

Intensification of multi-decadal sea level variability in the western tropical Pacific during recent decades

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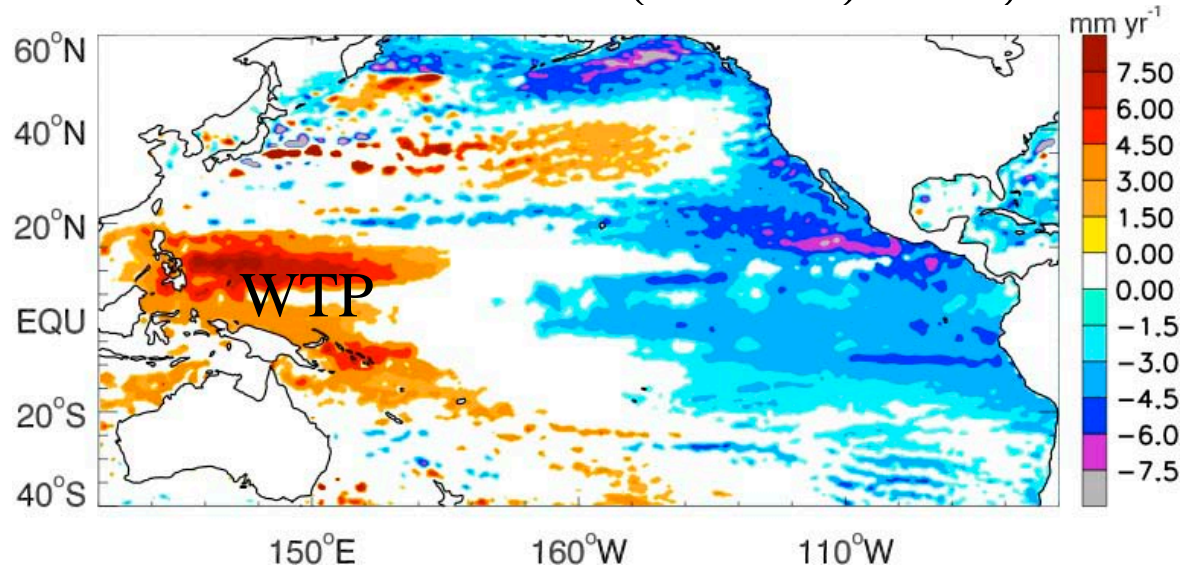
In collaboration with:

G.A. Meehl, A. Hu, M.A. Alexander, T. Yamagata, D. Yuan, M. Ishii, P. Pegion, J. Zheng, B. Hamlington, X.-W. Quan, and R. Leben

June 18, 2013 CESM workshop, Breckenridge, Colorado

1. Background

Linear trend of satellite (AVISO) SSH, 1993-2010



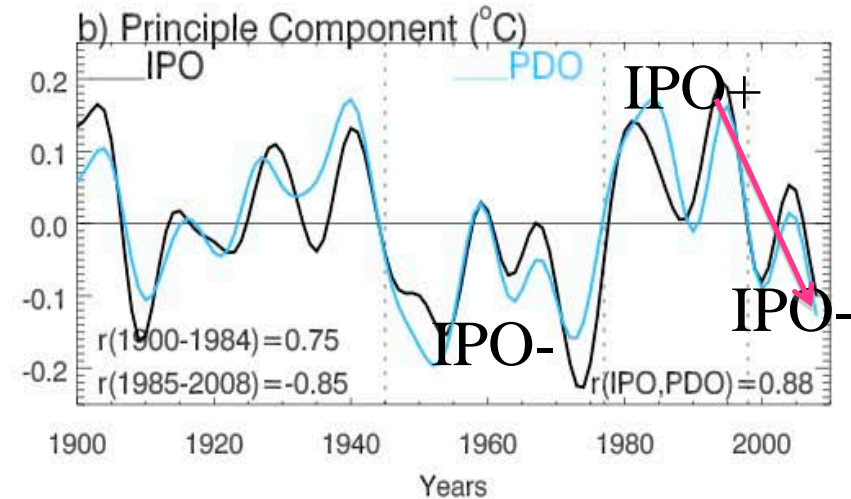
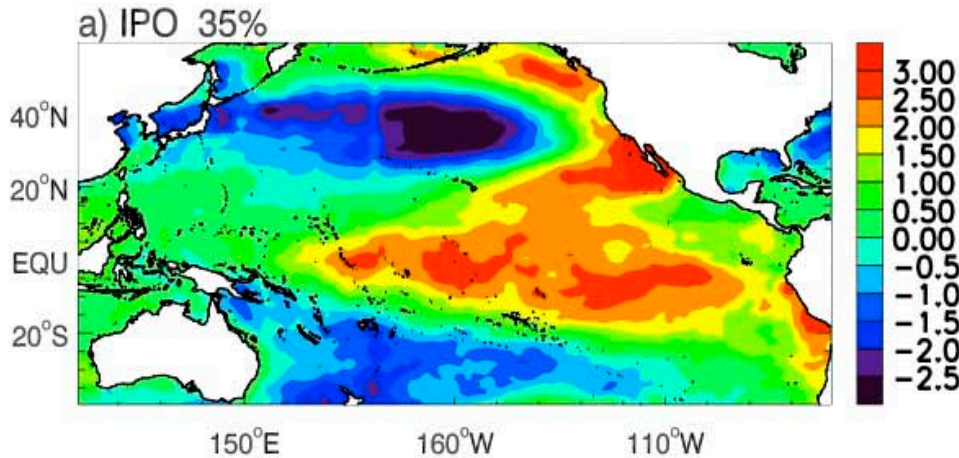
Global mean sea level rise (SLR) removed

Recent studies:

WTP sea level variability is highly correlated with the indices of PDO, IPO & ENSO

(Merrifield 2011, Merrifield et al. 2011, 2012; Zhang&Church 2012, Meyssignac et al. 2012)

EOF1 of 8-yr lowpassed HadISST: The IPO



Issues:

The IPO transition from 1993-2010 is not stronger than those of preceding decades, as will be shown next, whereas the WTP sea level rise is markedly intensified.

Goal:

Explain the causes for the intensified WTP SLR since the 1990s

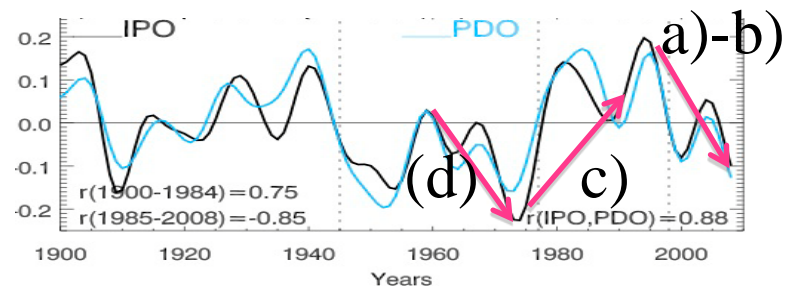
2. Approach

Combine observational analyses with model experiments

- *Sea level, surface winds & SST (observed & reanalysis products);*
- *Perform a wind-driven Linear Ocean Model (LOM) experiment;*
- *Perform idealized AGCM experiments using NSIPP (NASA Seasonal-to-Interannual Prediction Project) model with idealized SST;*
- *Analyzed the Results from CAM3&CAM4 GOGA & TOGA experiments (NCAR Clim. Var. working group)*

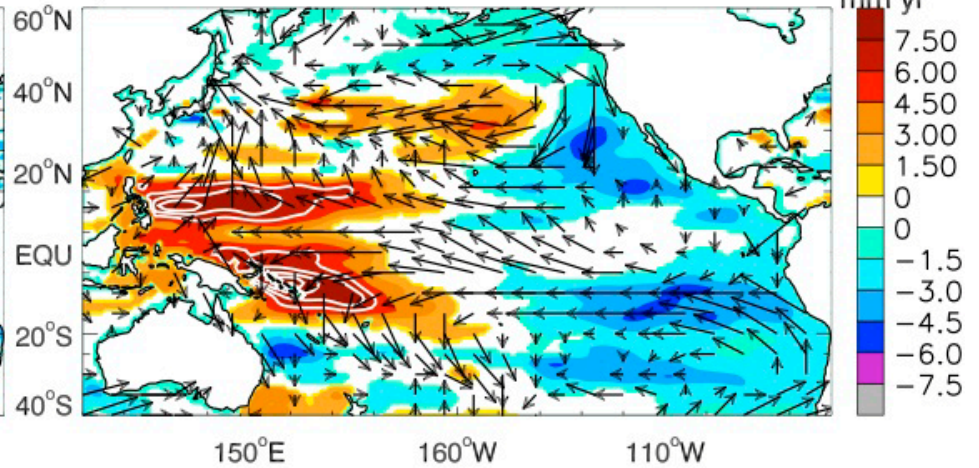
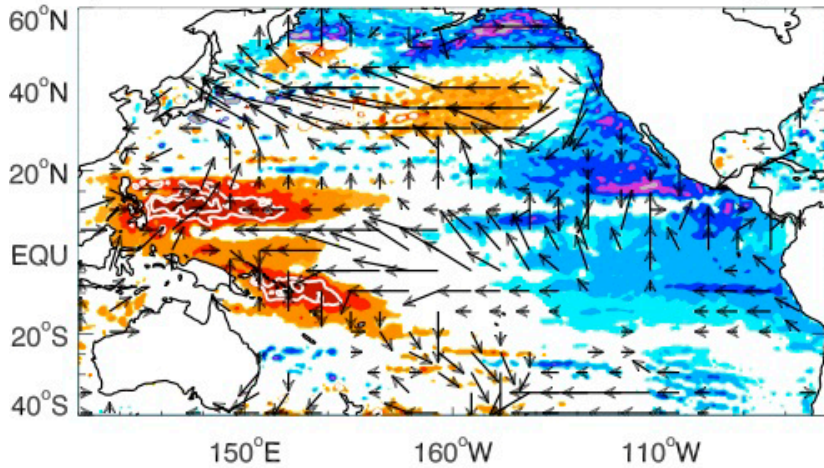
3. Results

93-08: -0.014C/yr
59-75: -0.014C/yr
93-09: 5.2mm/yr
59-75: 2.0mm/yr

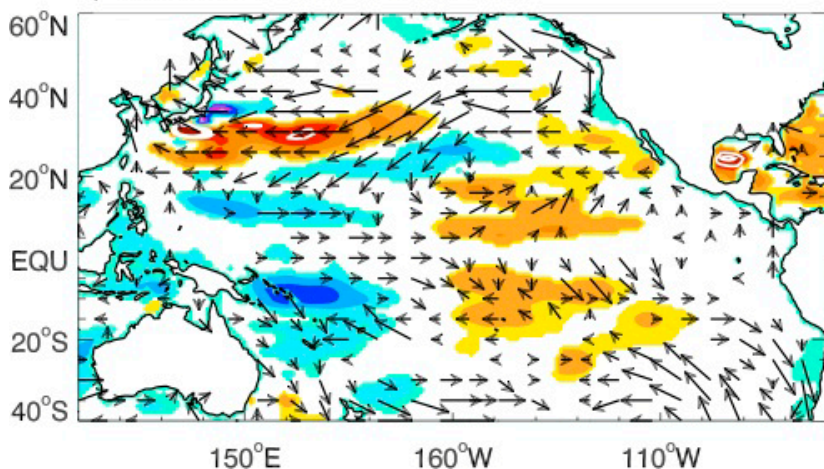


Intensified WTP SLR since 1993

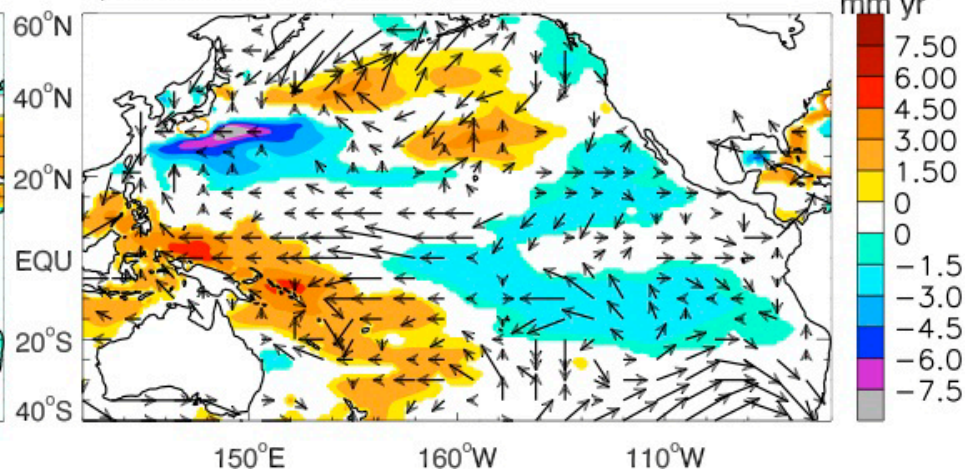
a) AVISO SSH & CCMP wind, 93-09 $1.0 \text{ m}^2\text{s}^{-2}\text{yr}^{-1}$ → b) Thermo.SL & ORA wind, 93-09



c) Thermo.SL & ORA wind, 76-92

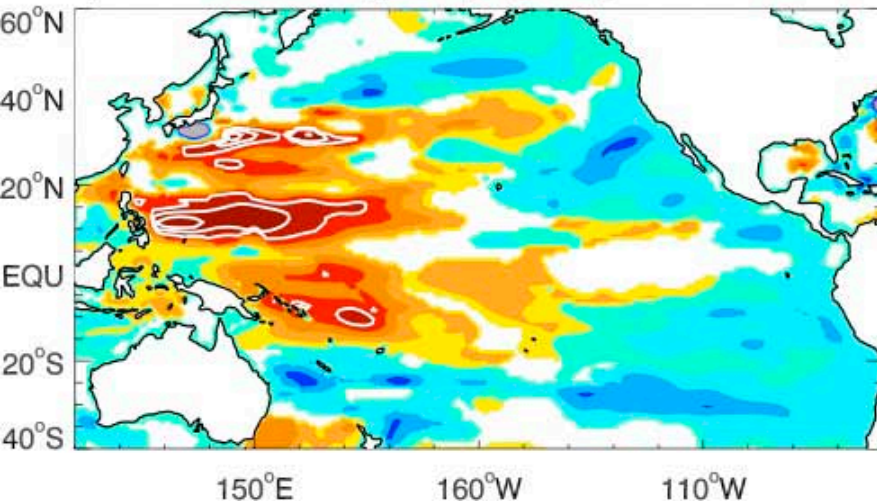


d) Thermo.SL & ORA wind, 59-75

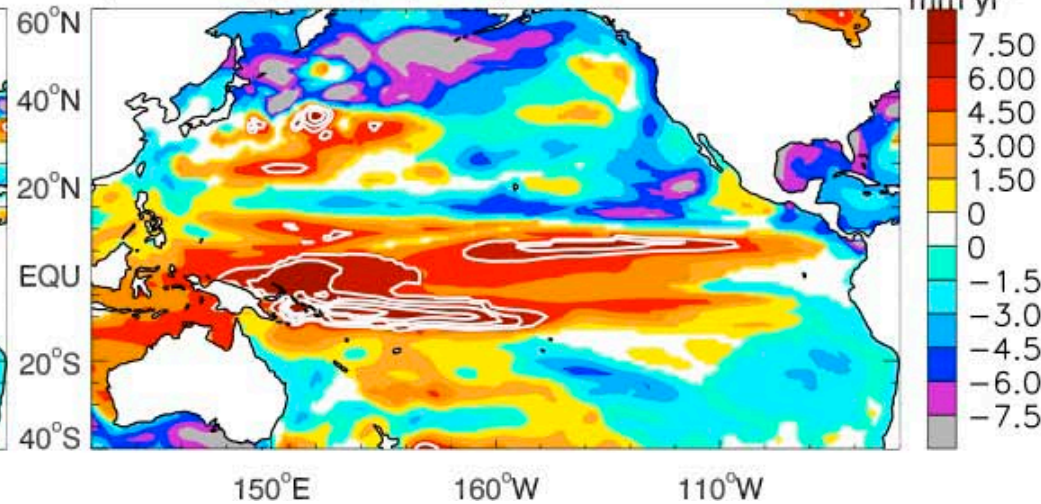


SLA difference: (93~09) – (59~75)

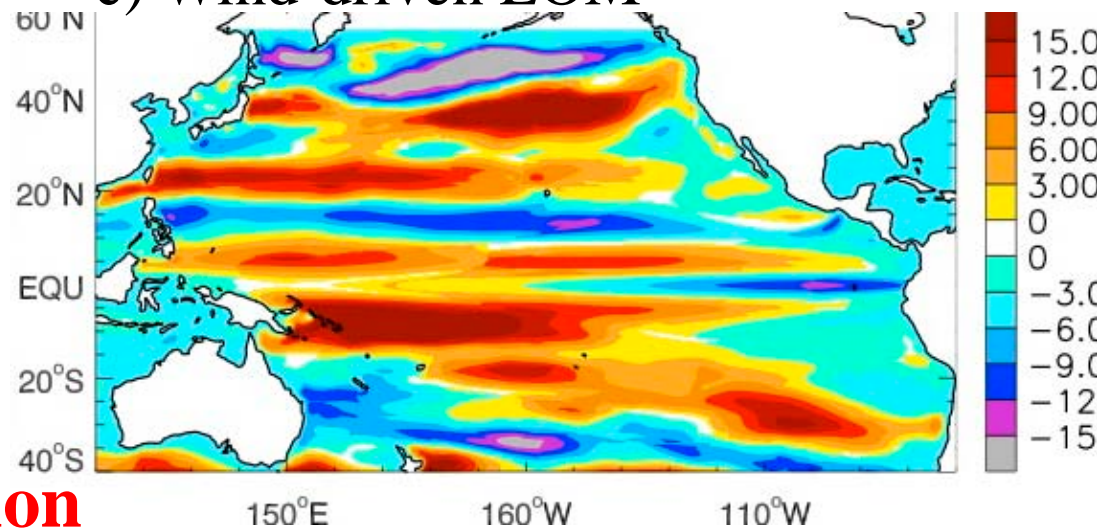
a) Thermo.SL trend, (93-09) - (59-75)



b) ORA-S3, (93-09) - (59-75)



c) Wind-driven LOM

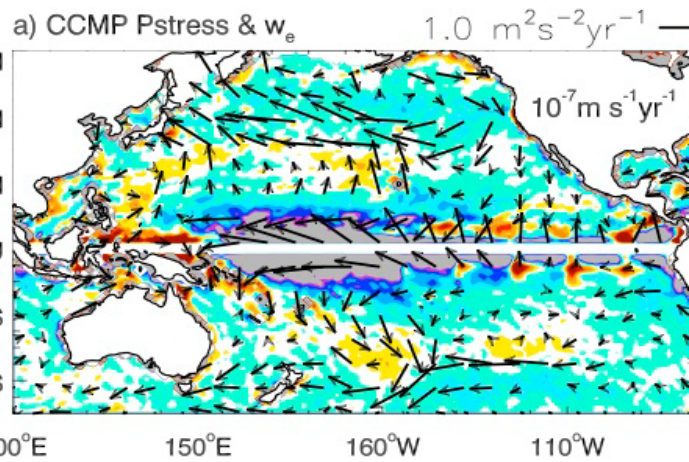


Similar WTP SLA
intensification: different
reconstructed sea level
data [Hamlington et al (2011);
Meysignac et al. (2012)]

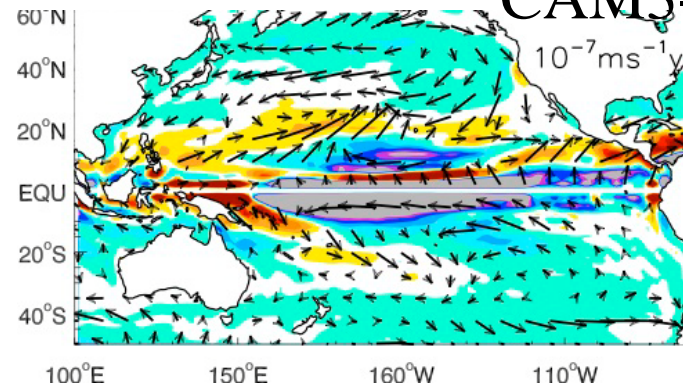
**Robust WTP intensification
of SL variability since the 1990s!**

Surface wind stress & Ekman pumping velocity: 93-09 linear trend

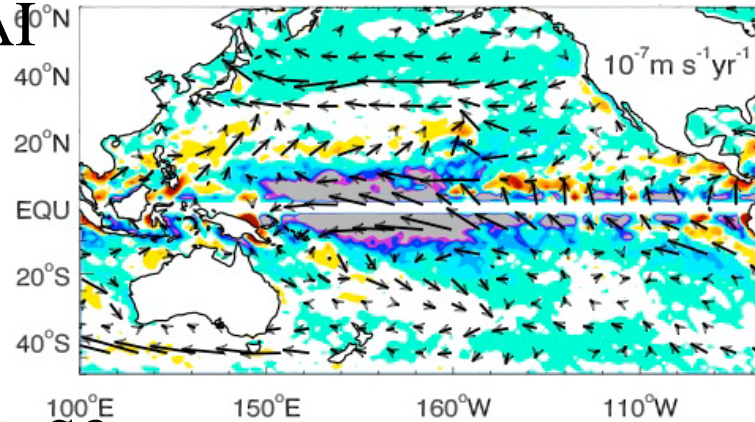
CCMP



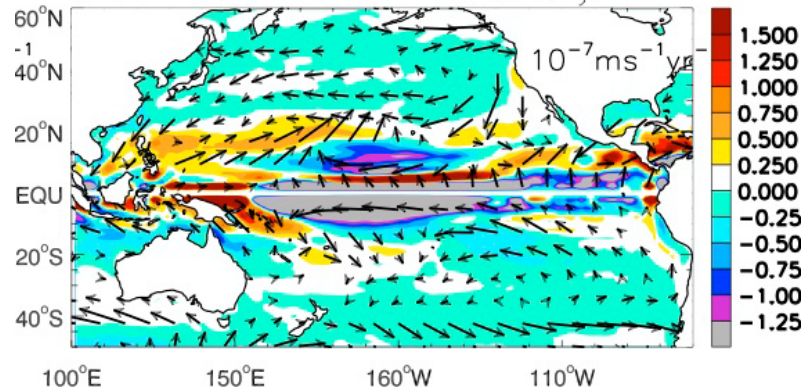
CAM3-GOGA



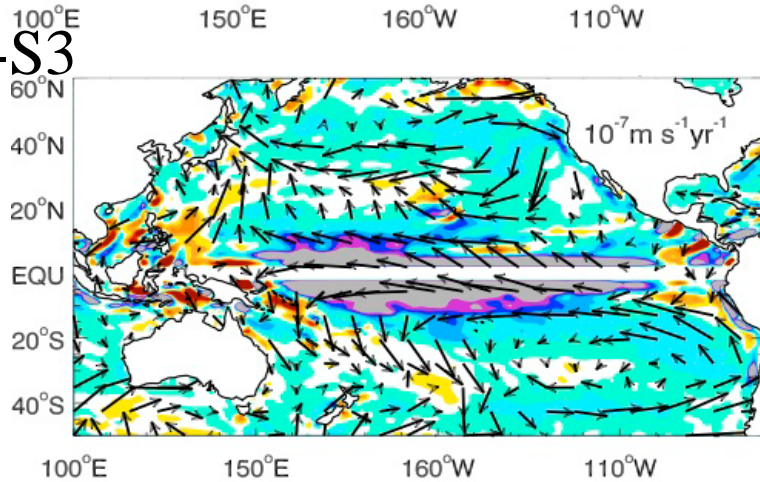
ERA-Interim



CMA3-TOGA



ORA-S3

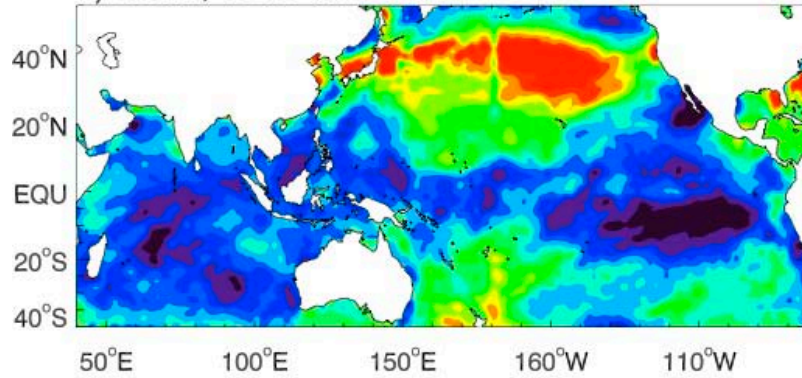


Sutton & Hadson (2005): AMO has little effect on Tropical Indo-Pac SST;

Kushnir et al. (2010): Tropical Atl. SST: little influence on WTP wind

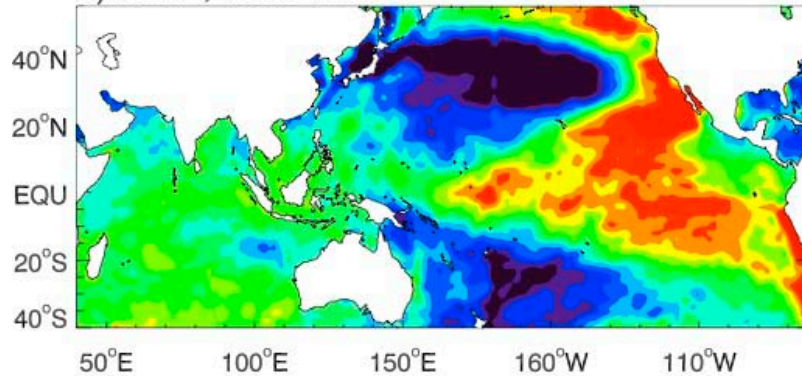
SST anomalies during different IPO phases

a) SSTA, 1945-1977 IPO-



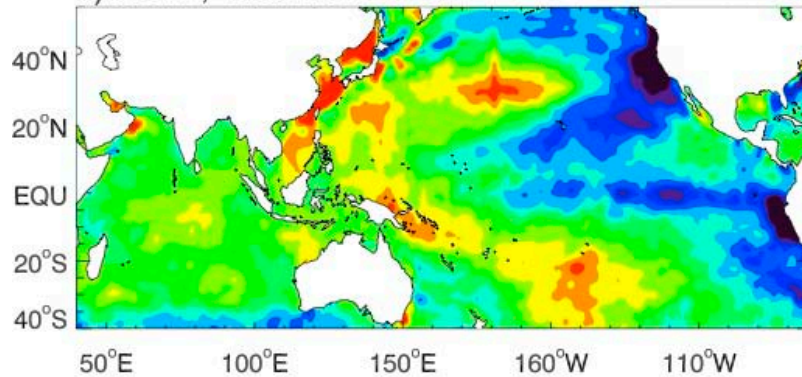
1945-1977 IPO-

b) SSTA, 1978-1998 IPO+



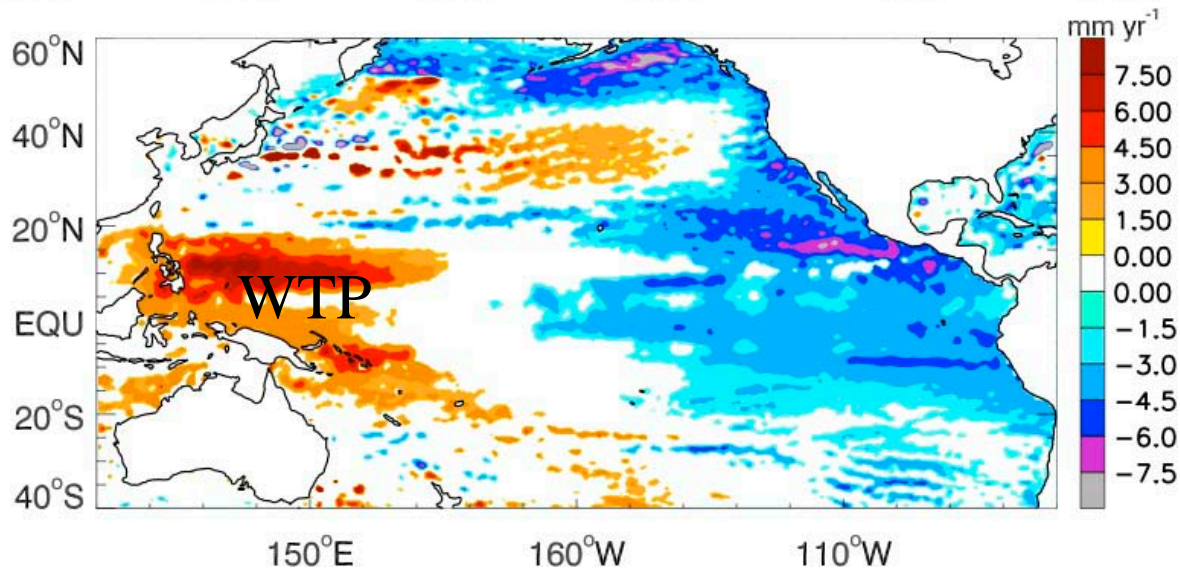
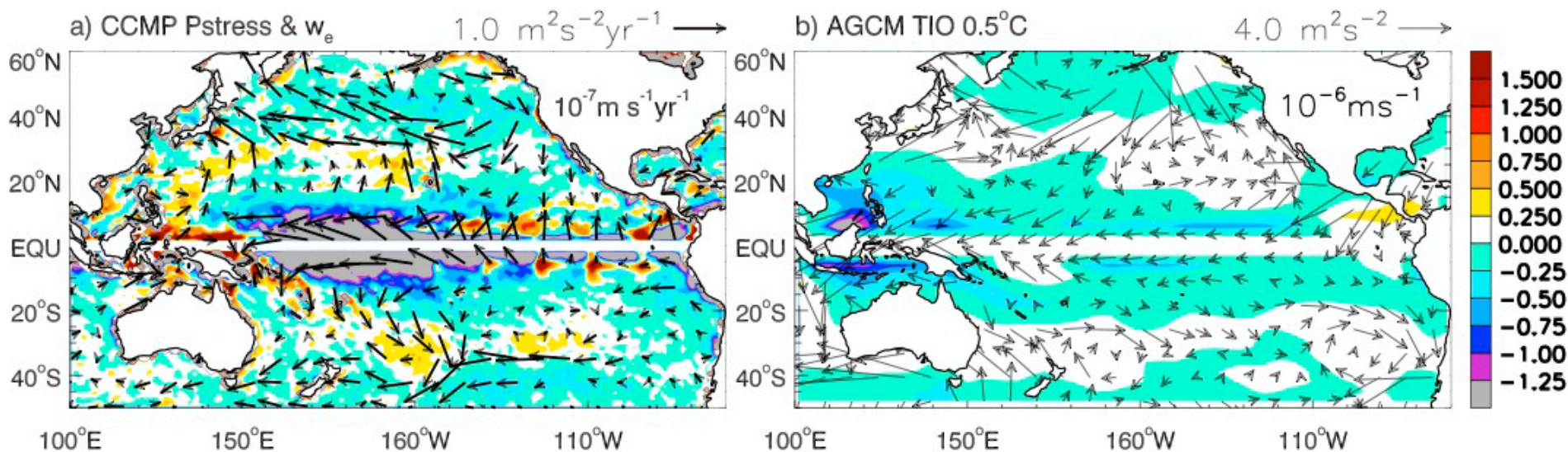
1978-1998 IPO+

c) SSTA, 1999-2010 IPO-



1999-2010 IPO-





4. Summary

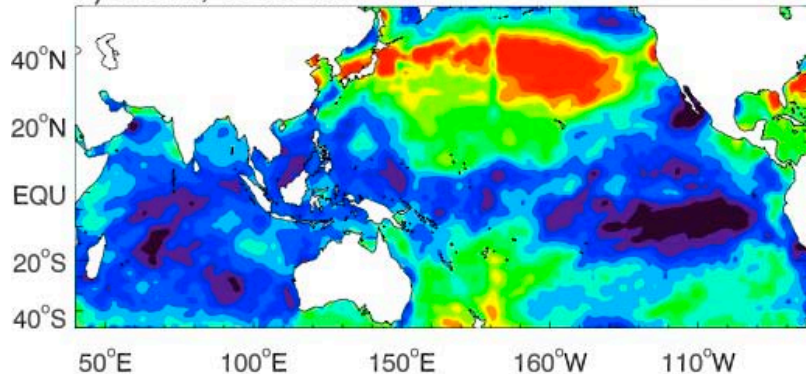
- **The intensified SLR in the WTP since the 1990s relative to the preceding decades is forced by the enhanced easterly trades and negative Ekman pumping velocity in the central-western tropical Pacific basin;**
- **The enhanced surface winds are contributed from warming in the Indian Ocean (and western tropical Pacific), which generates equatorial easterlies and negative Ekman pumping velocity that enhance the surface wind anomalies associated with the negative IPO, producing the intensified SLR in the WTP.**

Acknowledgements

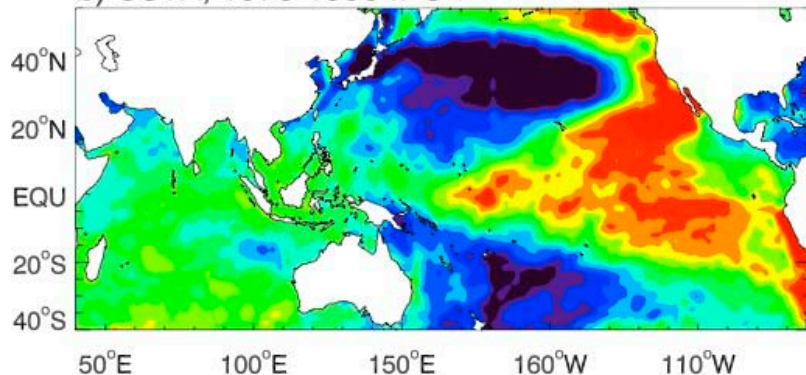
W. Han is supported by NSF CAREER award OCE 0847605 and NASA OSTST award NNX08AR62G. We gratefully acknowledge NCAR CISL for computational support, and Clara Deser and Adam Philips for providing 2000-2008 CAM3 TOGA output.

SST anomalies during different IPO phases

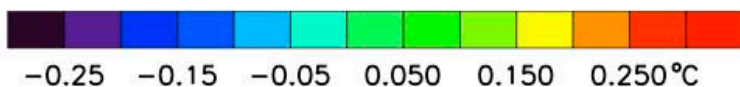
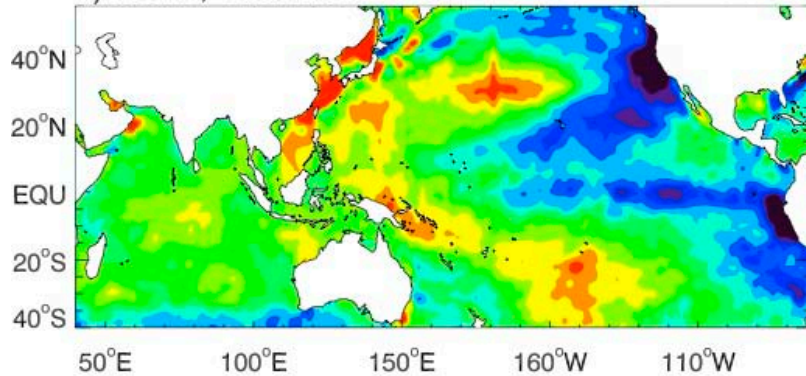
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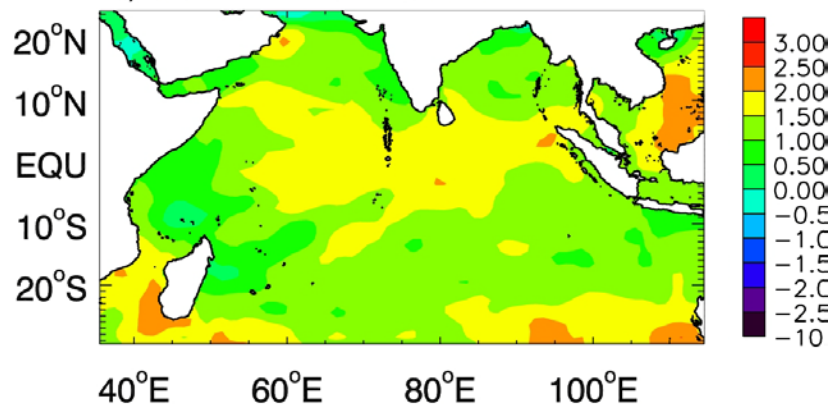
b) SSTA, 1978-1998 IPO+



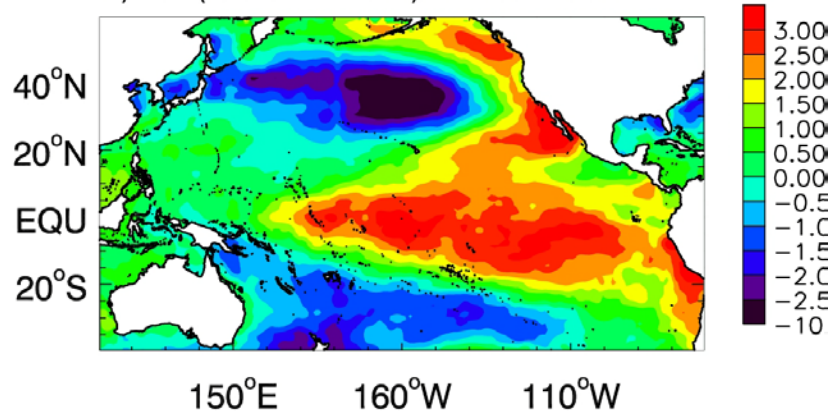
c) SSTA, 1999-2010 IPO-



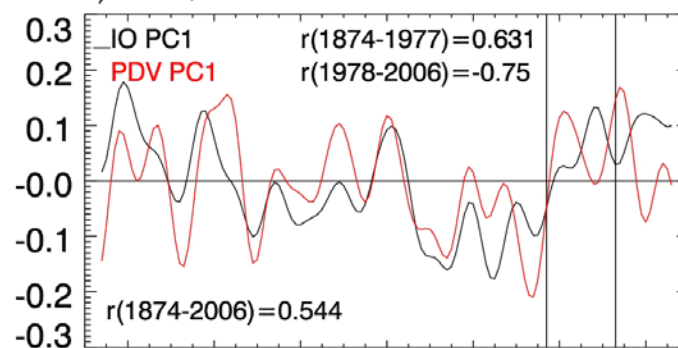
a) IO SST EOF1: 1874-2006 56%



b) PDV (Pacific SST EOF1): 1874-2006 36%



c) IO PC1/PDV PC1



1880 1900 1920 1940 1960 1980 2000