# Depiction of Tropical Instability Waves in the NCEP Climate Forecast System Reanalysis

Caihong Wen, Yan Xue and Arun Kumar
Climate prediction Center, NCEP/NWS/NOAA, Maryland, U.S.A
Caihong.wen@noaa.gov

## Introduction

Satellite observation provide an unprecedented view of mesoscale oceanic eddies and their interactions with the atmosphere over the global ocean(Chelton et al.2004; Xie 2004). One of the most notable forms of such small-scale ocean-atmosphere interactions is Tropical Instability Waves(TIWs). TIWs are manifested as westward-propagating wavelike oscillations near the SST fronts in the equatorial cold tongues. Satellite observations reveal SST perturbations are highly coherent in space with variations in surface wind.

The NCEP Climate Forecast System Reanalysis (CFSR) represents a new reanalysis effort with first guess from a high-resolution coupled system, offering prospects for improved simulation of small-scale features. ***The objectives of this analysis are to assess the characteristics of the equatorial Pacific TIWs simulated in the CFSR and how well they agree with in situ and satellite observations, with the aim to inform the user community about the feasibility of CFSR as an analysis and monitoring tool for TIWs.***

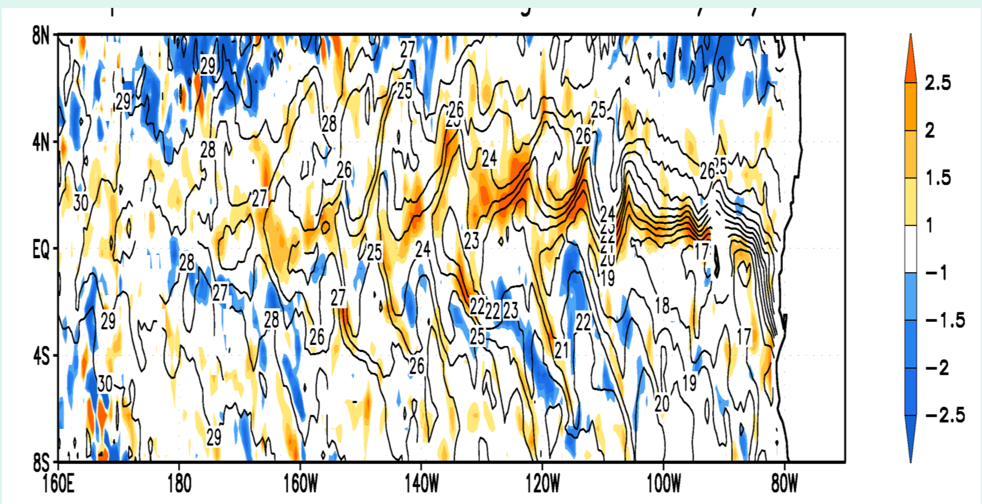


Figure Snapshot of wind divergence (shaded) from QuikSCAT winds and SST from the TMI SST (contour) on 1st Oct 2007.

## Model and DATA Validation

### CFSR

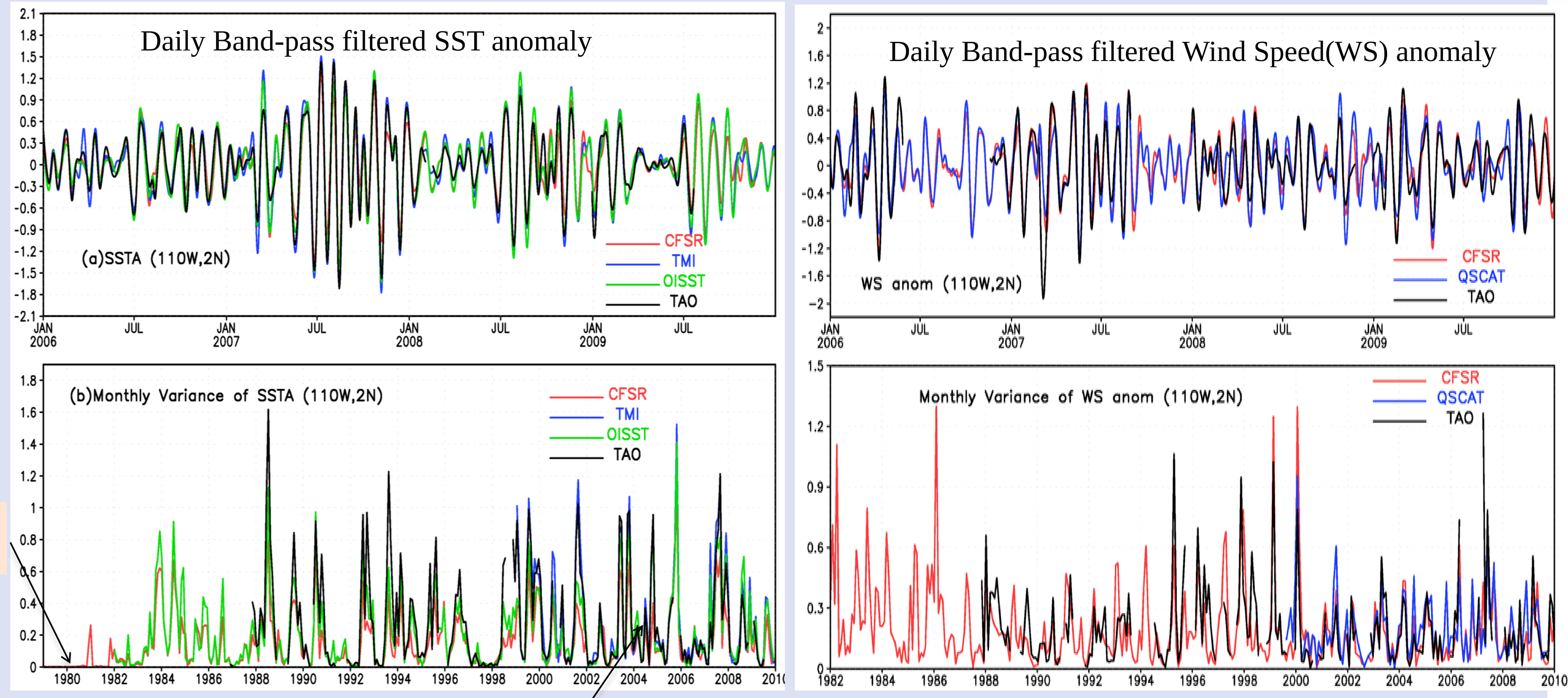
- Atmosphere model :Operational NCEP Global Forecast System (GFS);
- Ocean model: GFDL MOM4 Ocean model with an interactive sea – ice;
- Land model: Operational Noah Land Model;
- 3D-Var data assimilation scheme;
- 6-hour coupled model forecast as the first guess field;
- SST nudged to daily quarter degree OI SST;
- High spatial and temporal resolution (available at hourly resolution and 0.5° x0.5° grid);
- 31-yr period (1979-2009) daily fields

| | SST(° C) | | | | | | $WS_{10}$(m/s) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 40°W,2° N | | 125° W,2° N | | 110°W,2° N | | 140°W,2° N | | 125°W,2° N | | 110°W,2° N | |
| | CFSR | TMI | CFSR | TMI | CFSR | TMI | CFSR | Quik SCAT | CFSR | Quik SCAT | CFSR | Quik SCAT |
| ACC | 0.93 | 0.97 | 0.9 | 0.92 | 0.91 | 0.97 | 0.91 | 0.89 | 0.9 | 0.87 | 0.86 | 0.82 |
| RMS | 0.12 | 0.08 | 0.18 | 0.21 | 0.21 | 0.13 | 0.20 | 0.23 | 0.2 | 0.23 | 0.23 | 0.26 |
| (STD,°C) | (0.3) | (0.3) | (0.39) | (0.39) | (0.5) | (0.5) | (0.48) | (0.48) | (0.46) | (0.46) | (0.44) | (0.44) |
| ARC | 0.74 | 1.04 | 0.73 | 1 | 0.76 | 1.02 | 0.85 | 0.94 | 0.80 | 0.86 | 0.85 | 0.86 |

Table 1. comparisons of SST and wind speed between the CFSR and TAO, and between TMI/QuikSCAT and TAO during 2001-2008. Time series of each data set are daily band-pass filtered at 20-40 day. Where ACC is anomaly correlation coefficient, RMS is anomaly root mean square error, ARC is anomaly regression coefficient with respect to TAO measurements. STD is standard deviation of TAO anomalies.

### Validation Data

- In situ :TAO SST and 10-m wind (http://www.pmel.noaa.gov/tao/data_deliv/deliv.html)
- Satellite: TMI SST and QuikSCAT wind (https://www.ssmi.com)
- SST analysis: Version 2 daily OISST (Reynolds et al. 2007)




## TIW Characteristics

### (1) Interannual variation

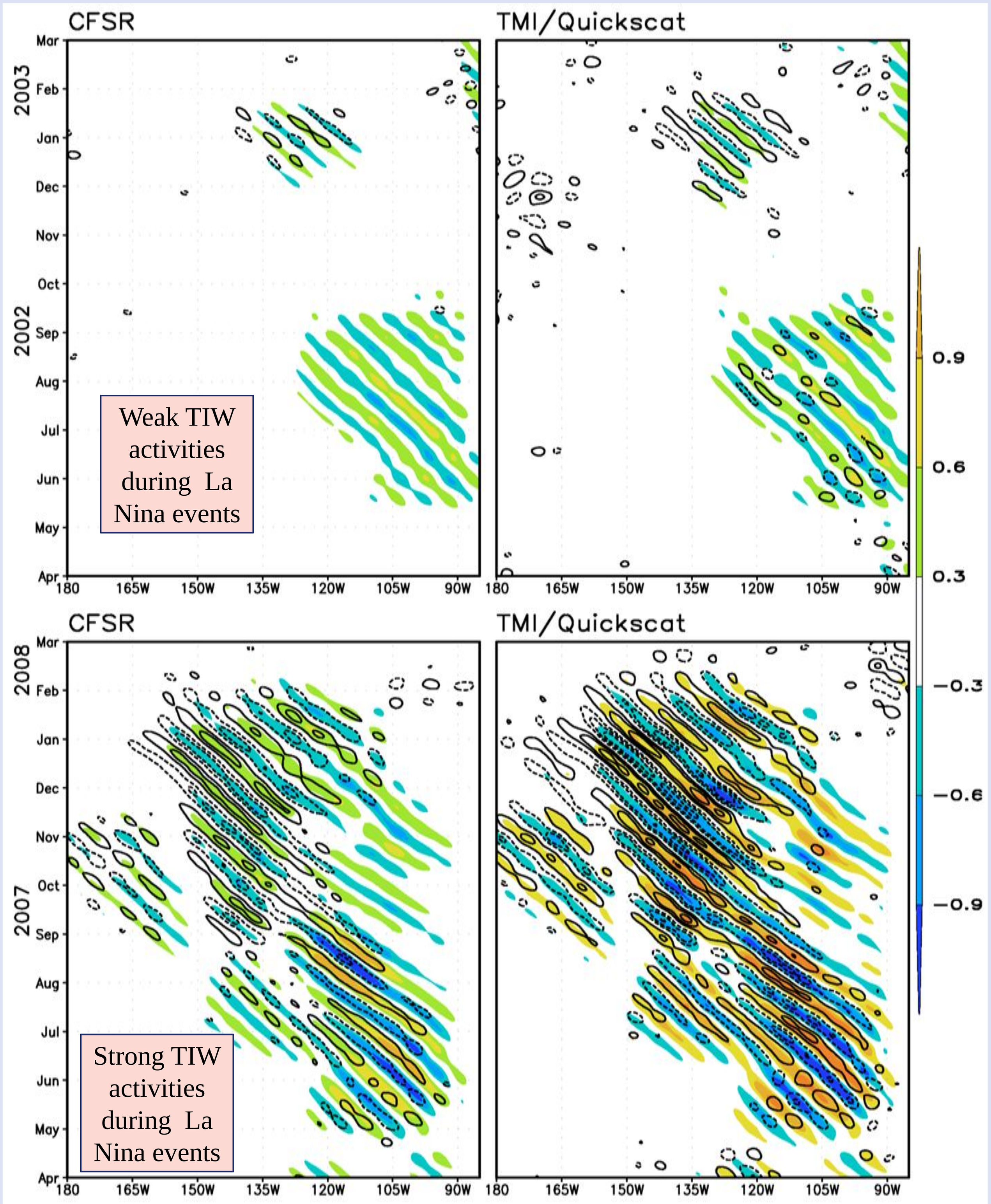
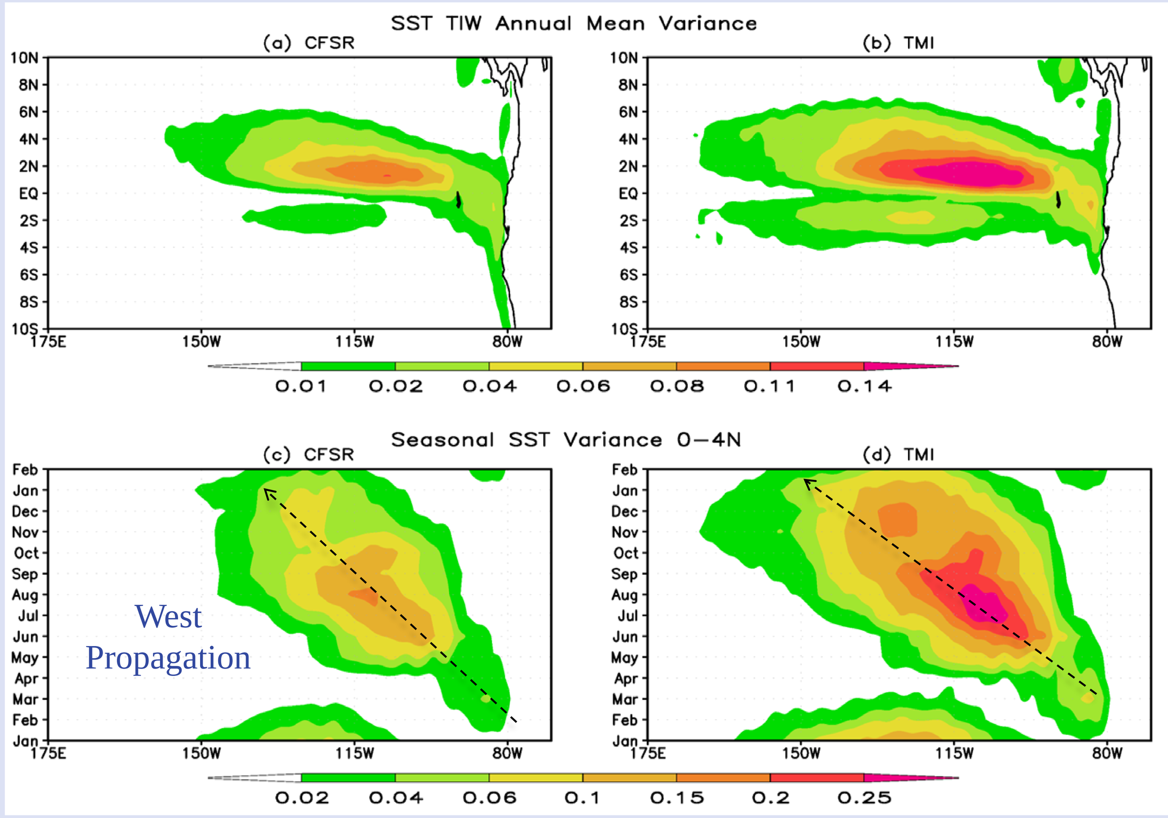



Figure SST anomaly (shaded, °C) and 10-m Wind Speed anomaly (contour, m/s) along 2° N. Variables were band-pass filtered at a period 20-40 day and wavelength 890-2200 km to highlight TIW-related variability.

### (2) Seasonal variation




### (3) SST and Atmospheric Covariability

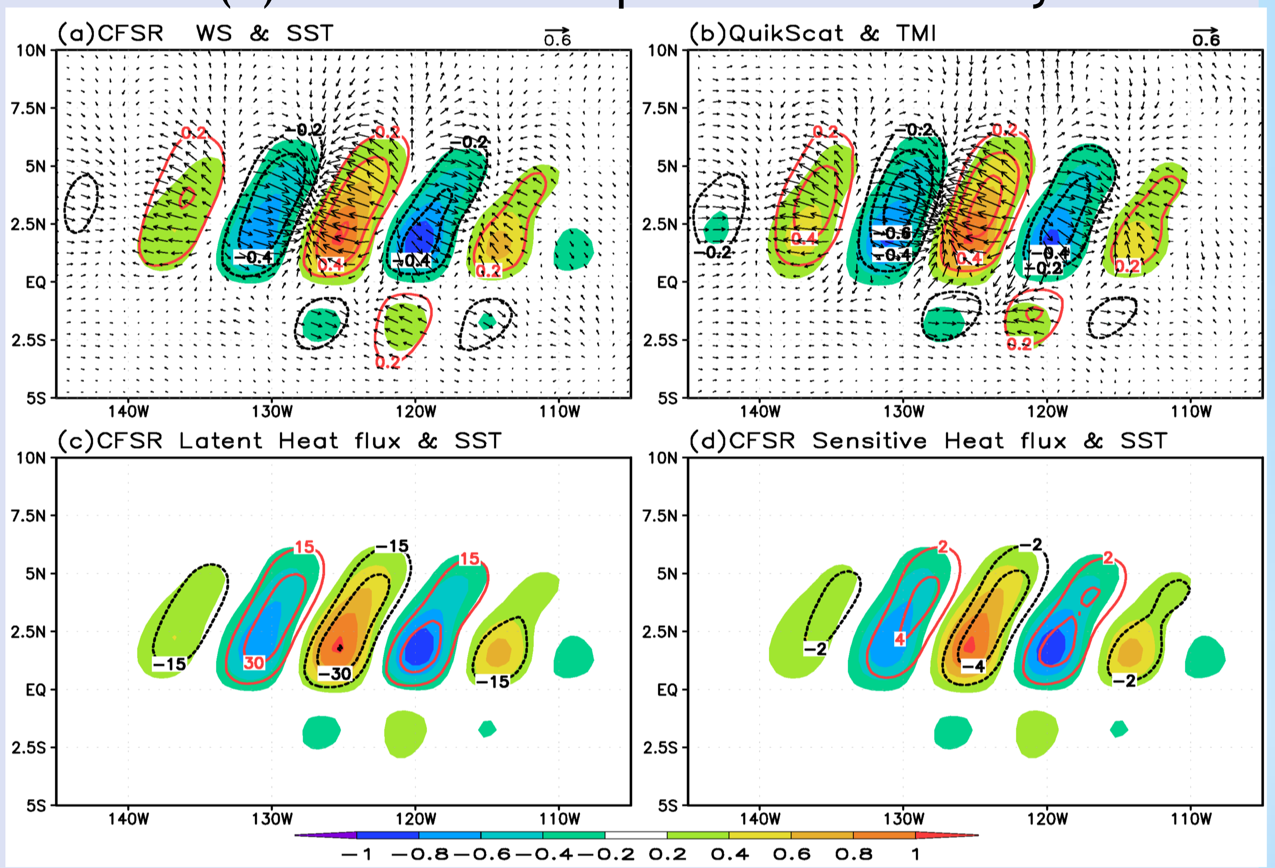



Figure Regression of filtered atmospheric variables on filtered SST anomalies at at 125° W, 2° N during active TIWs seasons (Jun-Jan) computed over 2001 to 2008 period.

## Summary

1. On subseasonal time scale of about 20-40 day, temporal variations of SST and wind anomalies are accurately replicated in the CFSR, although magnitudes are underestimated by about 25% with respect to in situ data.
2. Coupling strength measured by the wind response per unit SST anomaly is remarkable similar between the CFSR and Satellite observations.
3. TIW-induced SST variations exhibit pronounced seasonal and interannual variability which are tightly connected with cold tongue variations.
4. A remarkable in-phase relationship between SST and wind speed is represented in the CFSR as well as in TMI SST/QuikScat wind.
5. SST-wind coupling results in evaporative and sensible cooling over warm SST perturbations, indicating a negative thermal feedback.

References:

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Chelton, D. B., M. G. Schlax, M. H. Freilich, and R. F. Milliff, 2004: Satellite measurements reveal persistent small-scale features in ocean winds. Science, 303, 978.
Xie, S. P., 2004: Satellite observations of cool ocean-atmosphere interaction. Bulletin of the American Meteorological Society, 85, 195-208.