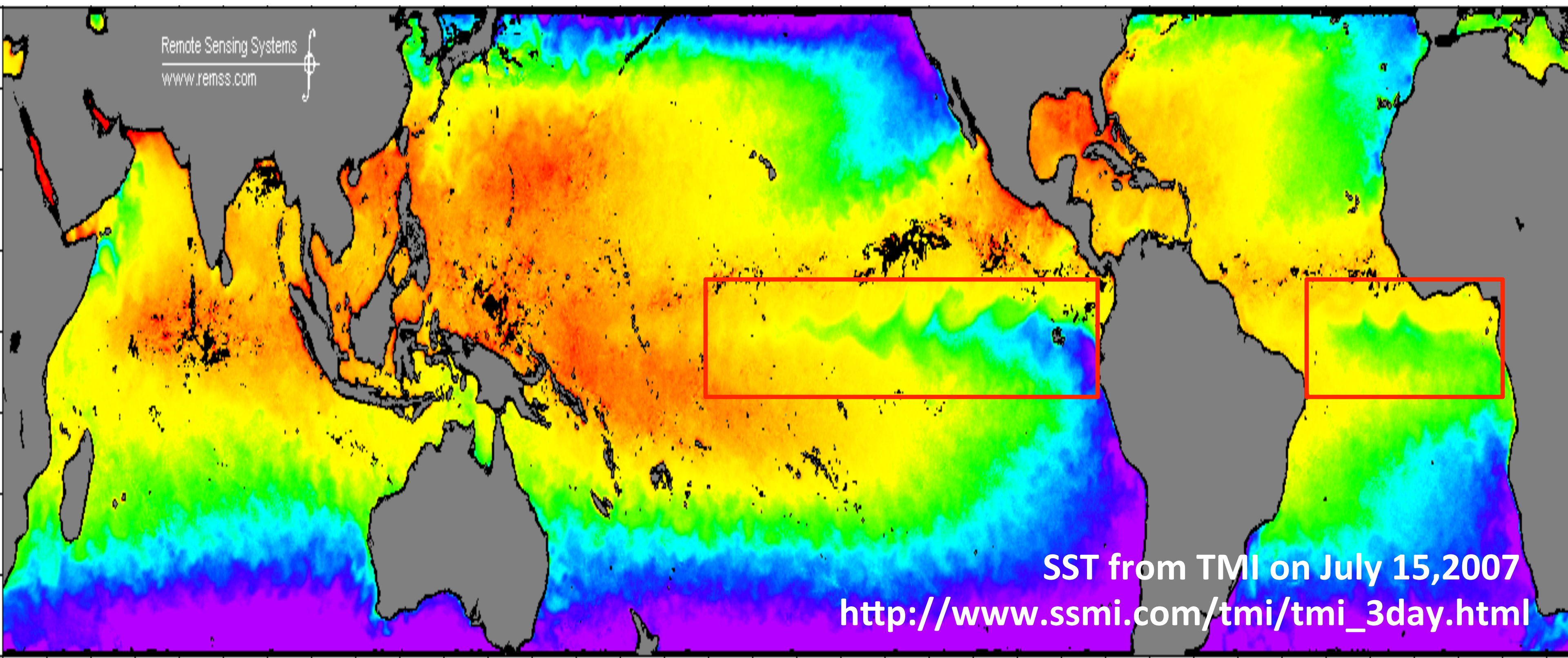
Ocean-Atmosphere Characteristics of Tropical Instability Waves(TIW) Simulated in the NCEP Climate Forecast System Reanalysis

4th World Climate Research Program International Conference on Reanalyses
8 May 2012

Caihong Wen, Yan Xue and Arun Kumar
Climate Prediction Center
NCEP/NWS/NOAA



Impact of TIW on Climate & Marine Ecosystem

- Momentum and heat budget (Jochum and Murtugudde 2006)
- Nutrient distribution (e.g. Strutton et al. 2001)
- Interannual variations, i.e ENSO (e.g. An 2008; Zhang and Busalacchi 2008)
- Mean ocean and atmosphere states

Challenges:

- In situ observations
  ----- too sparse
- Satellite Observations
  ---- limited surface variables and record
- NWP reanalysis products (e.g. NCEP R1,R2)
  ----- coarse resolution, SST boundary conditions

CFSR:

- Much higher resolution : 1979-2009

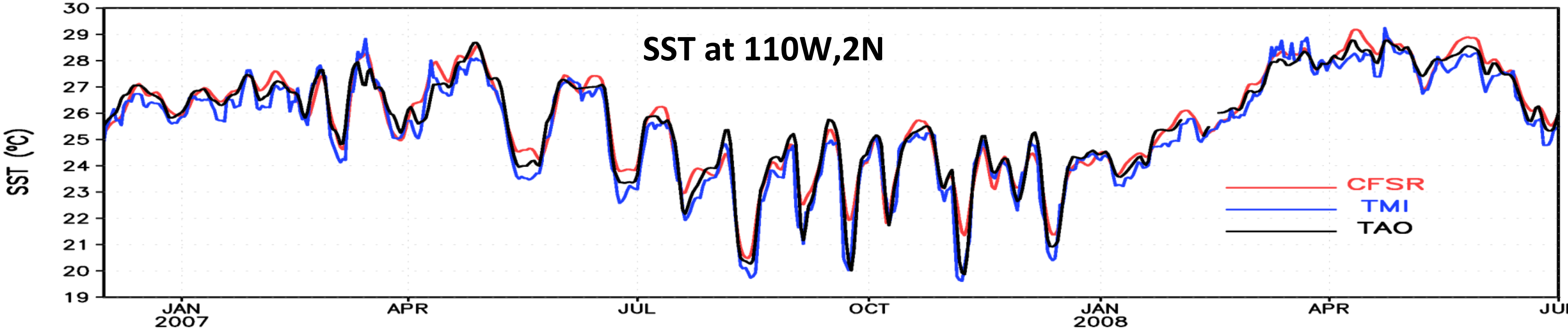
  Atmosphere:T382(~38km) Ocean:0.25^{o} ~0.5^{o}
- The guess forecasts was generated from a 6-h coupled system
- Assimilation of ¼ degree daily OI SST Analysis

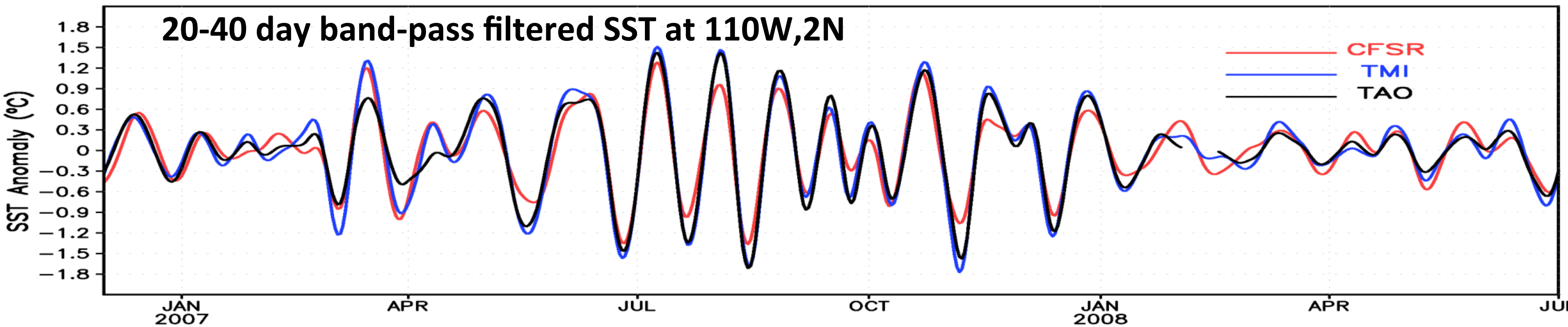
Purpose: Assess capability of the CFSR in capturing ocean-atmosphere interactions associated with TIWs

Data:

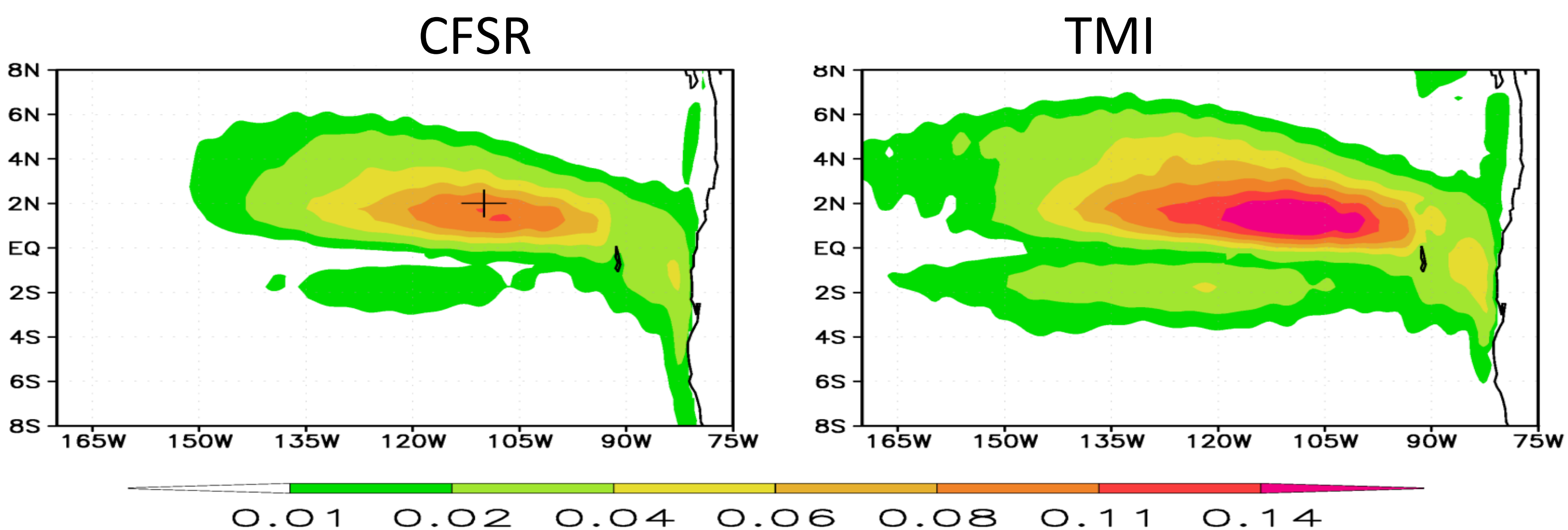
- CFSR : SST, HFLX,τ,P,T2m, WS,q, currents

  Daily data 2001-2008
- Satellite observations: TMI SST and QuikSCAT winds
- In situ: TAO

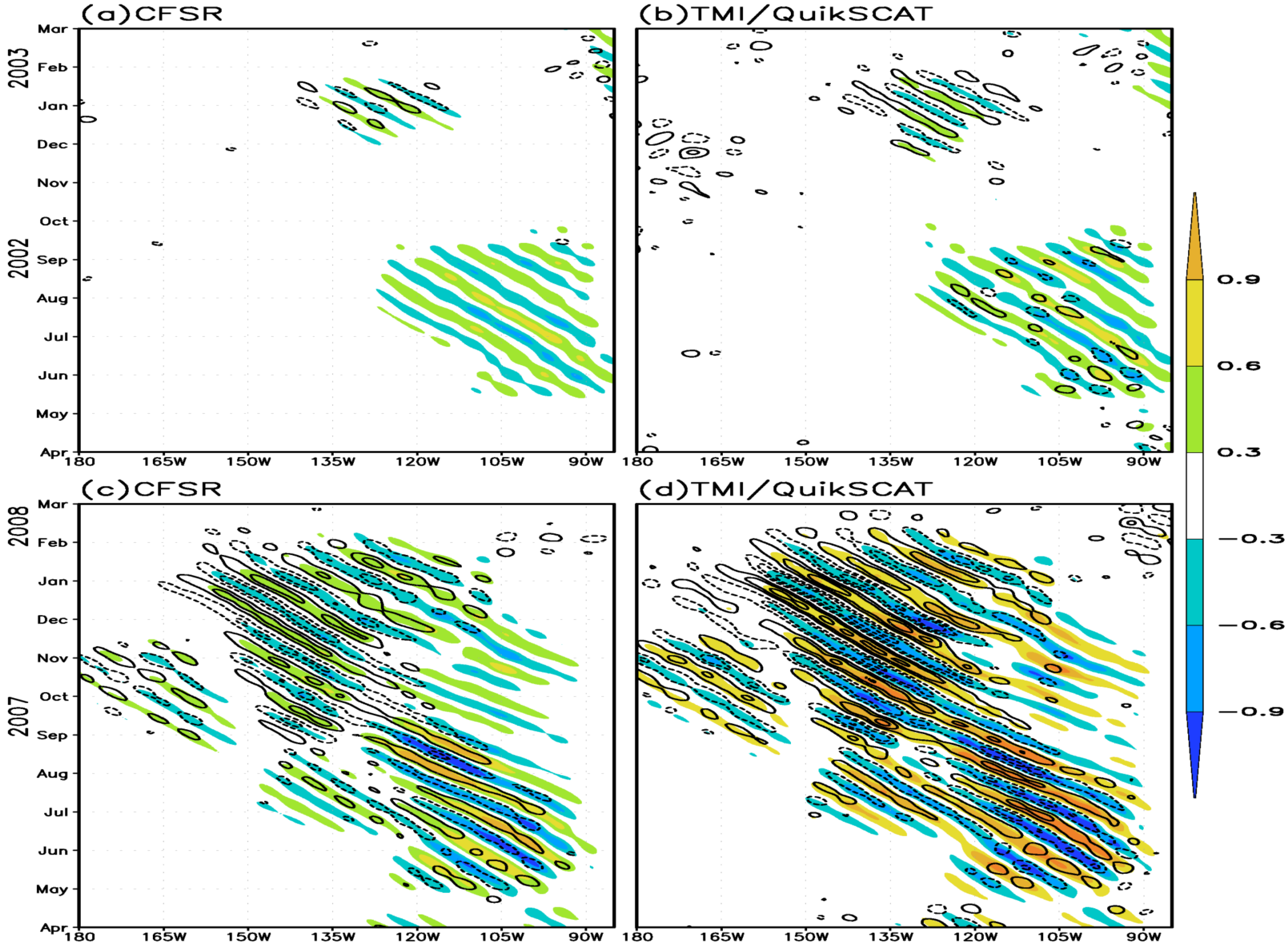




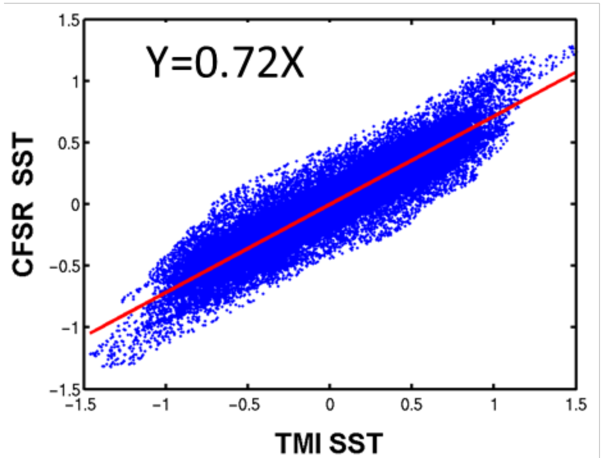
SST TIW Annual Mean Variance

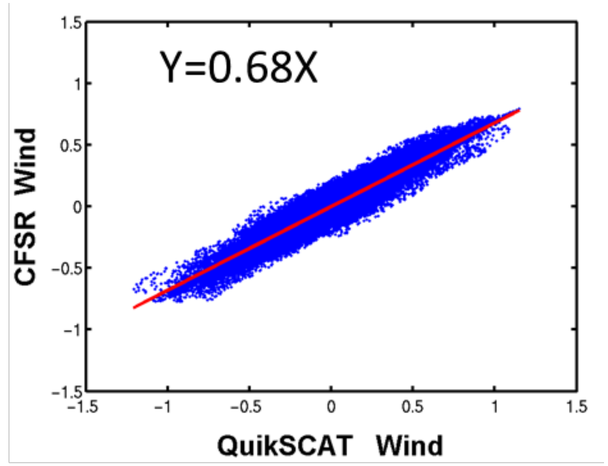


Coupling of SST and Surface Wind



Coupling of SST and Surface Wind



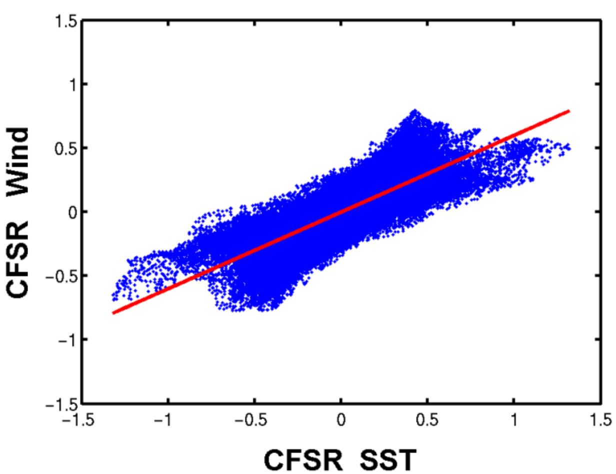


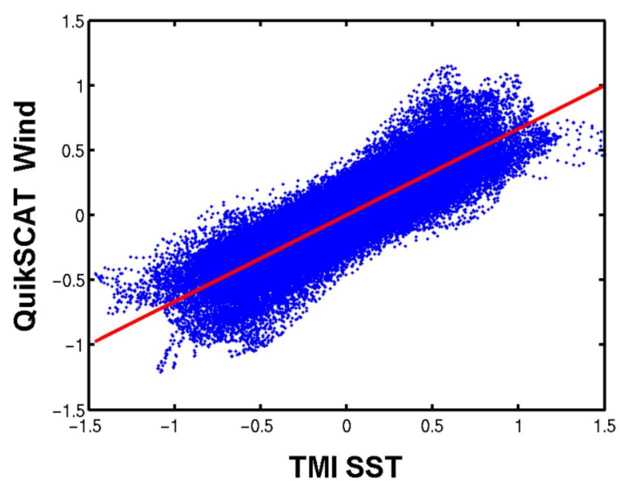
- 150° W – 110° W, 2°N, June-January, 2001-2008
- Both SST and wind perturbations are about 70% of the satellite observations.

Coupling Strength (coefficient ms^{-1} per degree)

CFSR: 0.6

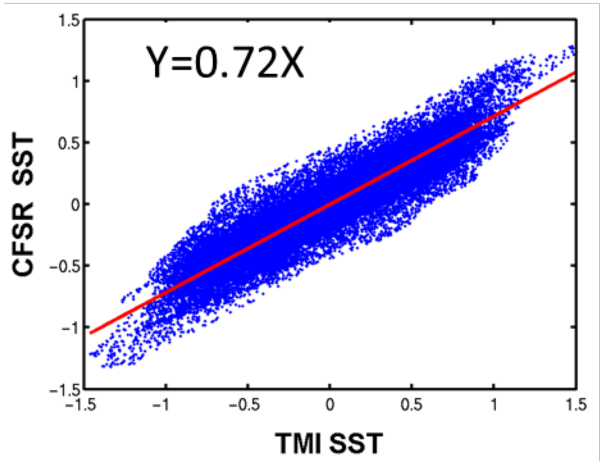
Satellite: 0.66

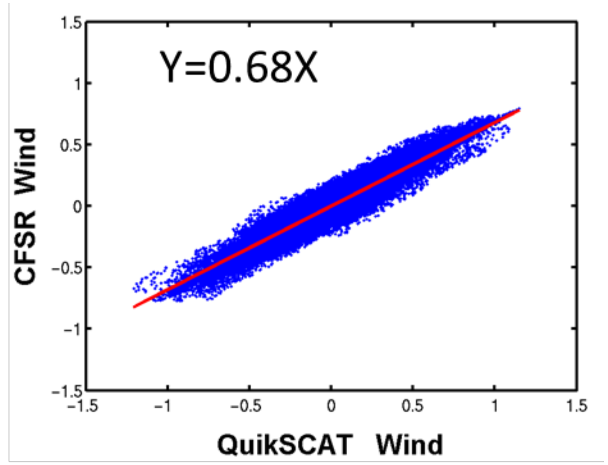




- The CFSR well reproduced the observed linear SST-Wind relationship

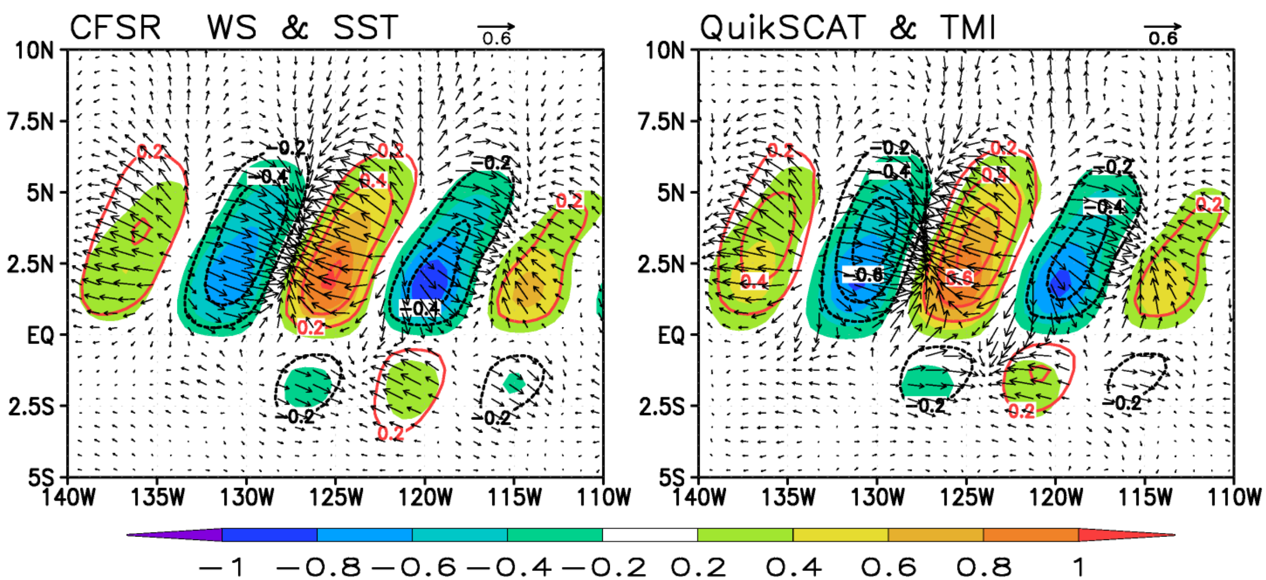
Coupling of SST and Surface Wind





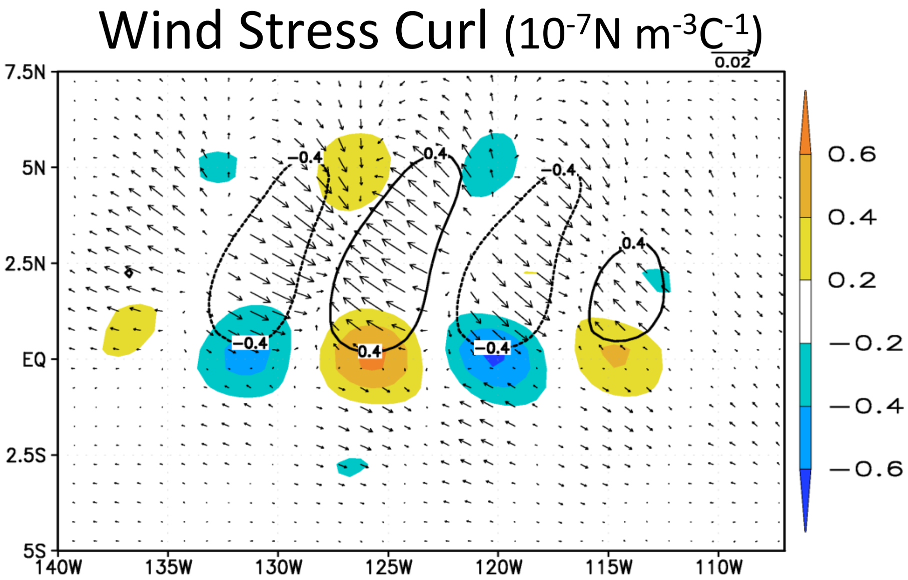
- 150° W – 110° W, 2°N, June-January, 2001-2008
- Both SST and wind perturbations are about 70% of the satellite observations.

Coupling Strength (coefficient ~**0.6** ms^{-1} per degree)



- The CFSR well reproduced the observed linear SST-Wind relationship

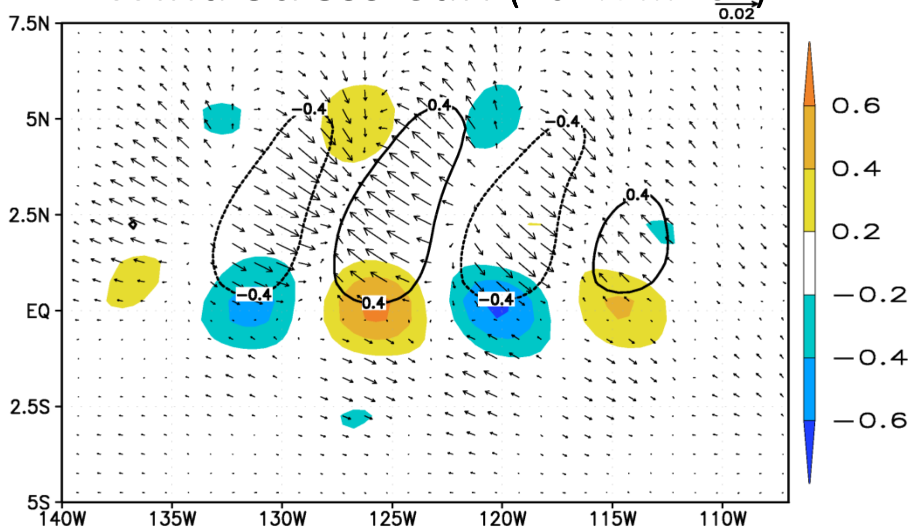
Wind Stress Response and Feedback



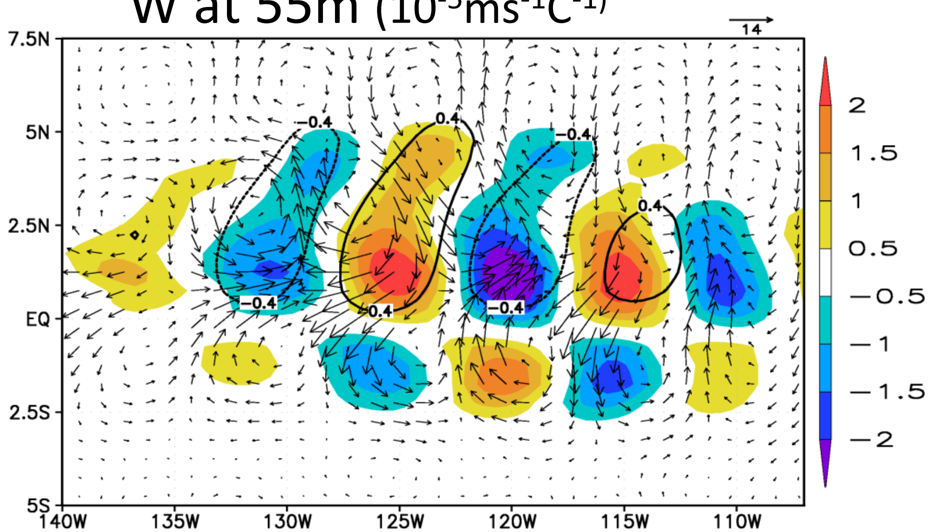
Does the perturbations of wind stress curl feed back to TIW through Ekman dynamics?

Wind Stress Response and Feedback

Wind Stress Curl (10^{-7}N $m^{-3}C^{-1}$)



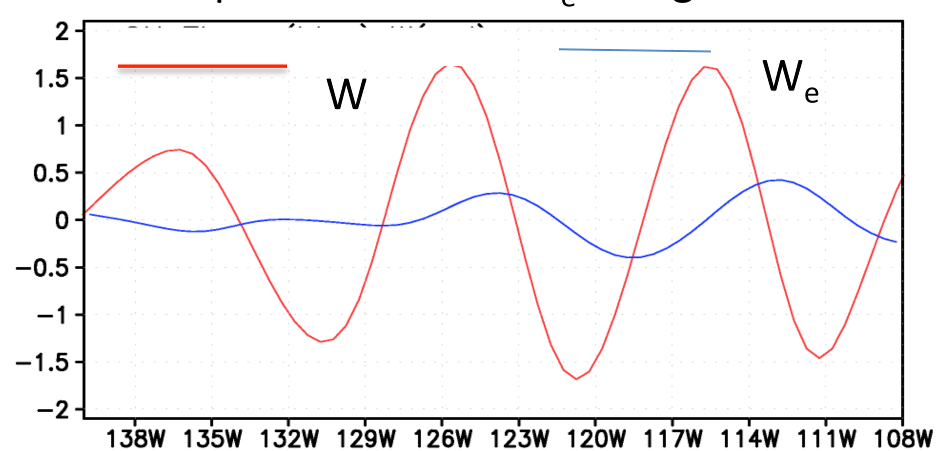
W at 55m ($10^{-5}ms^{-1}C^{-1}$)



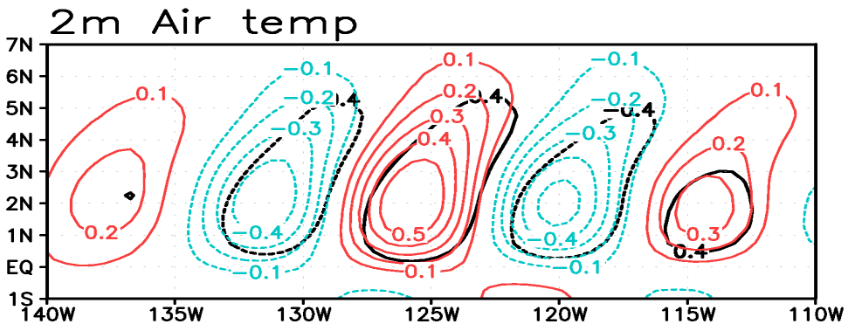
Does the perturbations of wind stress curl feed back to TIW through Ekman dynamics?

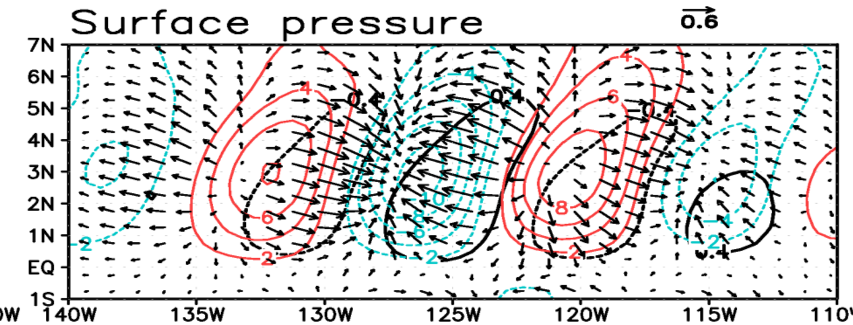
- **W_e is much weaker than W, indicating the small feedback effect on TIW growth**
- **Caveat: (1) Difficult to estimate Ekman pumping near the equator; (2) Impact of surface current on wind stress is neglect in the CFSR**

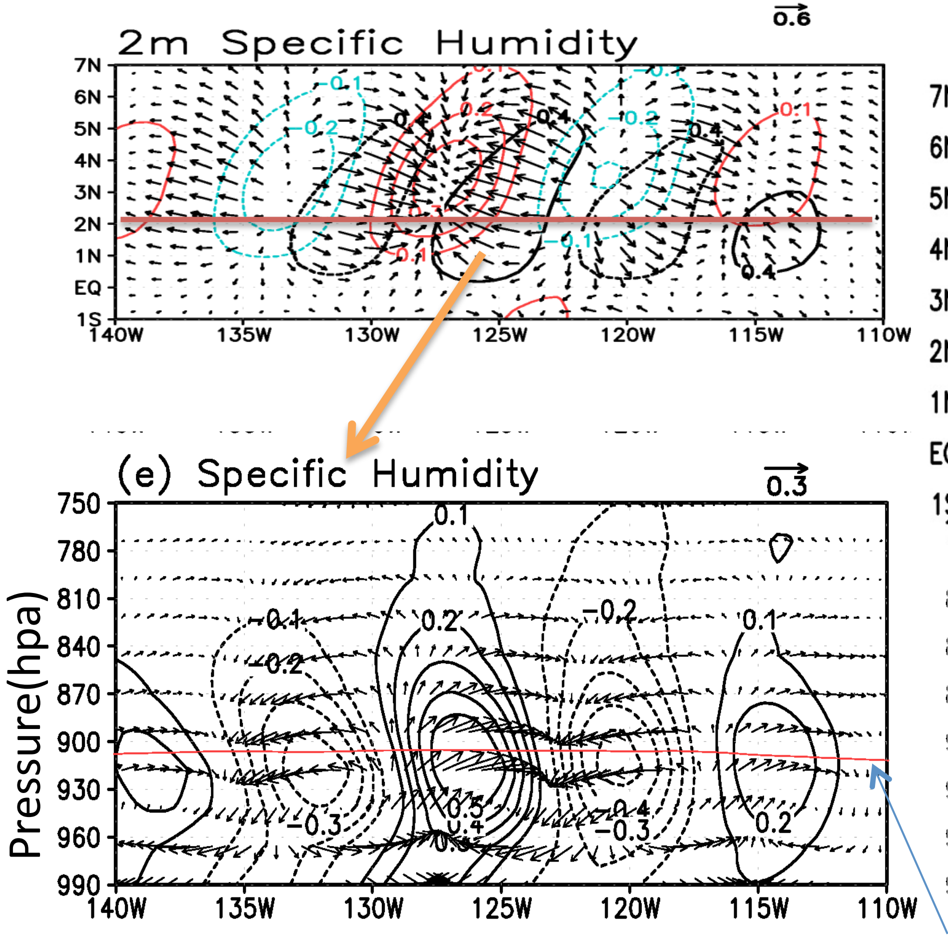
Comparison of W & W_e along 2N

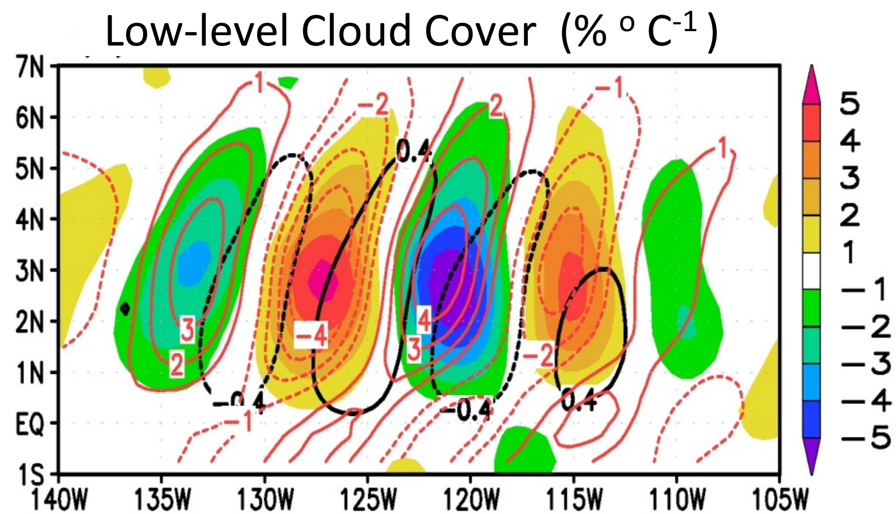


3-D Atmosphere Response



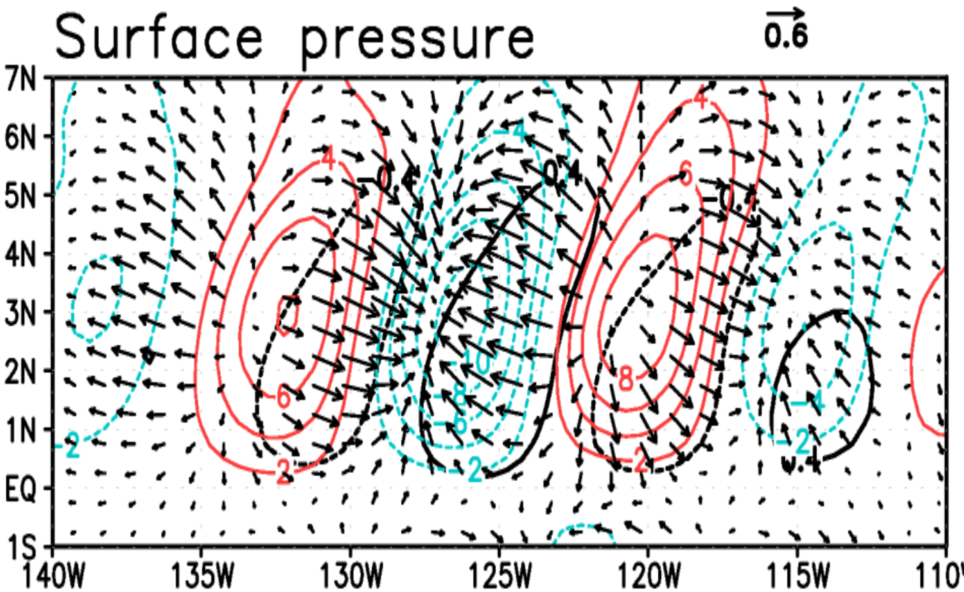




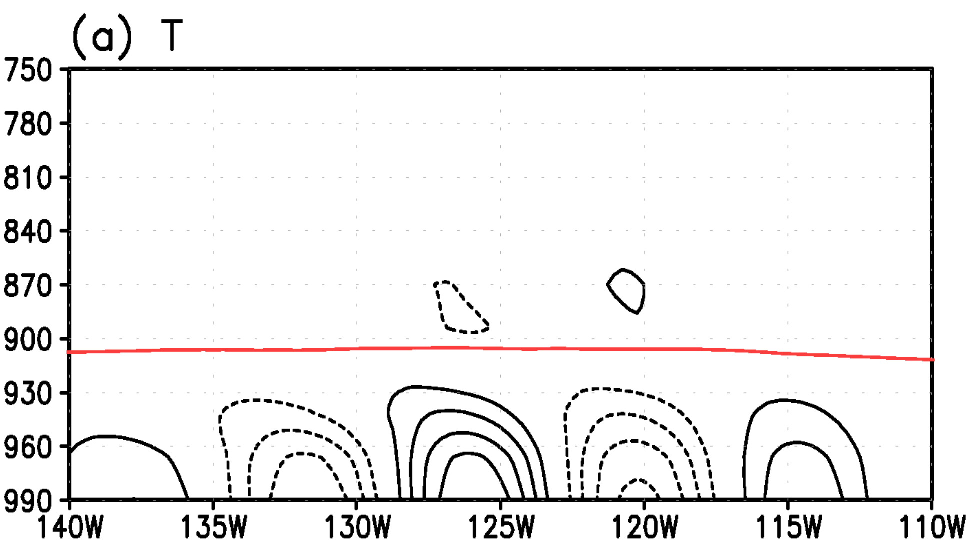


Consistency among different levels in the CFSR

Uncertainties in Atmosphere Response



CFSR: ~ 10 Pa $^{o}C^{-1}$
TAO: ~ 10 Pa$^{o}C^{-1}$ (Cronin et al. 2003)
Radiosonde : little TIW signal (Hashizume et al. 2002)

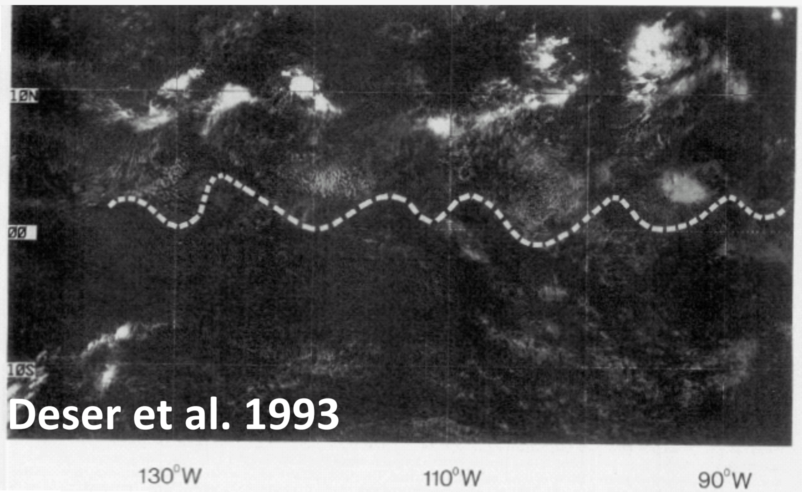


CFSR: Mainly confined in the PBL
Radiosonde: Strong temperature inversion (Hashizume et al. 2002)

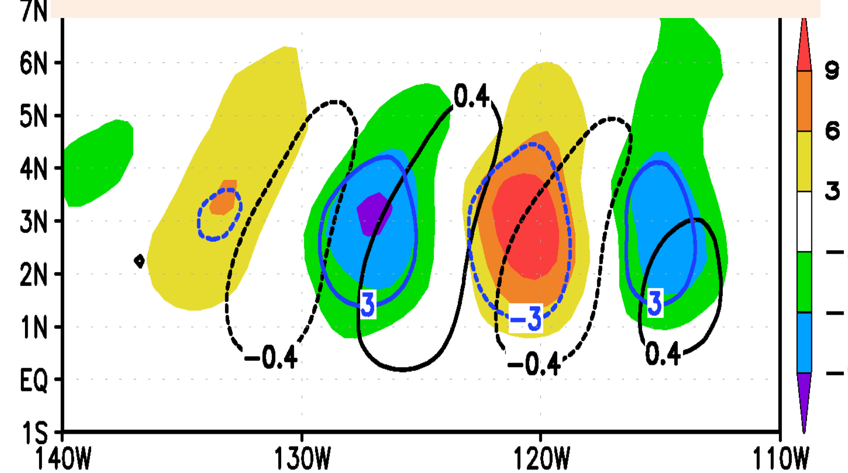
Response and Feedback of Surface Heat Flux

Solar heat flux and SST

Satellite Visible Cloud and SST



CFSR SW & Low-level Cloud Cover



Deser et al.(1993) :

- 4.2% per degree
- Over and upstream of positive SST anomalies
- Change in solar radiation of ~ 10 W/m^2 per degree
- Damping of local SST

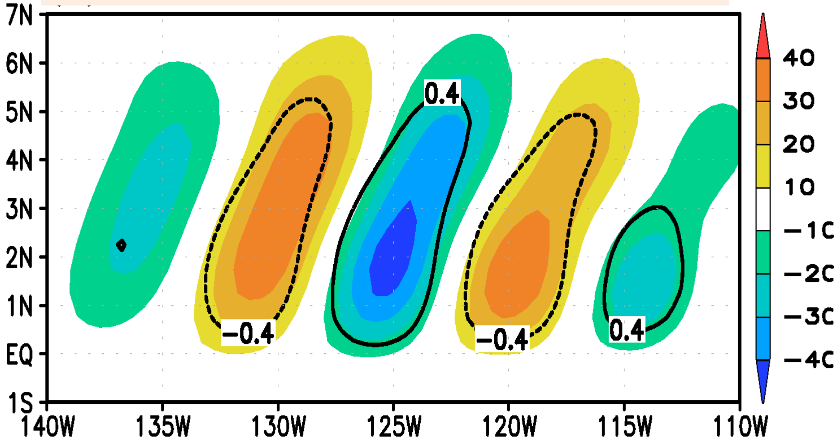
CFSR:

- 5% per degree
- Down stream of positive SST anomalies
- Change in solar radiation of ~9W/m^2 per degree
- Damping of local SST

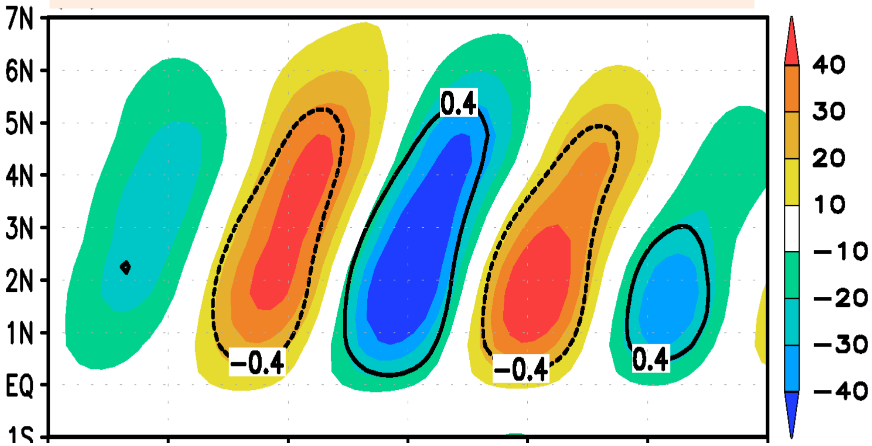
Response and Feedback of Surface Heat Flux

Latent heat flux and SST

Latent Heat Flux



Net Heat Flux



CFSR :

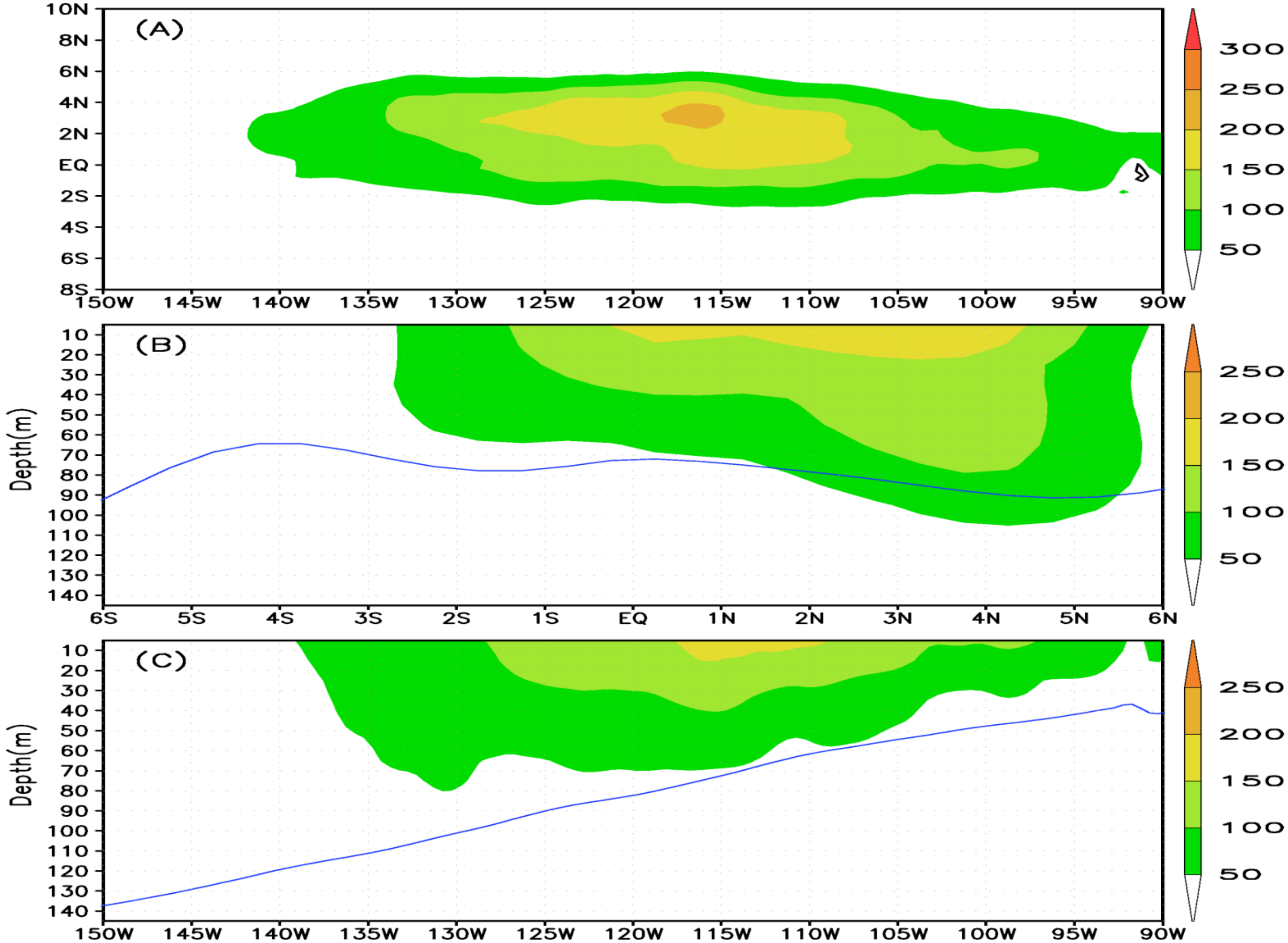
- 25 W/m^2 per ^{o}C of latent heat flux
- 40 W/m^2 per ^{o}C of net heat flux, resulting in -0.5 ^{o} C per month (MLD=50m)

- Zhang and McPhaden(1995): ~ 50 W/m^2 per ^{o}C of latent heat flux
- Thum et al. (2002): ~ 40 W/m^2 per ^{o}C of latent heat flux, resulting -0.5^o C per month (MLD=50m)

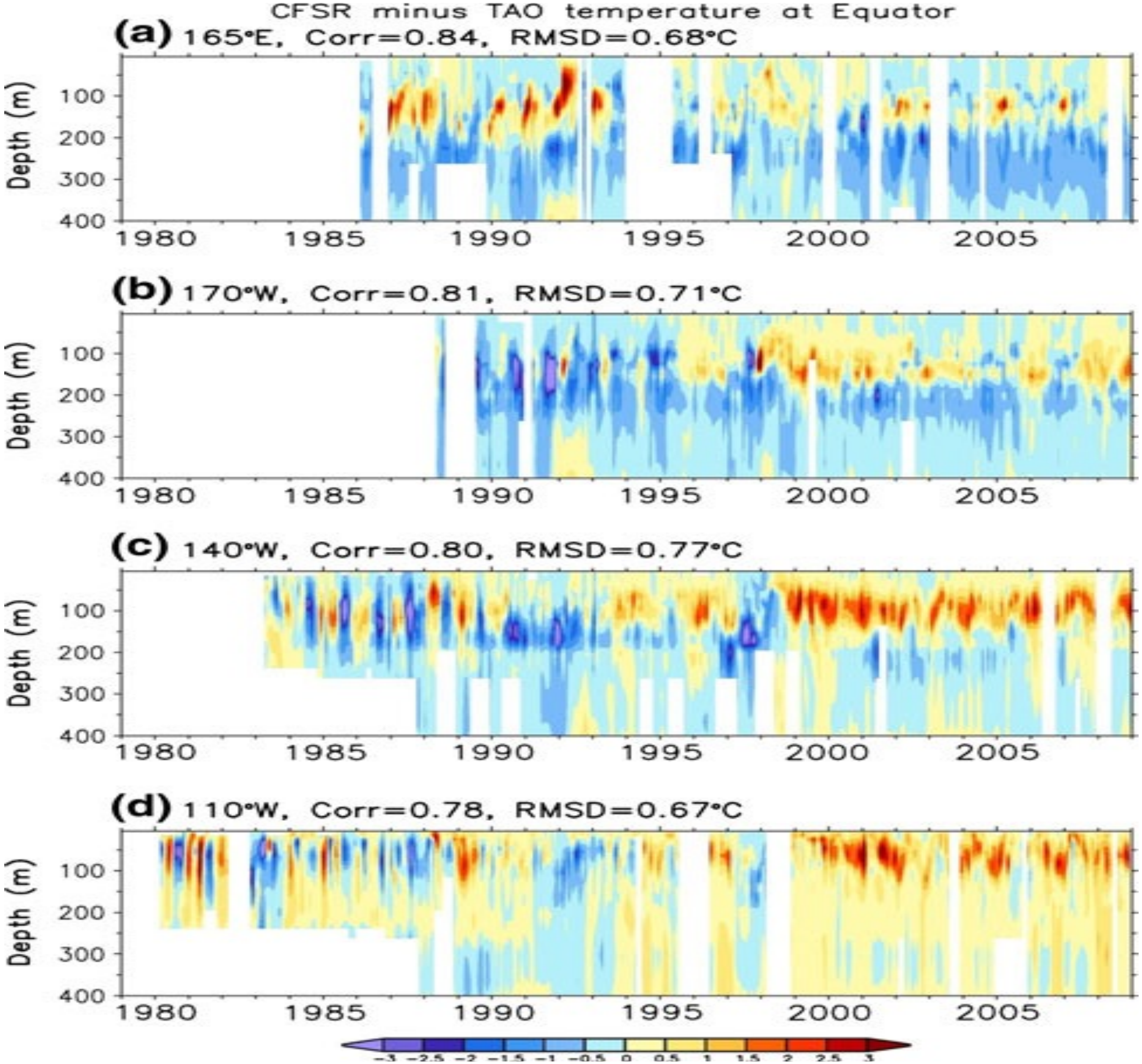
Summary

- An in-phase relationship between SST and surface wind was well represented in the CFSR;
- The CFSR exhibits coherent patterns associated with TIWs both in the ocean and the atmosphere ;
- The feedback of wind stress curl perturbation to TIWs is negligible;
- Uncertainties exist in surface pressure and vertical structure;
- Surface net heat flux are dominated by latent heat fluxes and have a large negative feedback to TIW SSTs variability.

Wen, C., Y. Xue and A. Kumar,2012: Ocean–atmosphere characteristics of tropical instability waves simulated in the NCEP climate forecast system reanaylsis, J. Climate. doi:10.1175/JCLI-D-11-00477.1, In press(available online).



Annual mean (2001-2008) of (a) EKE (cm2 s-2) at 5m; (b) EKE (cm2 s-2) at 110o W; (c) EKE (cm2 s-2) along 0oN. In (b) and (c), blue line presents the annual mean 20oC isotherm depth.



Yan et al. 2011