

Forced Atmospheric Circulations and Their Evolutions: 1979-2014

Tao Zhang, Martin P. Hoerling, Judith Perlwitz, and Taiyi Xu
CIRES and NOAA/ESRL PSD1

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Question:

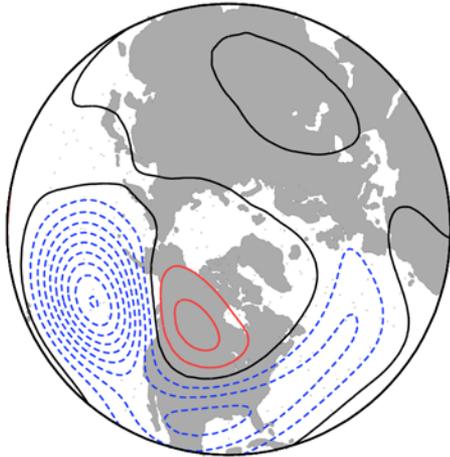
What is the SST-forced atmospheric variability during the recent period?

Data and method

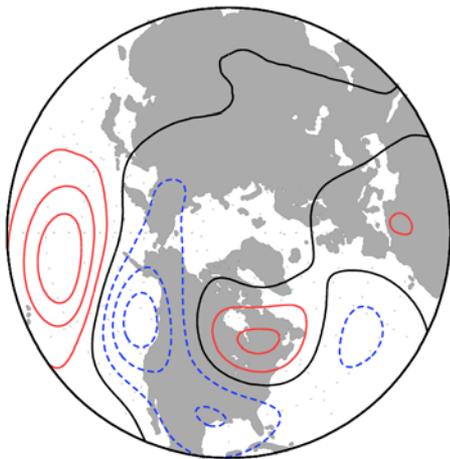
- AMIP runs from NCEP GFSv2, the atmospheric component of the Climate Forecast System (CFS) version 2 (*Saha et al.* 2014) at T126 and 64 layers, driven with specified observed monthly SST, sea ice, and CO₂ concentrations for 1979-2014.
- The forced signals are determined from ensemble-mean of the 50 members with the same forcings but with different initial atmospheric conditions , in order to effectively separate the atmospheric response from unforced internal atmospheric variability.
- EOF analysis of DJF 500-hPa height field over 1979-2014 for 20°N-90°N latitude bands
- composite analysis of Z500, surface temperature and precipitation based on stronger cases shown in PC time series for different EOFs.

First 2 EOF patterns of 50-member ensemble mean DJF Z500 from GFSv2 AMIP runs over 1979-2014

EOF1
(56.2%)

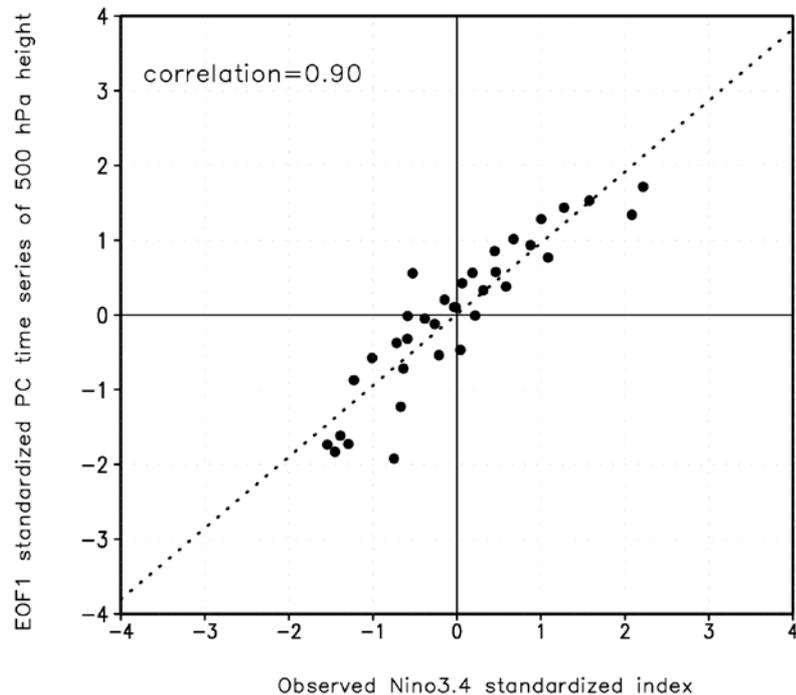


EOF2
(23.0%)



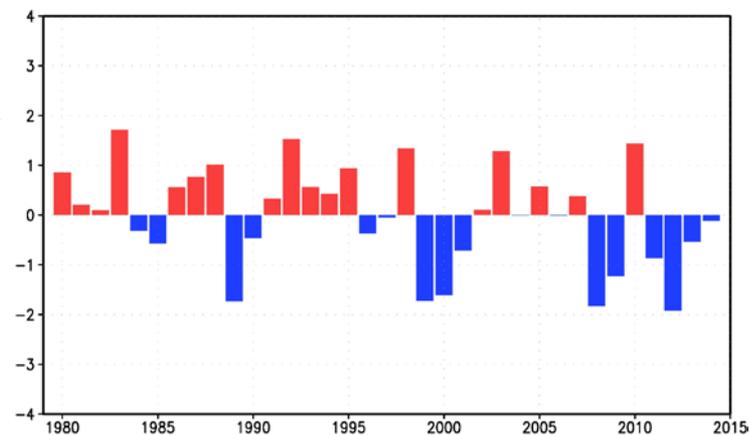
Scatter relationship between N3.4 index and EOF1 PC time series

EOF1
PC time
series

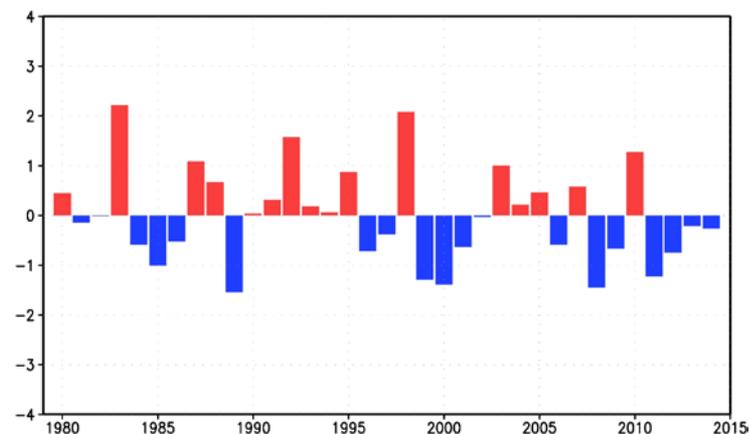


N3.4 index

EOF1 PC time series



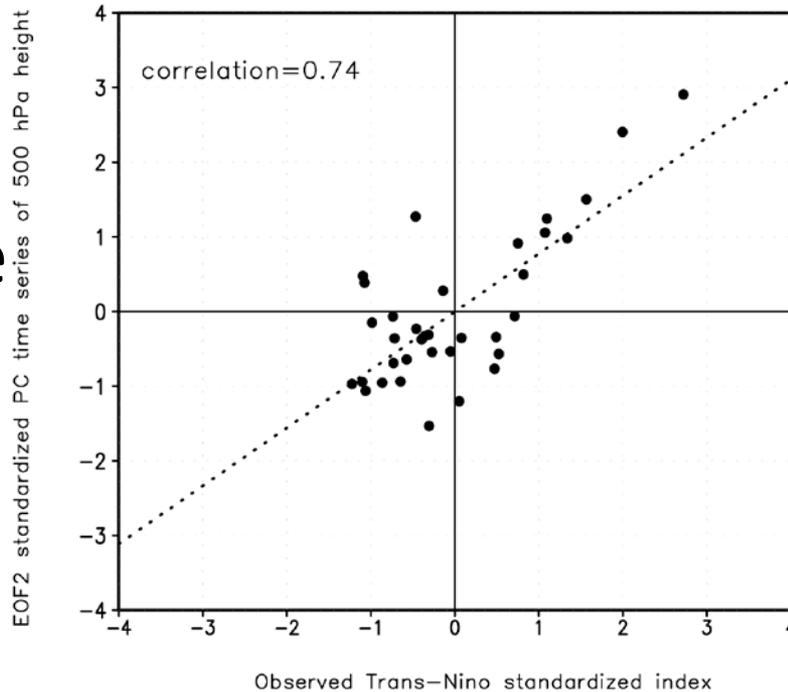
N3.4 index



N3.4 index: SST anomalies in Nino3.4 region, indicate ENSO events

Scatter relationship between TNI index and EOF2 PC time series

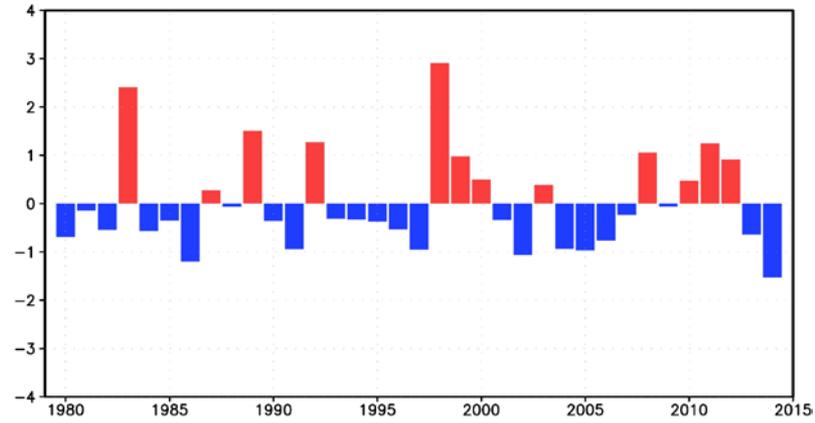
EOF2
PC time
series



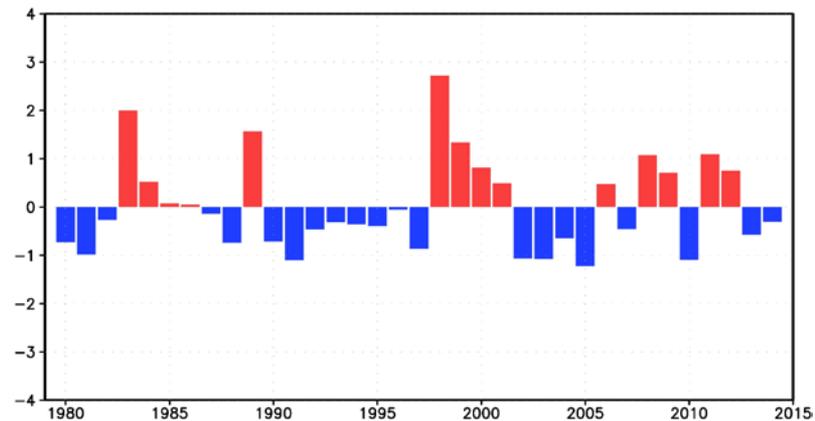
(Trenberth and
Stepaniak 2001)

TNI index

EOF2 PC time series



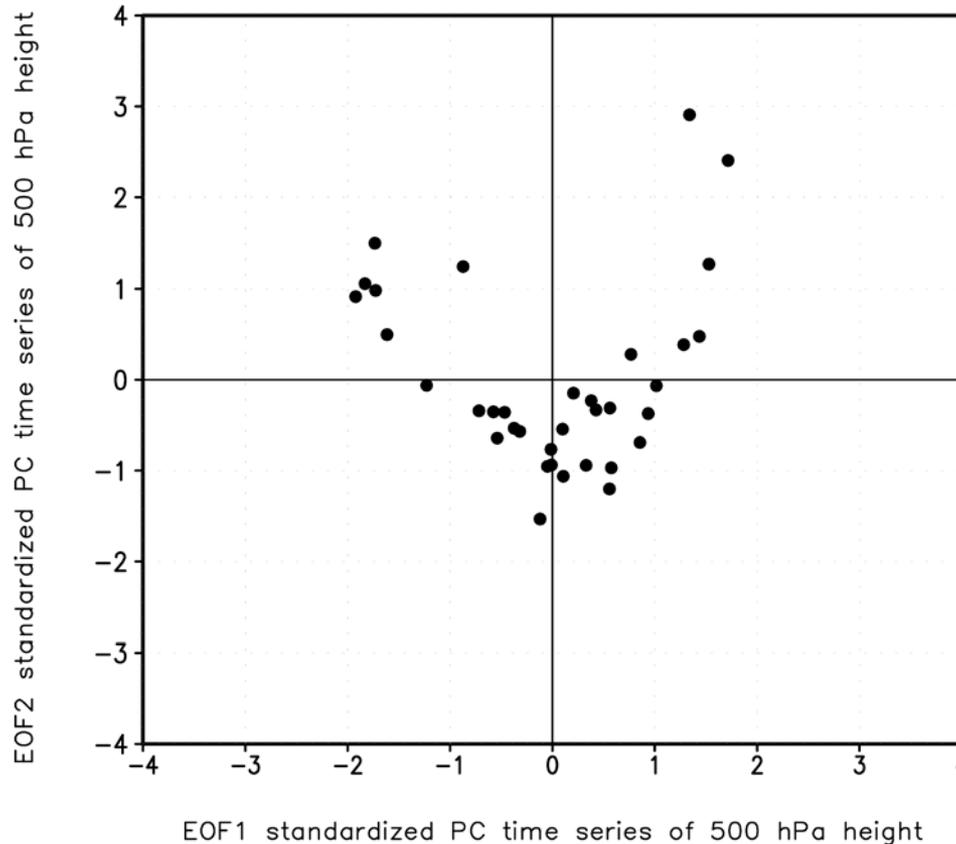
TNI index



TNI (Trans-Nino index) index: difference in normalized SST anomalies (Nino1+2 – Nino4), measures contrast in SSTs across equatorial Pacific and helps to capture the evolution of ENSO during transition period

Scatter relationship between EOF1 and EOF2 PC time series

EOF2
PC time
series

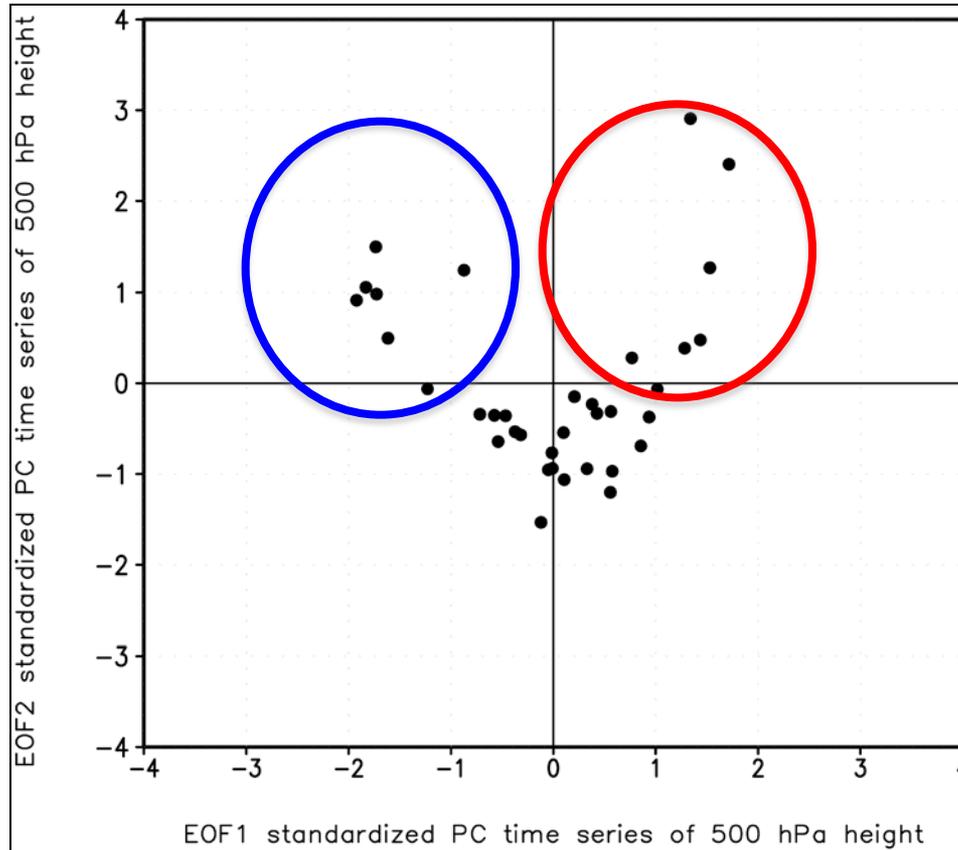


EOF1 PC time series

- 1) Nonlinear U-shaped structure
- 2) Both stronger positive and negative PC1 values correspond to stronger positive PC2 values
- 3) Stronger negative PC2 values correspond to weaker PC1 values (non-ENSO years).

Top 7 cases composite based on EOF1 PC time series

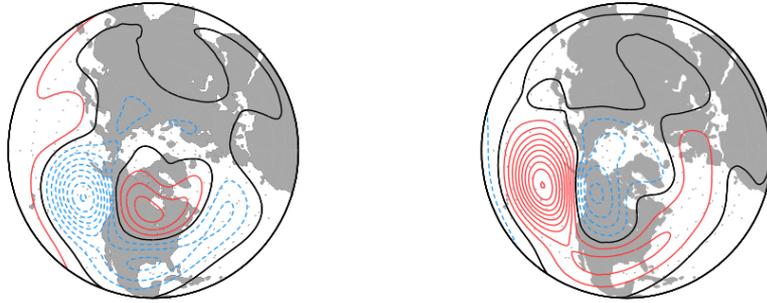
EOF2
PC time
series



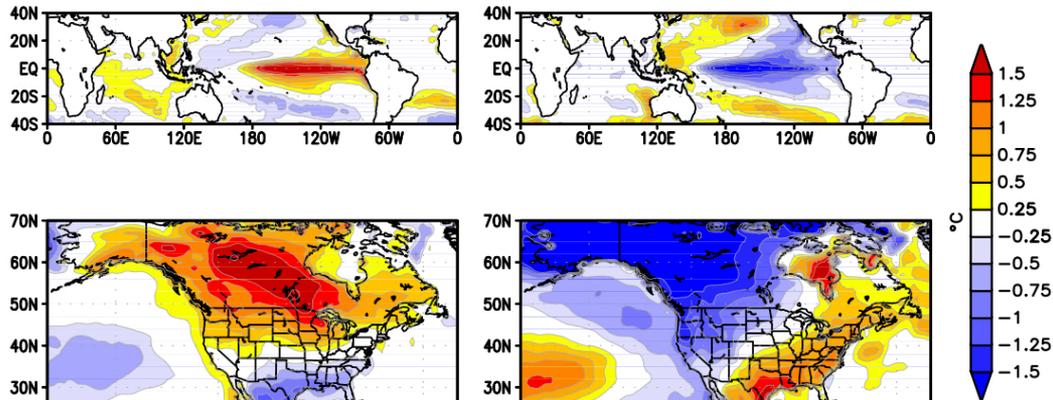
EOF1 PC time series

Composite for (left) positive and (right) negative phase of EOF1 PC time series

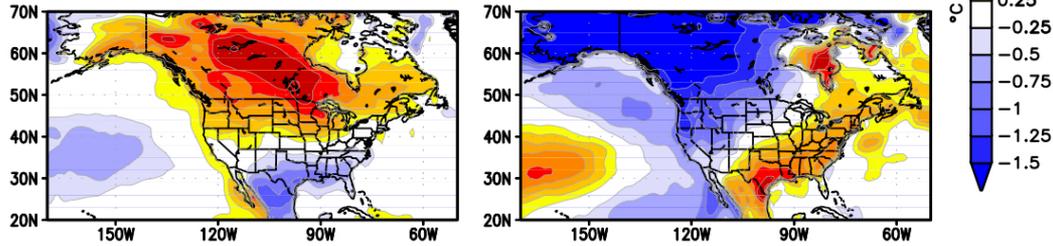
Z500



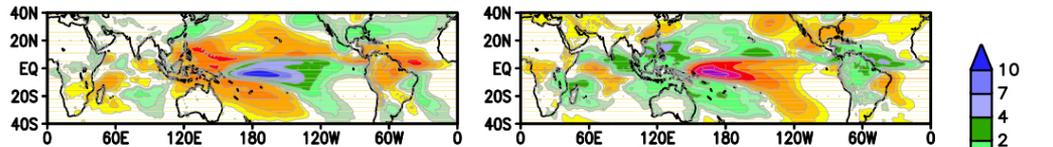
Tropical SST



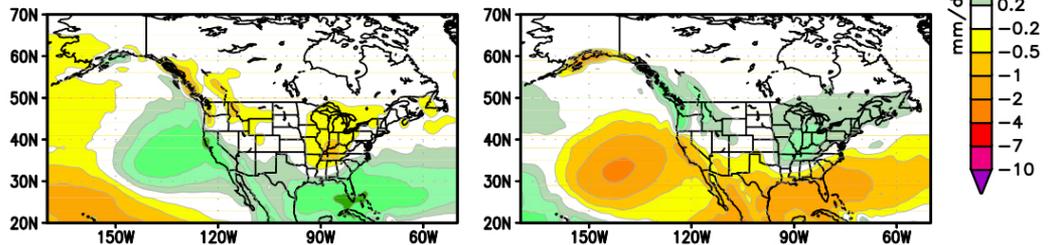
North American SFCT



Tropical precip.

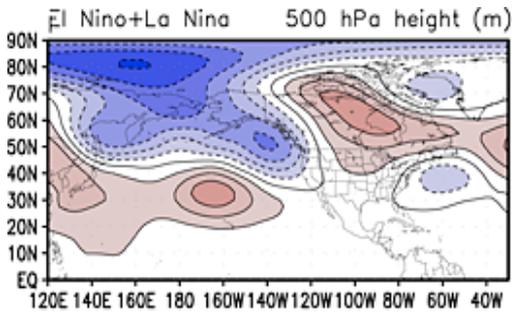
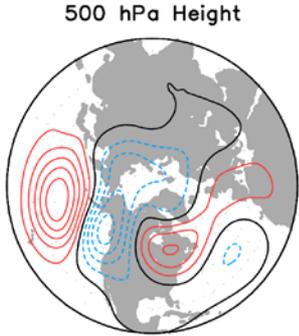


North American precip.

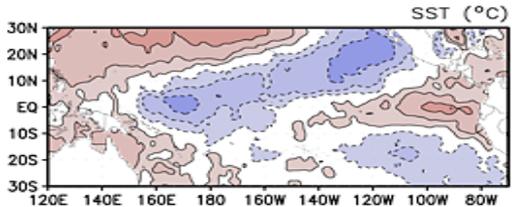
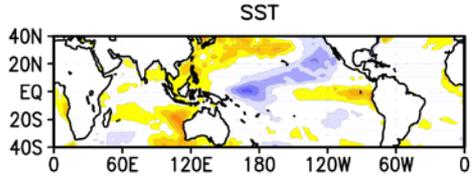


Sum between composites for two phases of EOF1 PC time series

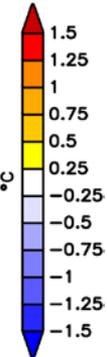
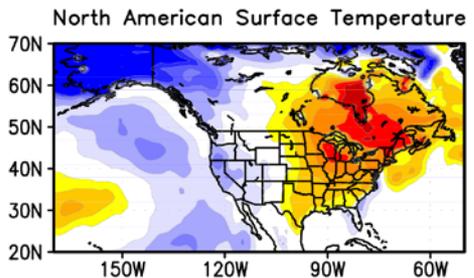
Z500



Tropical SST

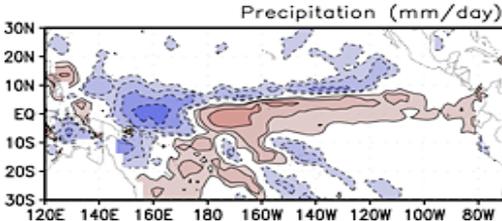
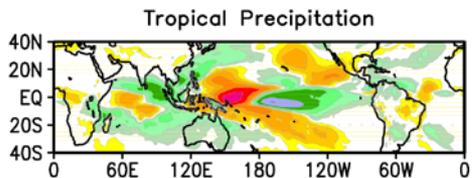


North American SFCT

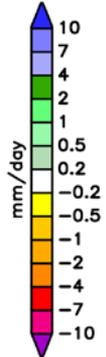
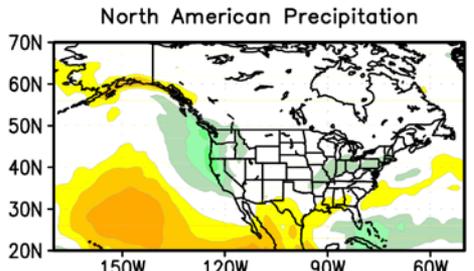


Similar to observed asymmetry in Z500, SST, precip (Zhang et al. 2014)

Tropical precip.

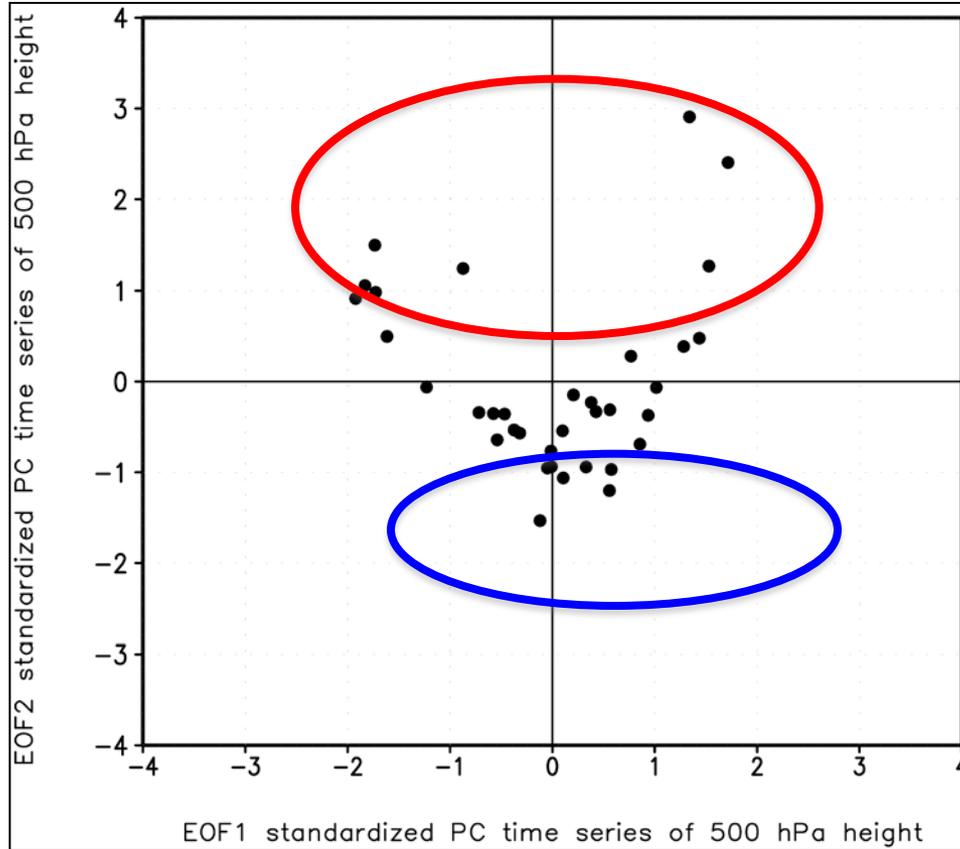


North American precip.



Top 7 cases composite based on EOF2 PC time series

EOF2
PC time
series

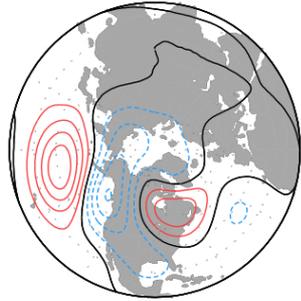


EOF1 PC time series

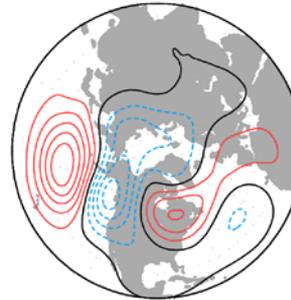
positive phase of EOF2

Sum between two phases of EOF1

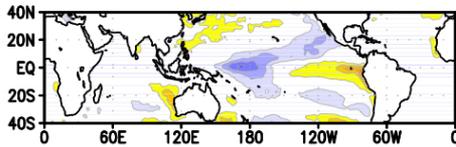
Z500



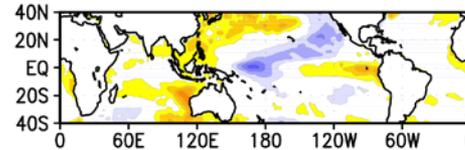
500 hPa Height



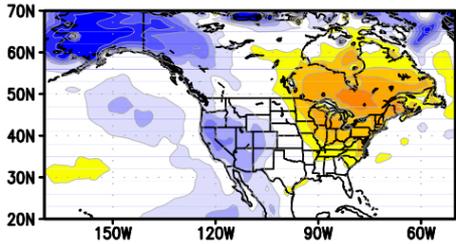
Tropical SST



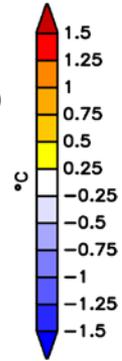
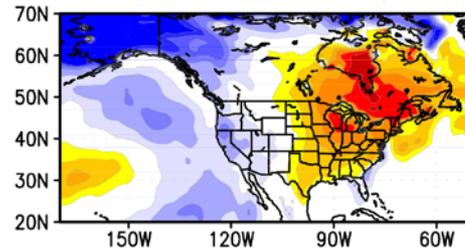
SST



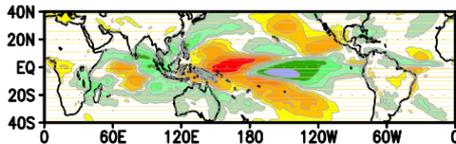
North American SFCT



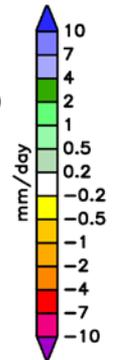
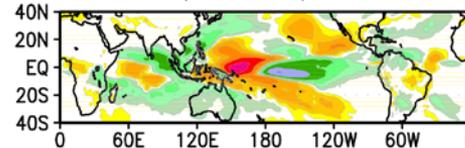
North American Surface Temperature



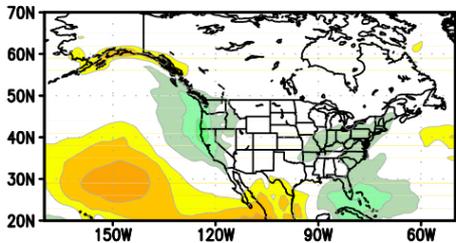
Tropical precip.



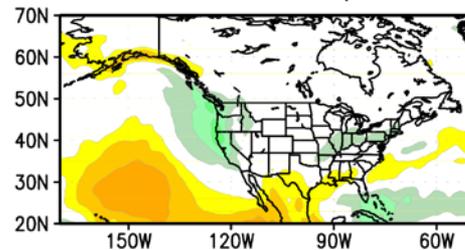
Tropical Precipitation



North American precip.

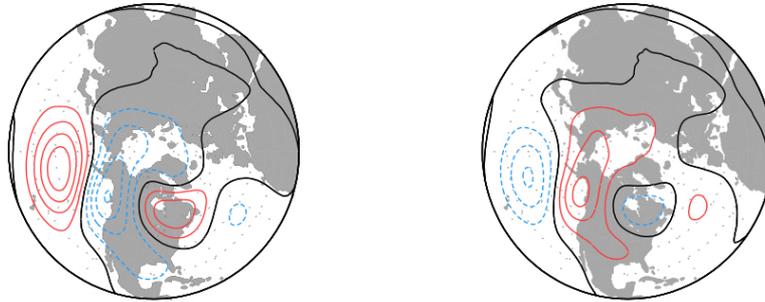


North American Precipitation

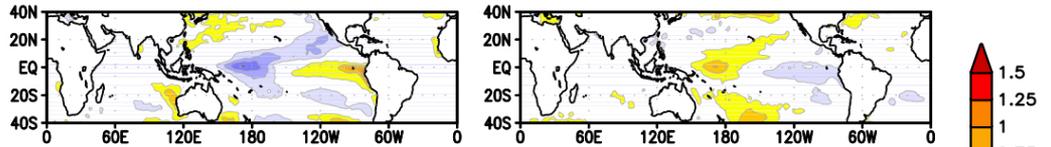


Composite for (left) positive and (right) negative phase of EOF2 PC time series

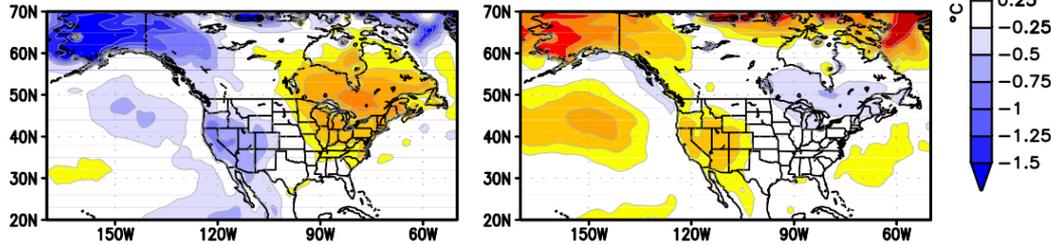
Z500



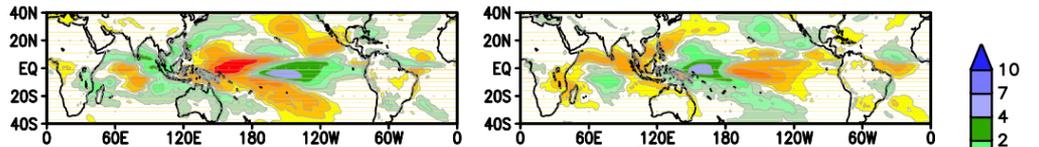
Tropical SST



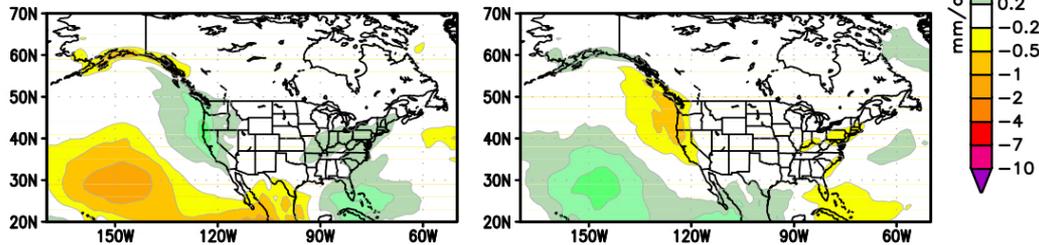
North American SFCT



Tropical precip.

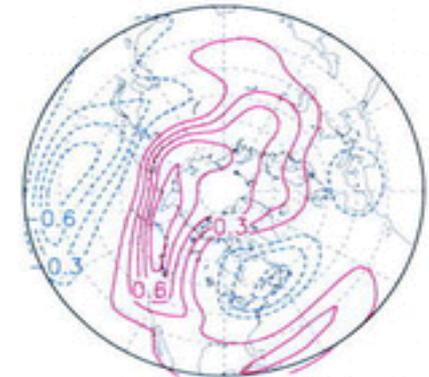
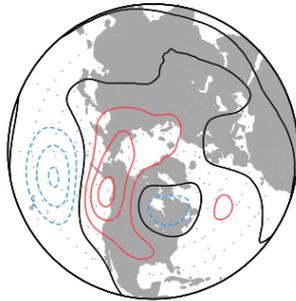


North American precip.

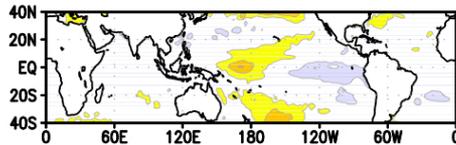


negative phase of EOF2

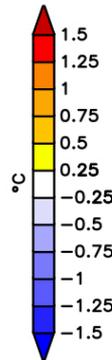
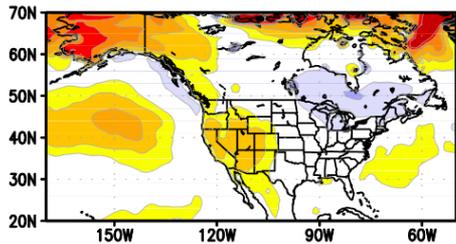
Z500



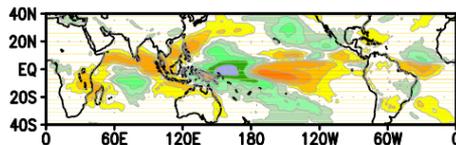
Tropical SST



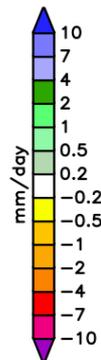
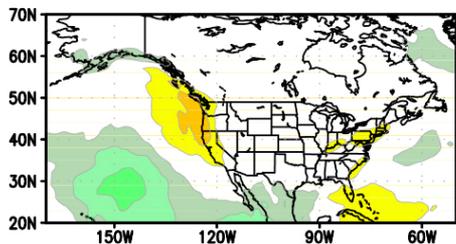
North American SFCT



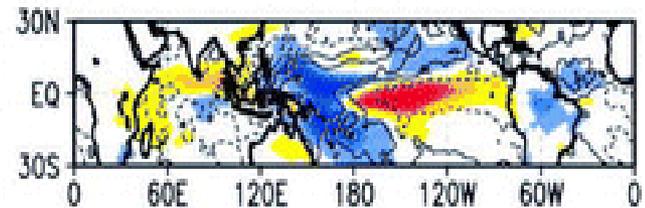
Tropical precip.



North American precip.



Resembling the mode of Hoerling and Kumar (2002), related to non-ENSO SST forcing.



Summary

- Two dominant modes are identified using EOF analysis of the ensemble mean wintertime 500-hPa height response, which are found to be associated with tropical SST forcings. The evolutions of the first mode and second mode are highly correlated with tropical SST N3.4 index and TNI index, respectively.
- The dominant mode is indeed the classic atmospheric teleconnection associated with the linear ENSO signal and explains 56% of the forced height variance.
- The second mode explains 23% of the externally forced variance, with the positive phase representing the asymmetry in ENSO teleconnections between two phases of ENSO, and the negative phase being related to ENSO precursor that is often observed prior to a mature ENSO event.
- Pronounced effect of second mode of atmospheric response on US surface climate is characterized with a cold (warm) and wet (drought) condition during the positive (negative) phase over the West Coast.