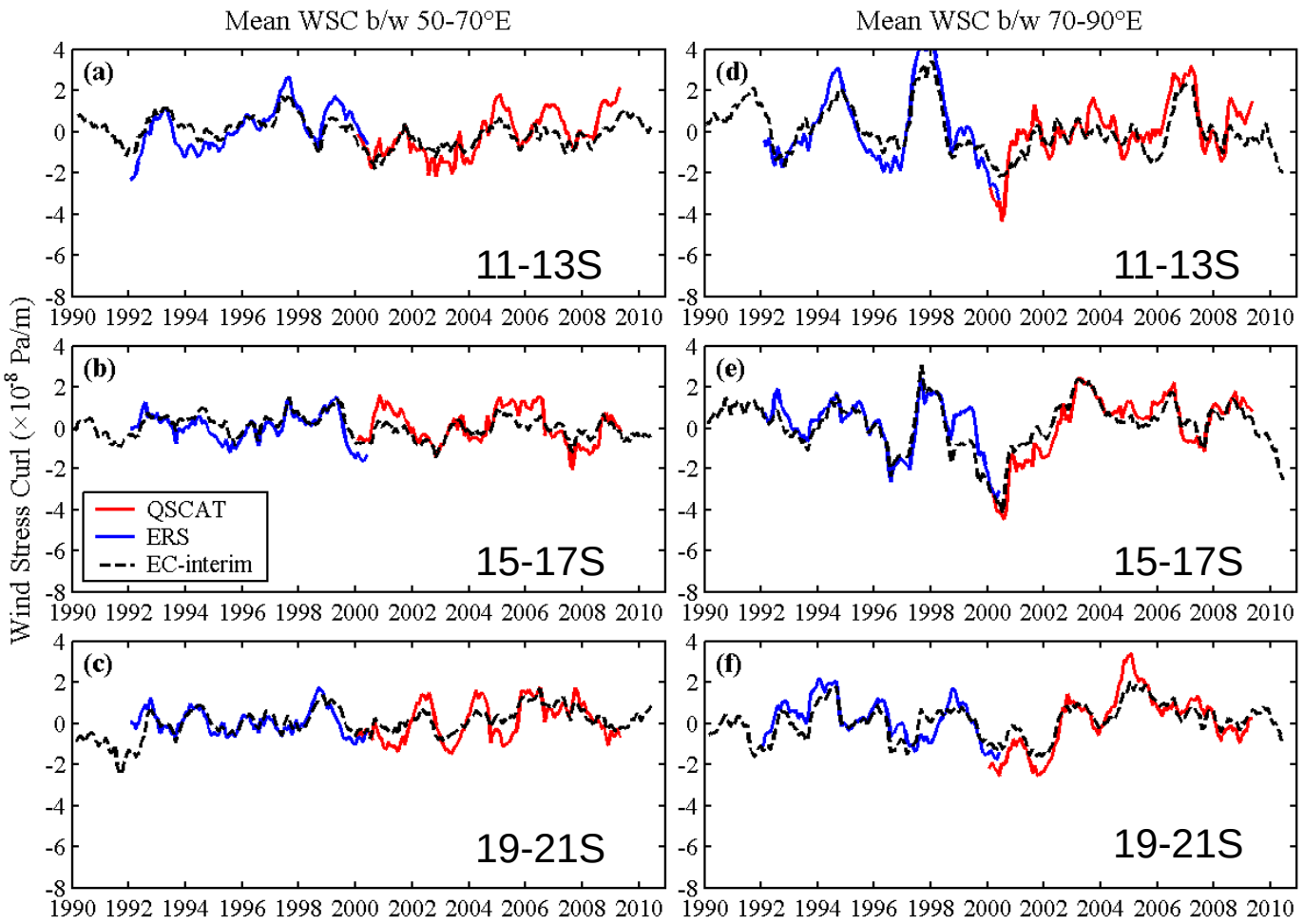
C_R: observed value (D. Chelton)

τ：monthly wind stress from ECMWF interim 1989-2010;

ε：Newtonian Damping Rate (selected by model fit)

He：altimeter observed value (subtract 3mm/yr global mean sea level trend)

Variability of wind stress curls



- ECMWF interim product is consistent with the satellite scatterometer observations
- Interannual variations have larger amplitudes at 70-90E than at 50-70E.

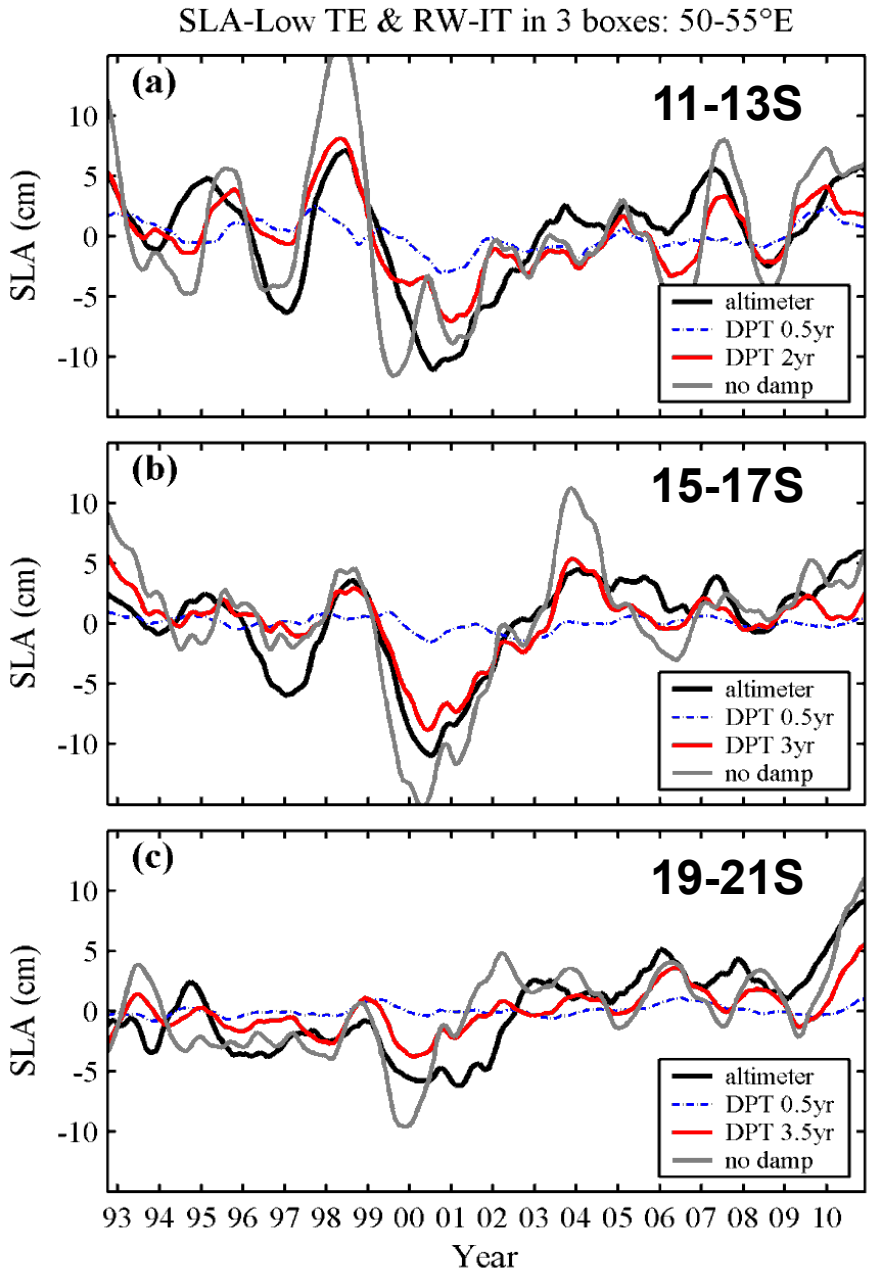
Modeled western SSH anomalies (Hw) – choices of ε

ε^{-1}=2 year
correlation : 0.68

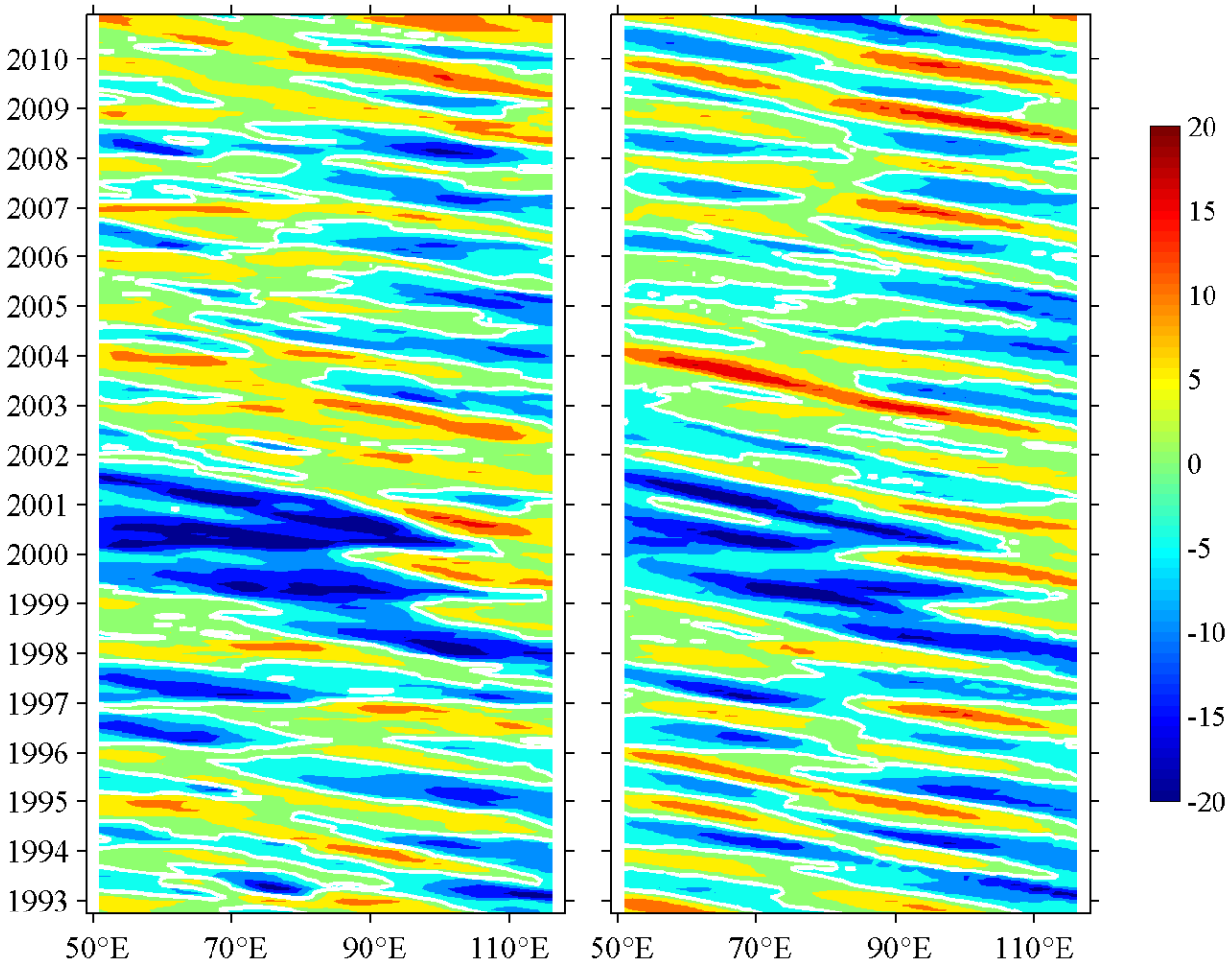
ε^{-1}=3 year
correlation : 0.80

ε^{-1}=3.5 year
correlation : 0.62

Red lines: modeled results with the best fit



Observed and modeled SSH anomalies along 15º-17ºS

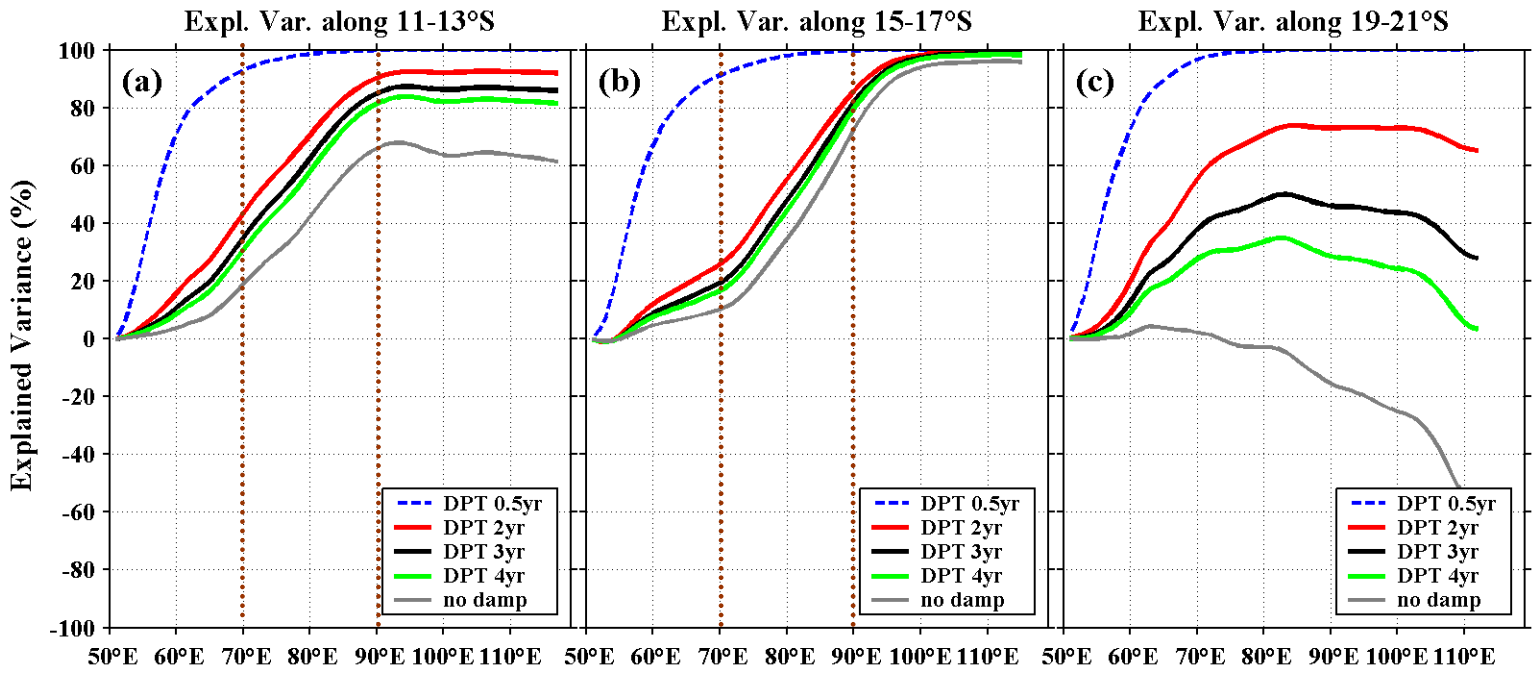


The correlation reaches 0.79 at the latitude band 15-17ºS

It takes 21 months for baroclinic Rossby wave from 115E to 50E.

Explained variance of wind forcing at different Newtonian damping rates

Integrated from western boundary

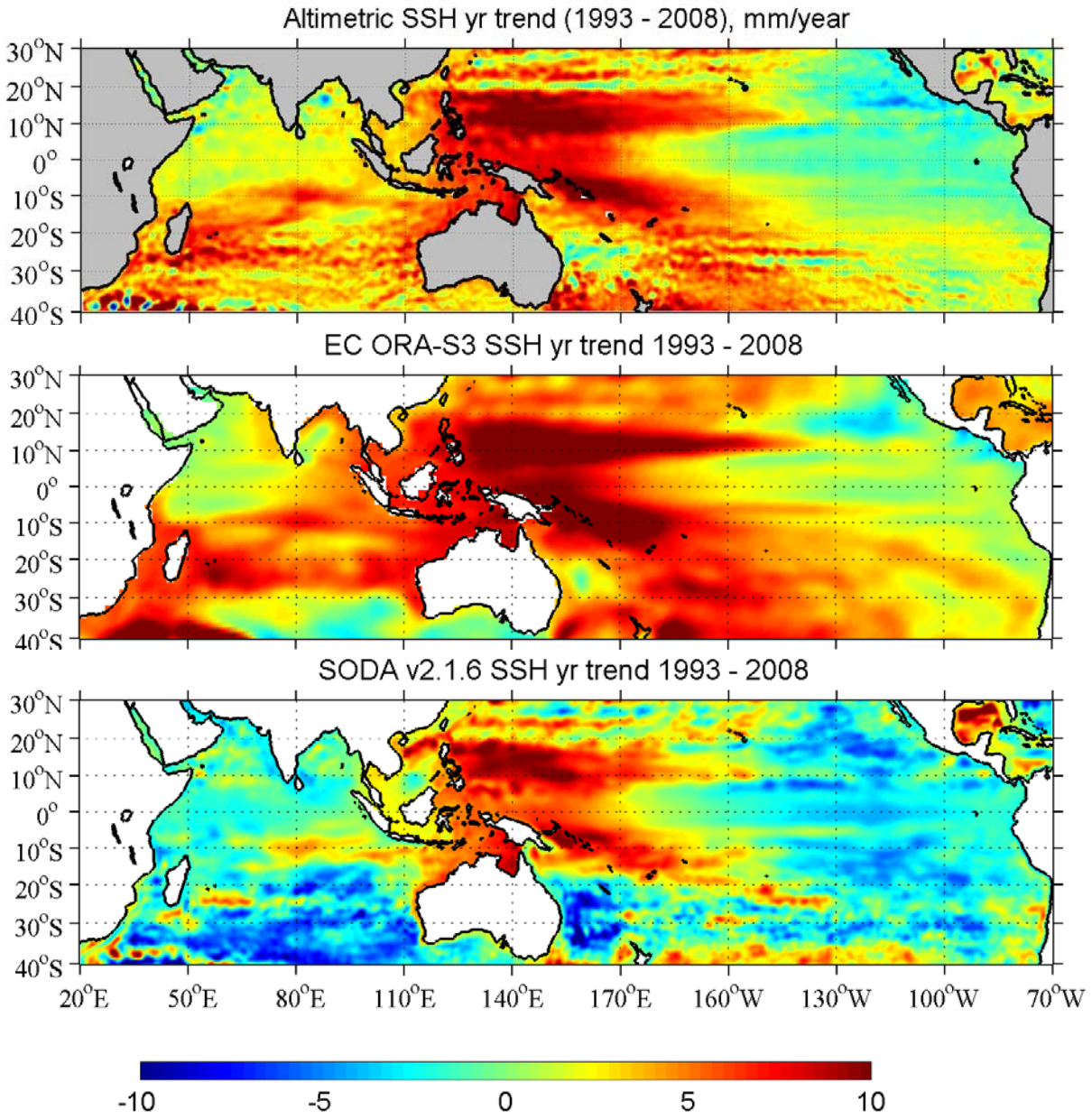


- At 11º-13ºS and 15º-17ºS, the wind forcing between 70-90ºE contributes more than that between 50-70ºE
- At 19º-21ºS, the contribution from the Pacific remote forcing is the most significant, however it is sensitive to ε.

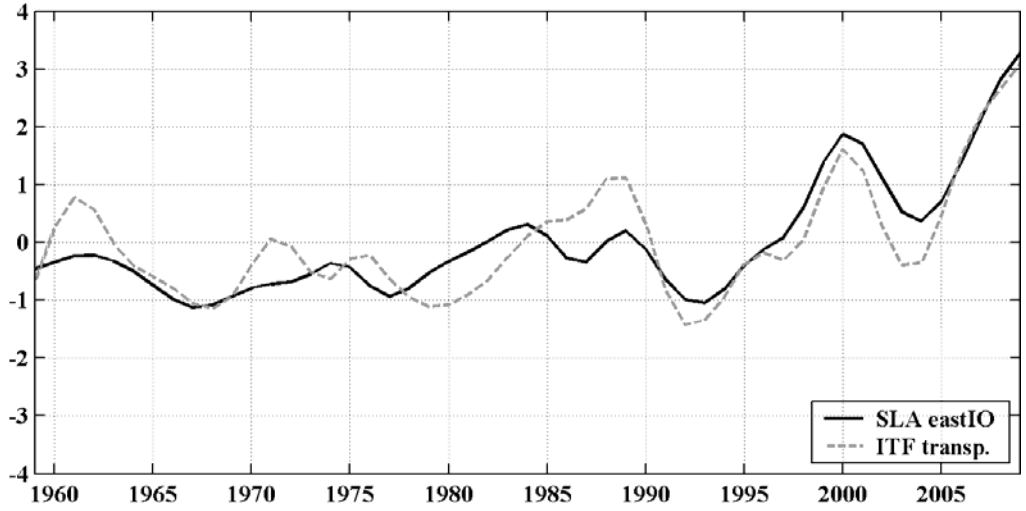
Sea level trends from global data-assimilation models

ECMWF forcing

ORA-S3 better reproduces the sea level trend



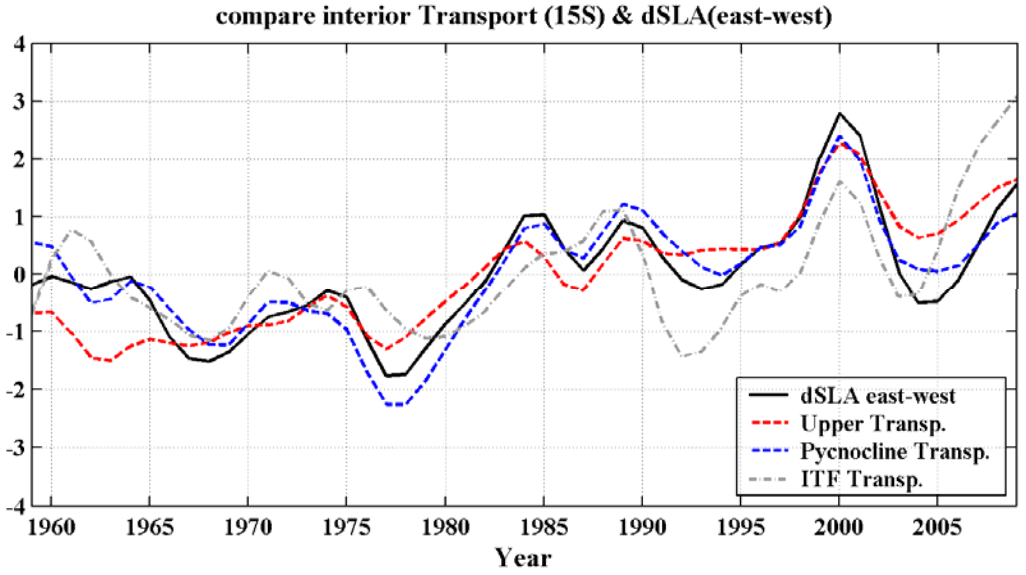
Normalized ITF transport (north of 15S) Vs. He (115-120E):



For the original data:

Correlation : -0.87
Linear Regress. Coef.: -0.23 Sv/cm

Normalized 15S pycnocline transport vs. dSLA (He - Hw):



For the original data:

Correlation : -0.94
Linear Regress. Coef.: -0.31 Sv/cm

*He & Hw could explained **40.6%** and **24.4%** of the variance, respectively.*

Summary

- **The low-frequency & seasonal sea level variability in SWIO could be well explained by the nondispersive baroclinic Rossby wave adjustment.**
- **North of the SEC bifurcation latitude (17S), sea level variability is primarily driven by local winds**
- **At 20S,Rossby waves generated at the eastern boundary have relative large amplitude and play more important roles in modulating the sea level variations in the western basin**
- **Sea levels in the east (He) is a good indicator of decadal ITF transport**
- **The interior meridional transport across 15S, which is an important contributor to the STC, is controlled by the sea level difference (E-W)**

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