What Drove Tropical and North Pacific and North America Climate Anomalies in 2014/15 Winter?

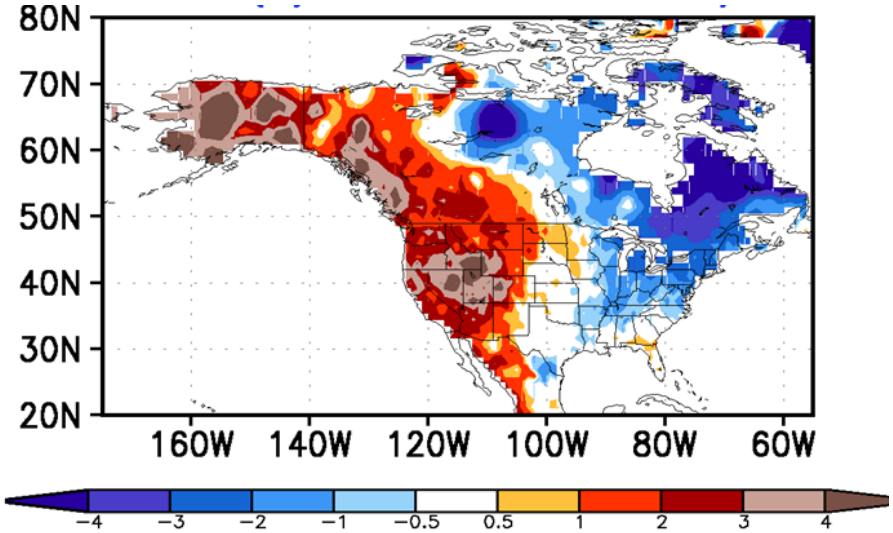
Peitao Peng, Arun Kumar and Zeng-Zhen Hu

Climate Prediction Center
NCEP/NWS/NOAA, College Park, MD 20740, USA

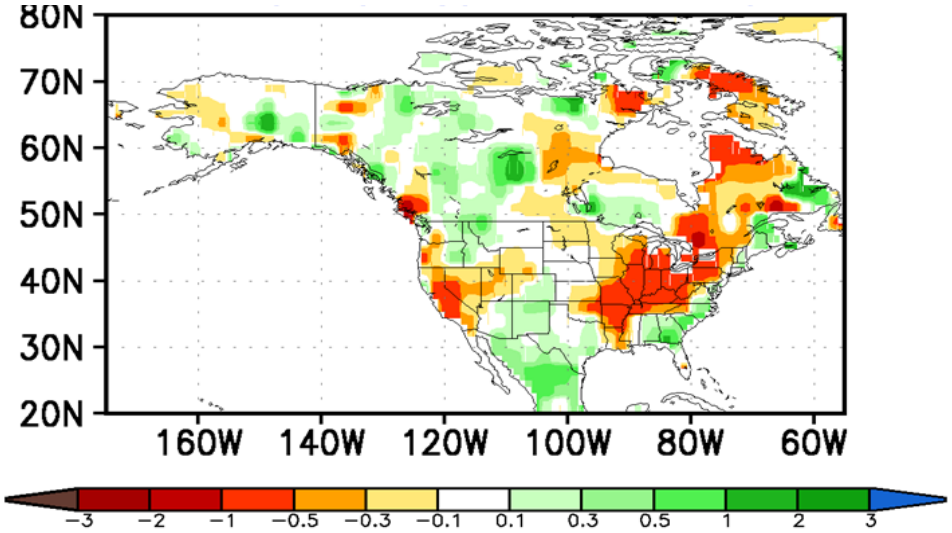
Acknowledgments: B. Jha, C. Wen, Li Zhang, M. Chen and J. Zhu

Observed DJF2014/15 Anomalies

T2m(K)

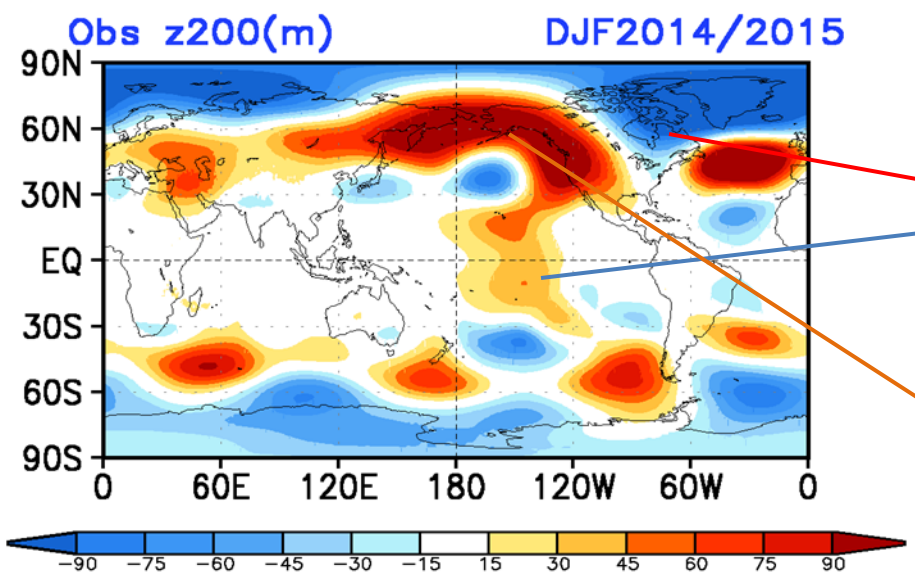


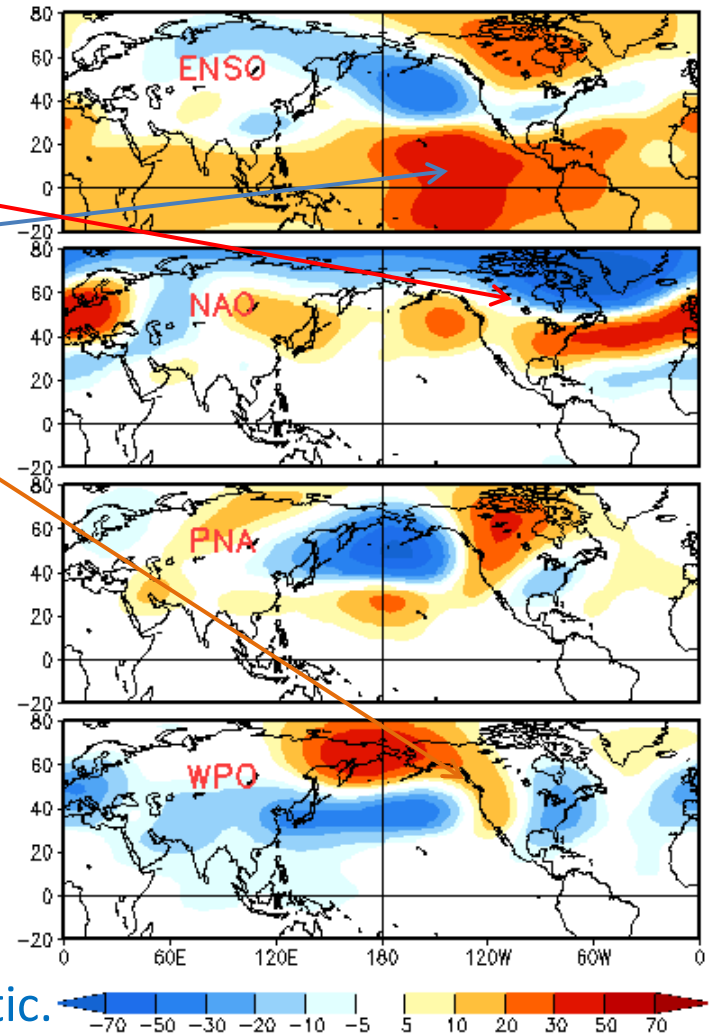
Prate(mm/day)



What caused the significant temperature anomalies with an east-west dipole structure in N. America?

Global Circulation



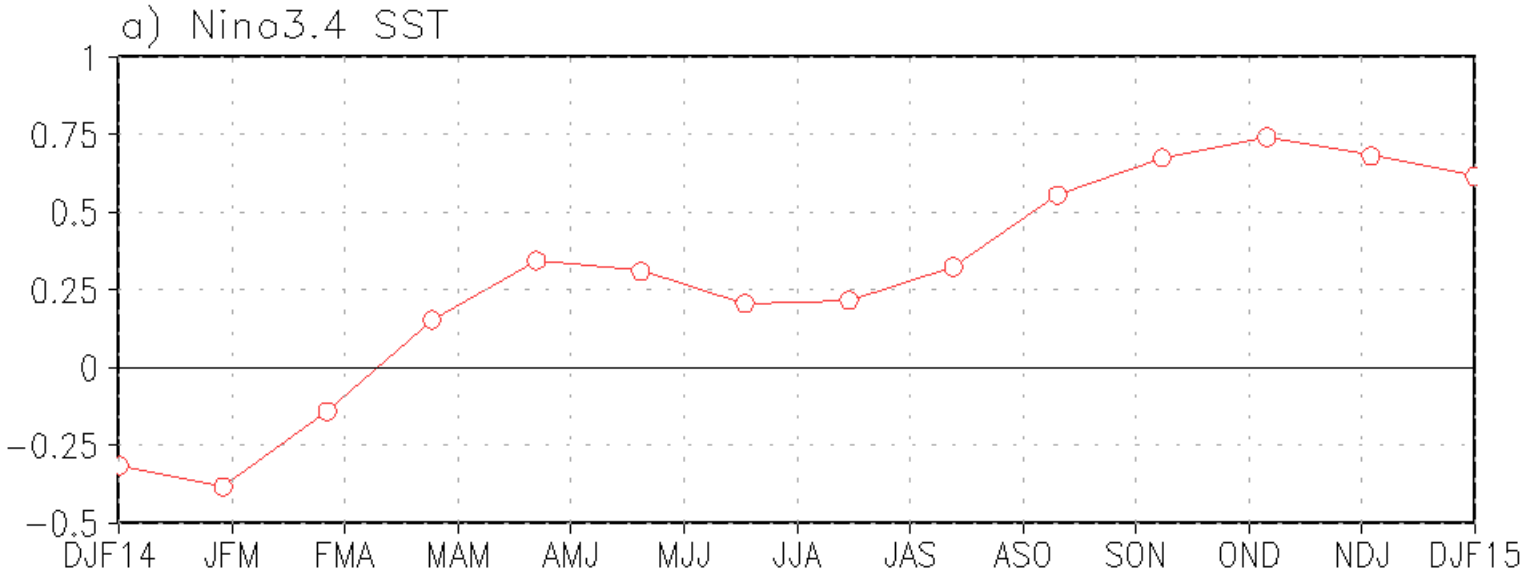


Three possible contributors:

1. ENSO signature in the tropical Pacific;
2. WPO signature in N. America and east Siberia
3. NAO signature in northeast Canada & N. Atlantic.

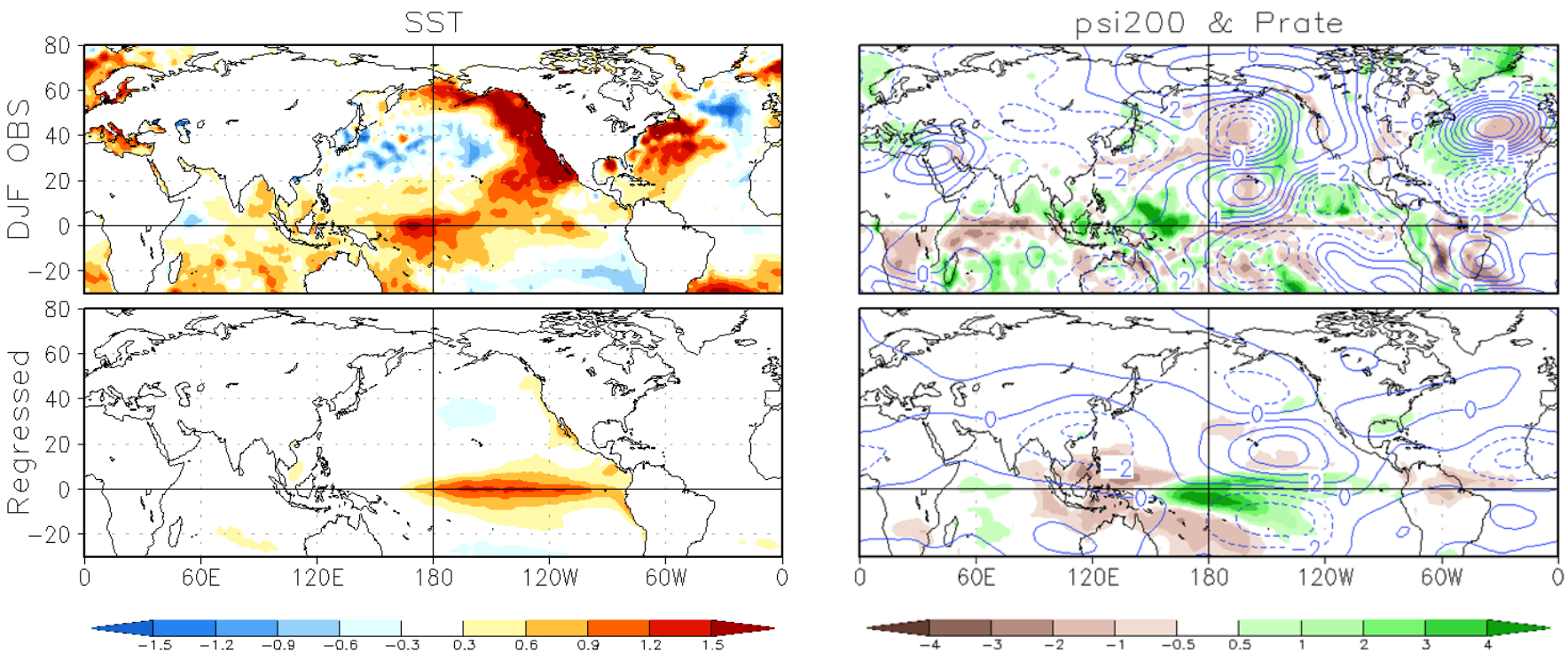
We will focus on SST forcing and its associated atmospheric anomalies

DJF SST Anomalies



Nino3.4 SST index quite closed to the threshold of an El Nino during spring and summer 2014, but El Nino didn’t occur in 2014/15.

OBS vs ENSO for SST, 200mb PSI and Prate



Main differences from ENSO:

1. Warm SST and Prate anomalies are westward shifted;
2. Anti-cyclonic pair straddles negative precipitation anomaly ;
3. Circulation pattern over N America is an east-west structure.

What are the leading modes driving the anomalies?

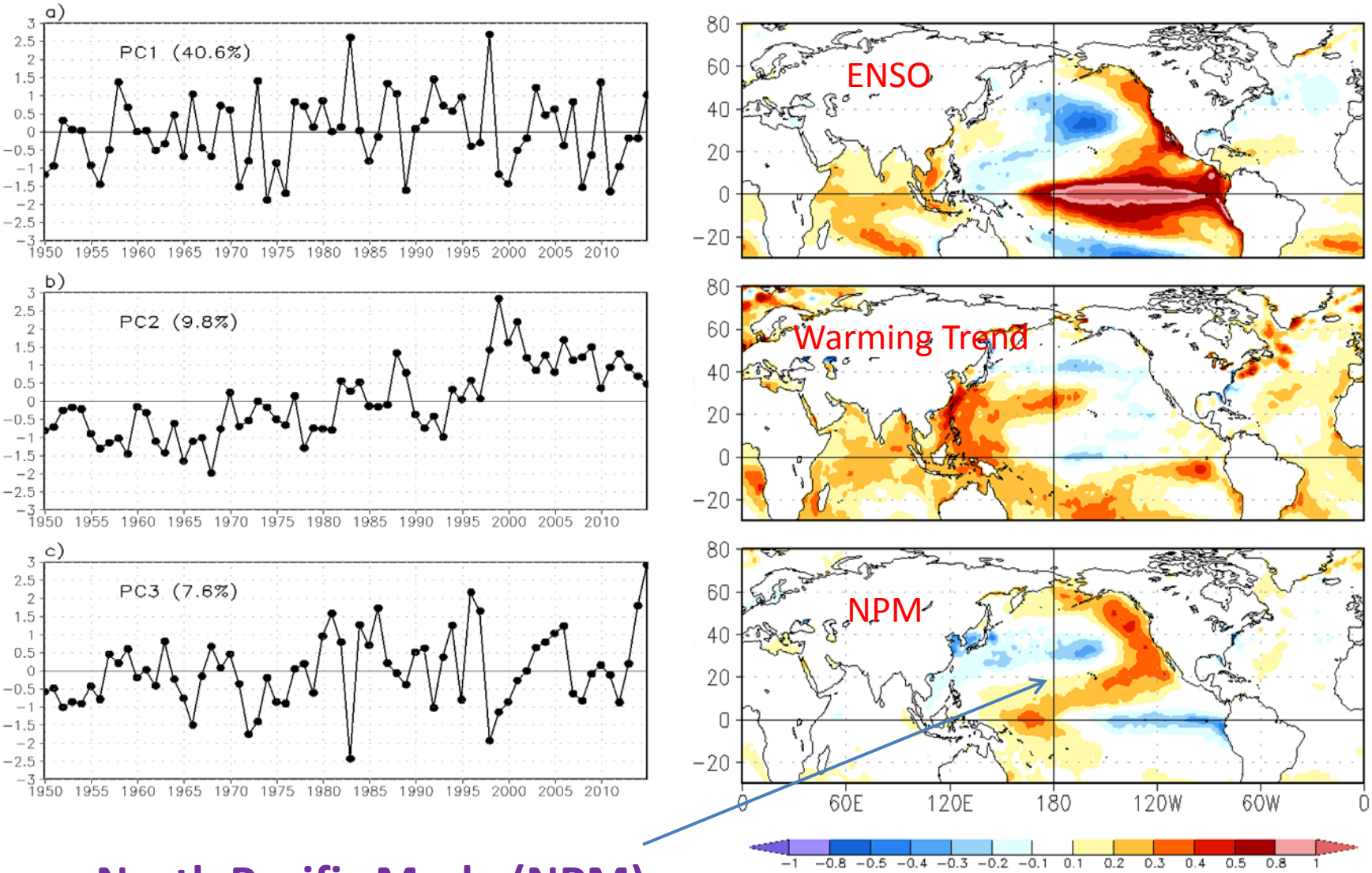
Decomposition and Reconstruction Analyses

1. Conduct EOF analysis of DJF mean SST (1949/50 -> 2014/15) for the area of north of 30S and 120E-80W, to get the leading modes of the variability in the region;

2. Examine spatial patterns of SST, 200mb stream function (PSI200) and precipitation rate (Prate) by regressing SST PCs to the data;

3. Reconstruct SST, PSI200 and Prate fields for 2014/15 DJF with SST PCs and the regression patterns, to identify the contributions of each mode to the observed anomalies.

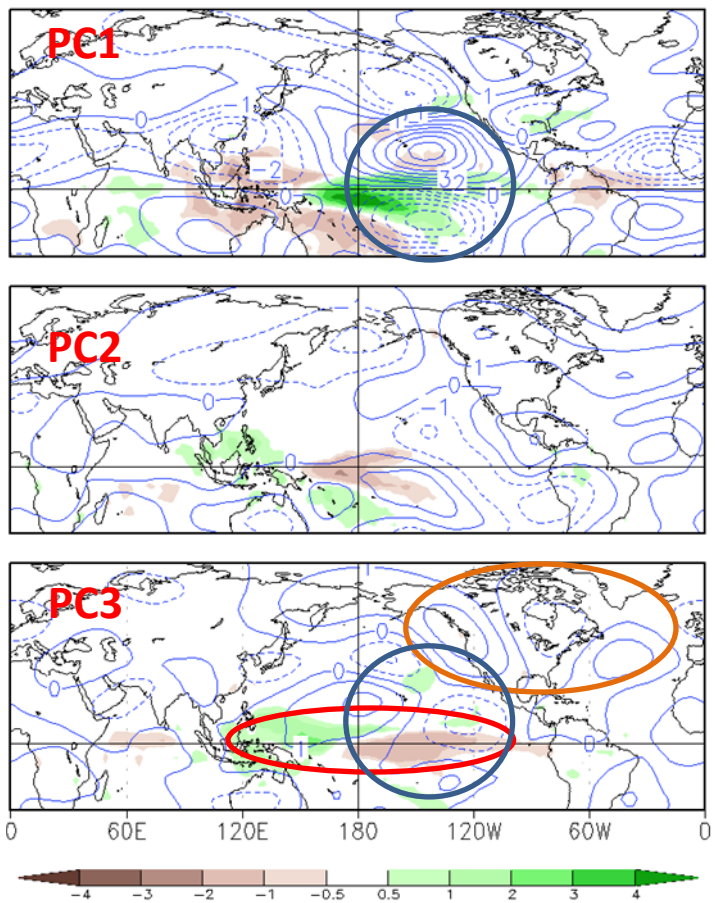
EOFs and PCs of Tropical and North Pacific DJF SST

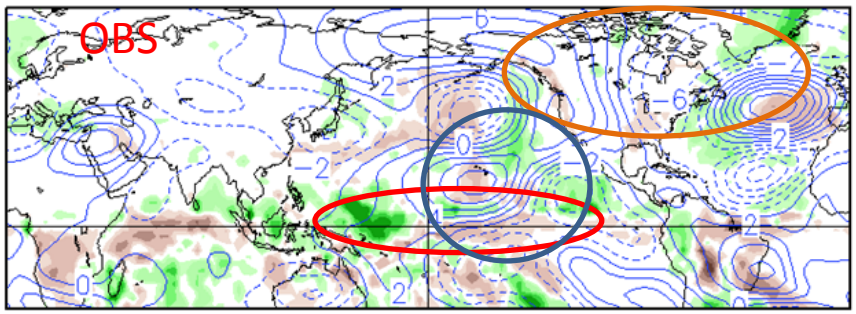


North Pacific Mode (NPM)

(Hartmann 2015)

SST PC Regressed PSI200 and Prate

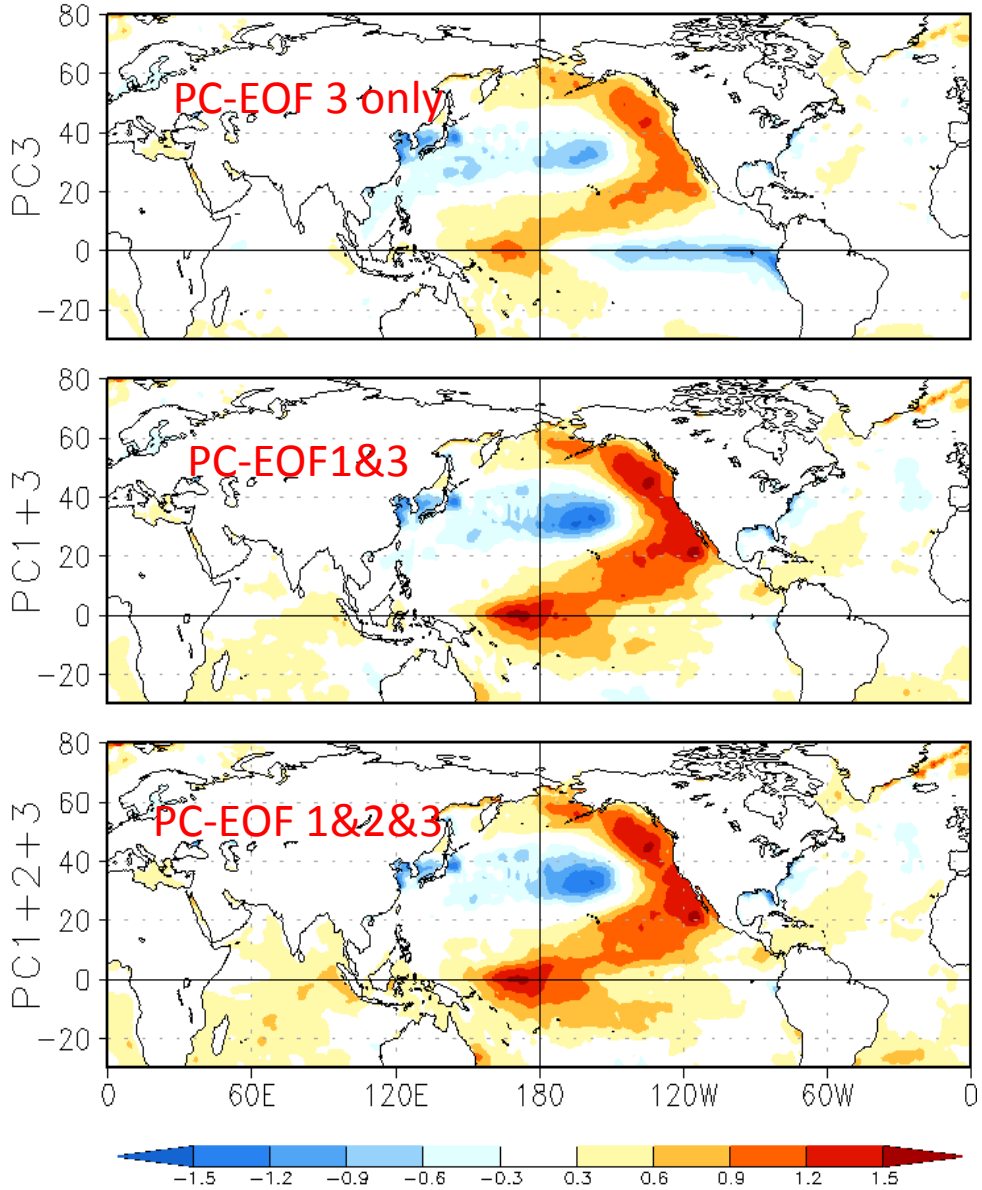




1. Tropical Prate similar to PC3 regressed pattern;
2. Tropical circulation has characteristics of both PC1 and PC3 regressed patterns;
3. N. American circulation is similar to PC3 related pattern.

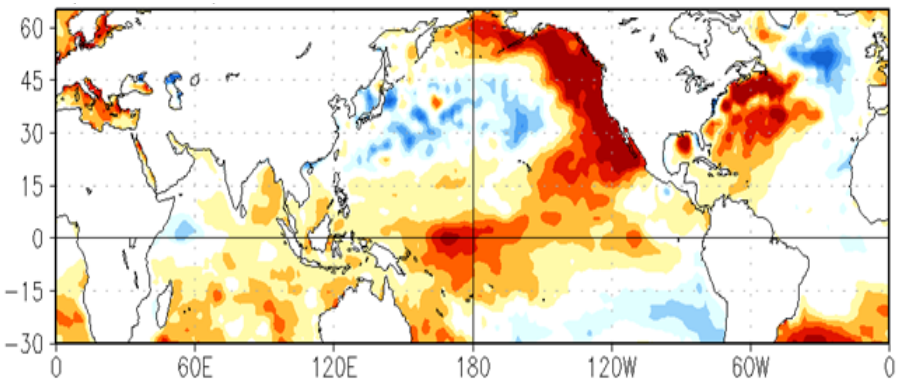
So both PC-EOF1 and 3 of SST contributed the observed anomaly in N. Pacific and N. American sector in DJF 2014/15.

Reconstructed DJF SSTs with EOFs and PCs



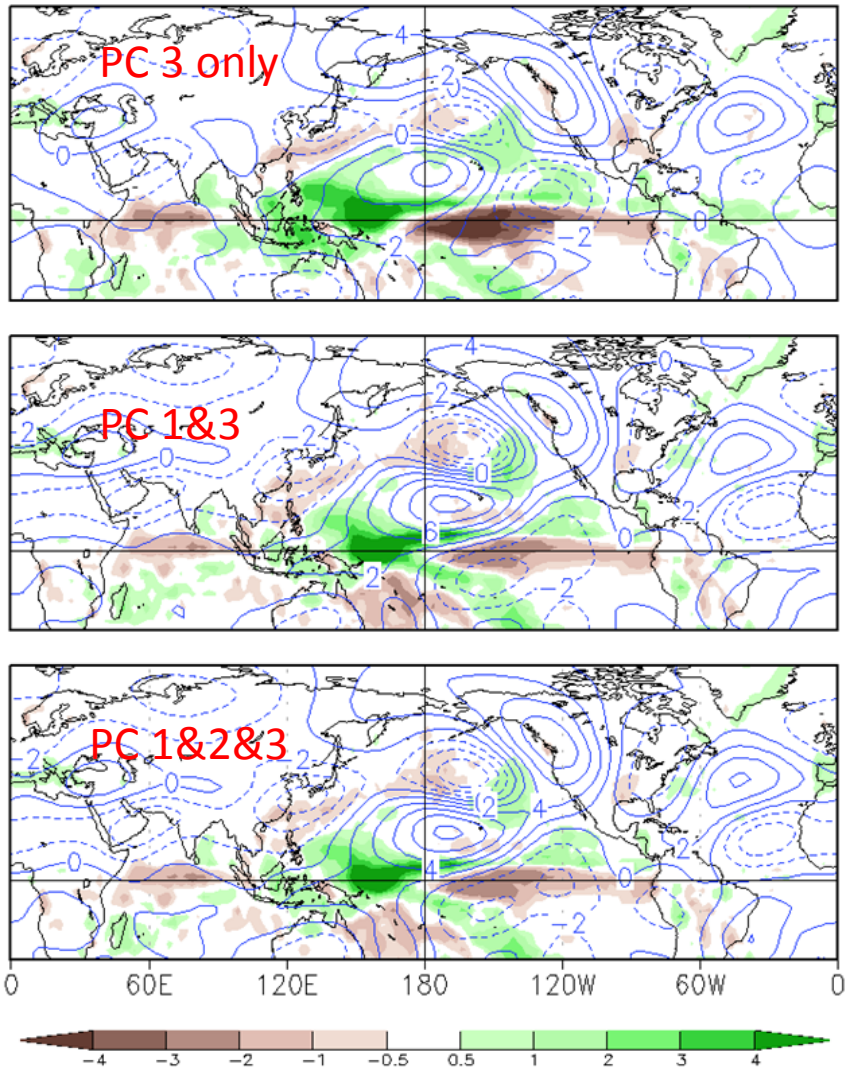
Reconstruction = PC * EOF Pattern

OBS



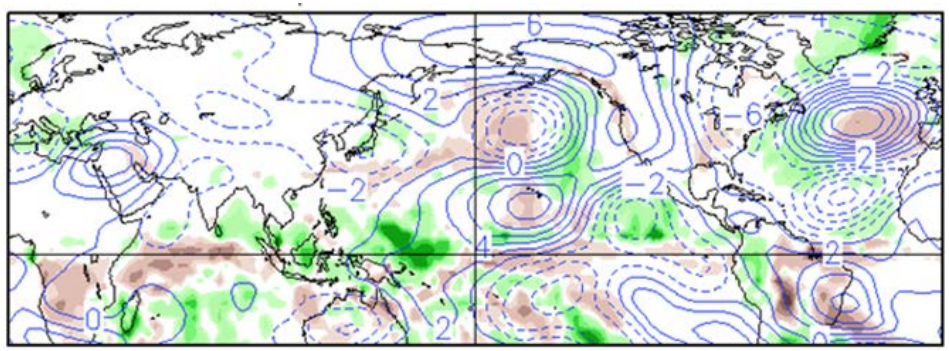
Reconstruction of PC-EOF 1&3 well resembles OBS, suggesting that both ENSO and NPM modes are the leading contributors to the observed SST anomalies in DJF 2014/15.

Reconstructed PSI200 and Prate with SST PCs and Regression Patterns



Reconstruction = PC * Regressed Pattern

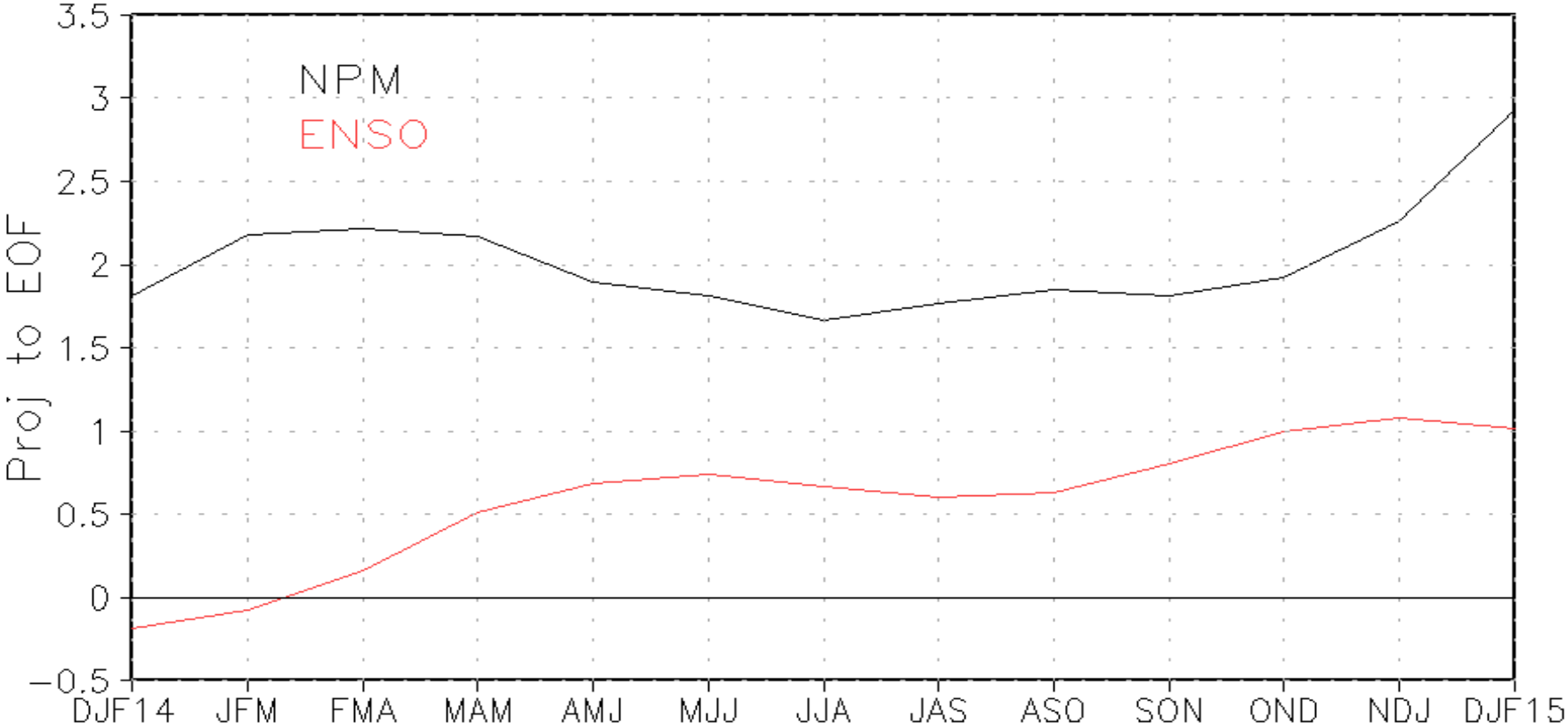
OBS



Reconstruction of SST PC 1&3 and regression patterns of PSI200 and Prate well resemble OBS, further *confirming that both ENSO and NPM modes are the leading contributors to the observed anomalies in DJF 2014/15.*

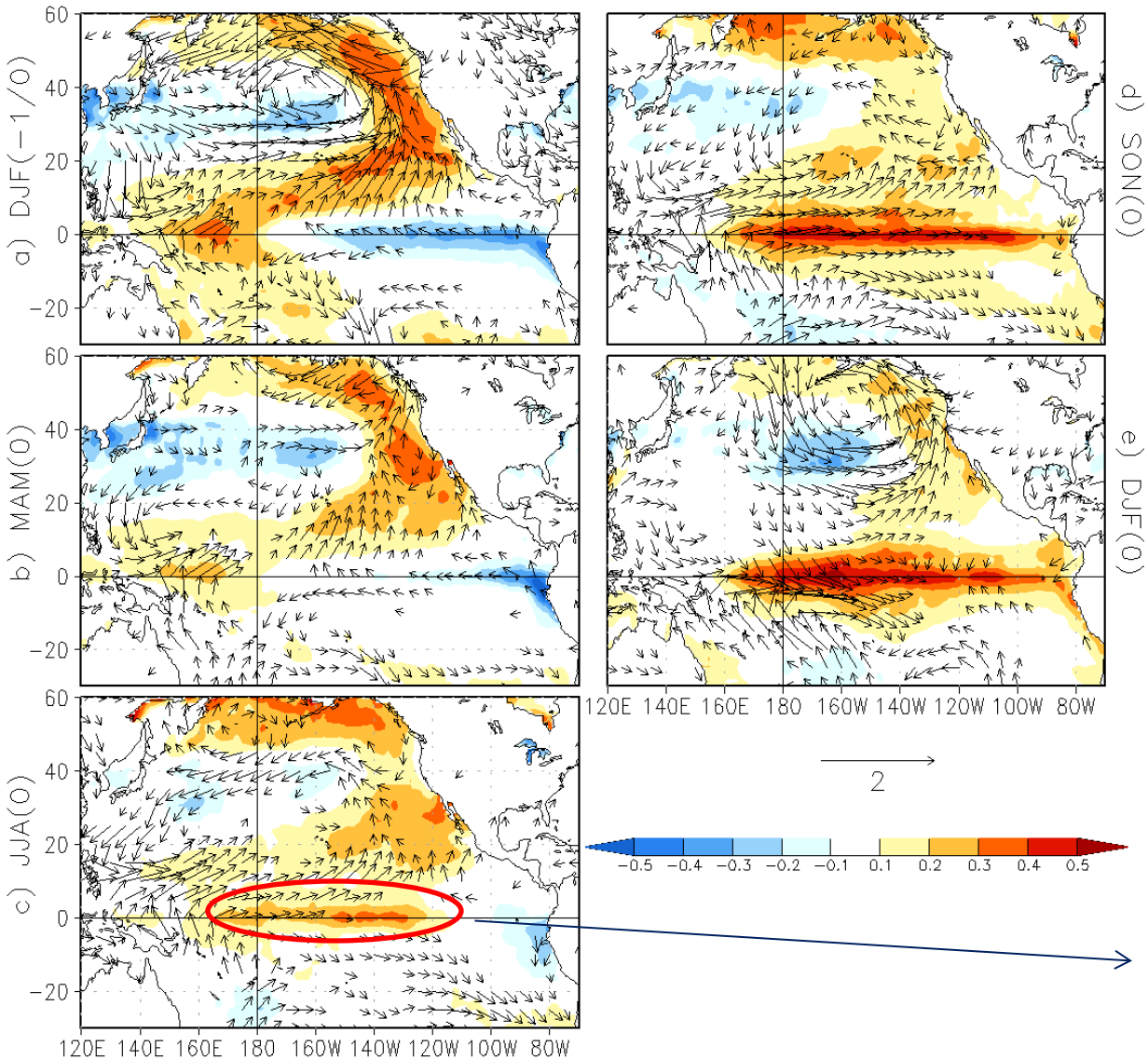
How did NPM and ENSO modes evolve in 2014?

Evolution of NPM and ENSO Indices in 2014



1. NPM dominated SST anomalies through the year, and ENSO mode is also important, but plays a secondary role;
2. NPM tends to be a precursor of ENSO (Hartmann 2015);
3. Why didn't 2014 ENSO develop?

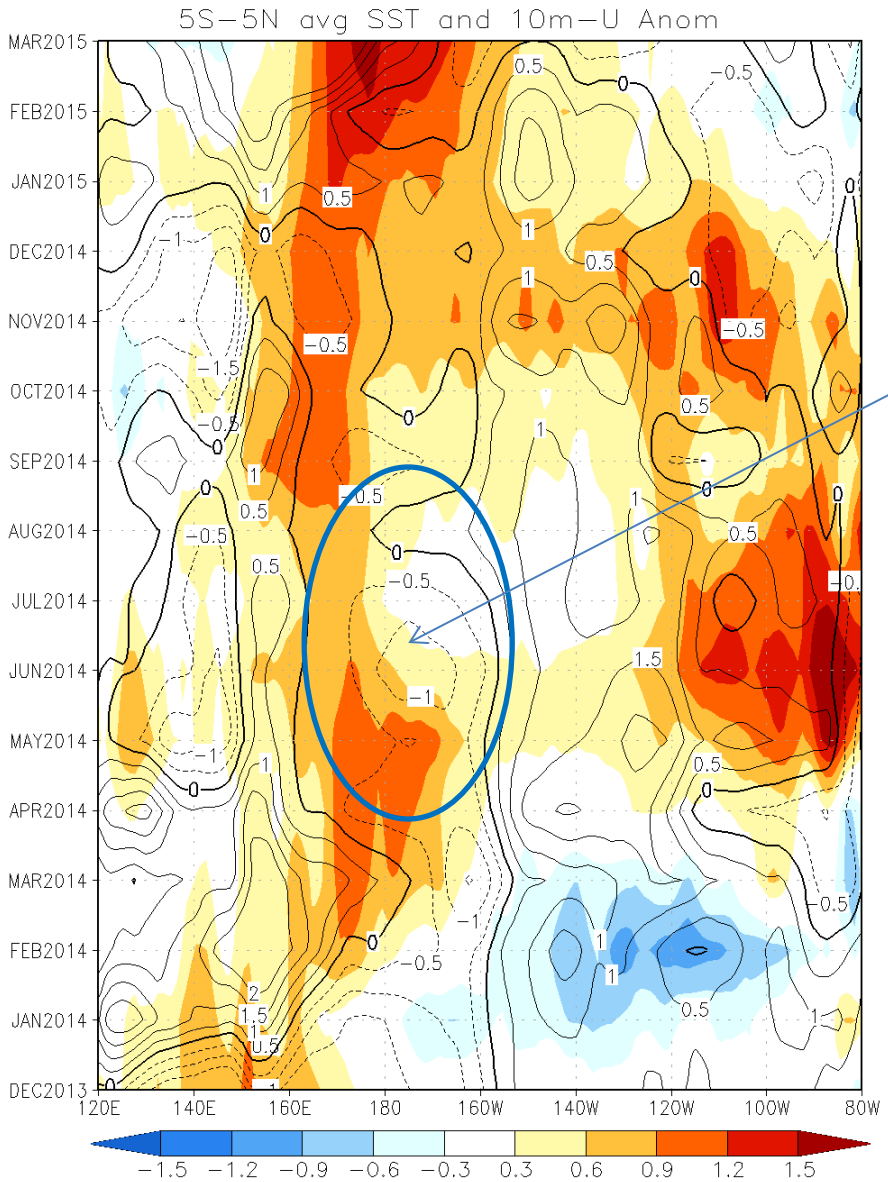
Lagged Correlations: SST & 10m-Wind Lag NPM Index



NPM tends to be a precursor of ENSO (Hartmann 2015): Through wind-evaporation-SST feedback (WES) and with climatological seasonal cycle, the anomalies associated with NPM propagate to the equator and trigger an ENSO event in the following winter.

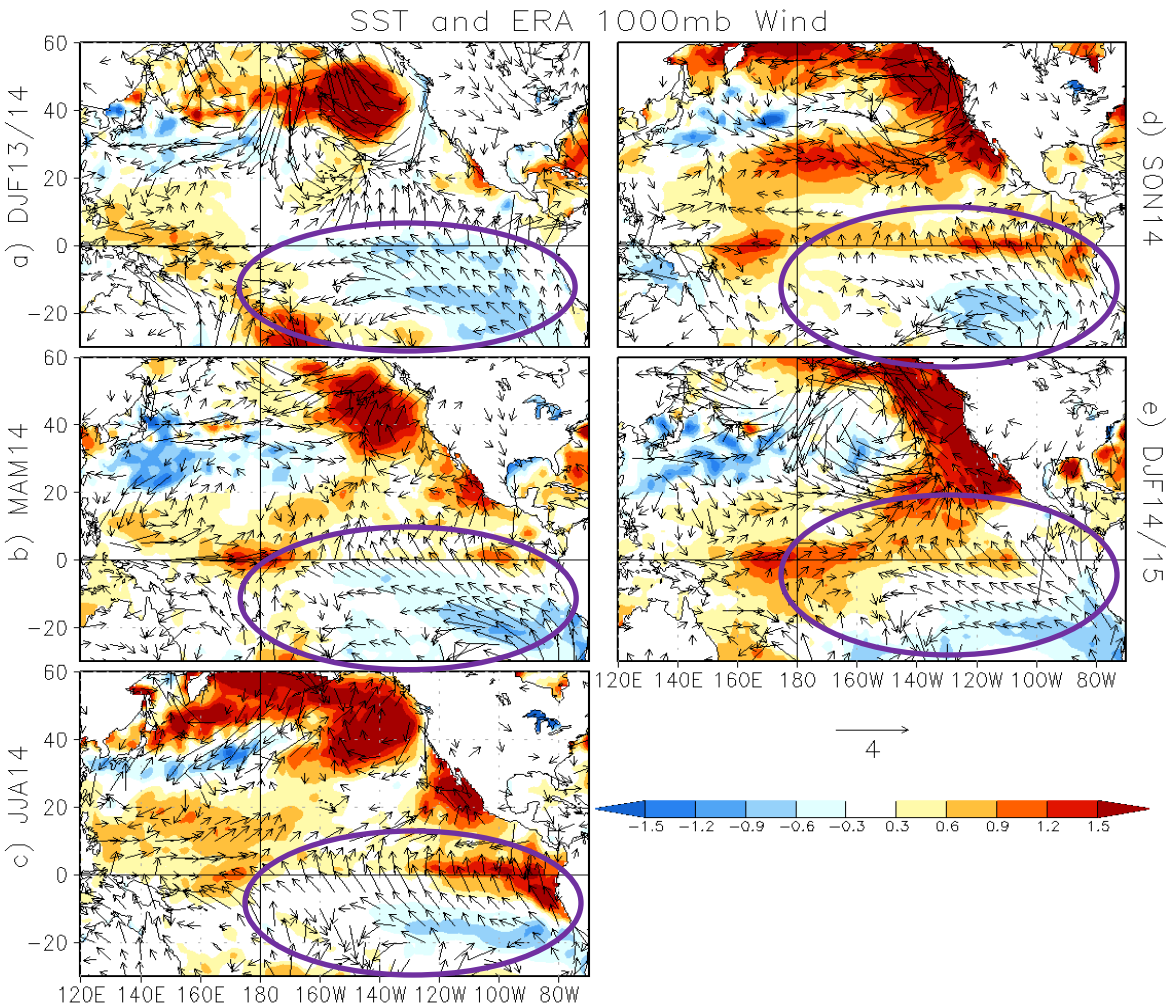
JJA westerlies in equatorial Pacific is crucial for an ENSO development ("seasonal footprinting Mechanism", Vimont et al. 2003)

Evolution of Equatorial Pacific Surface Wind and SST



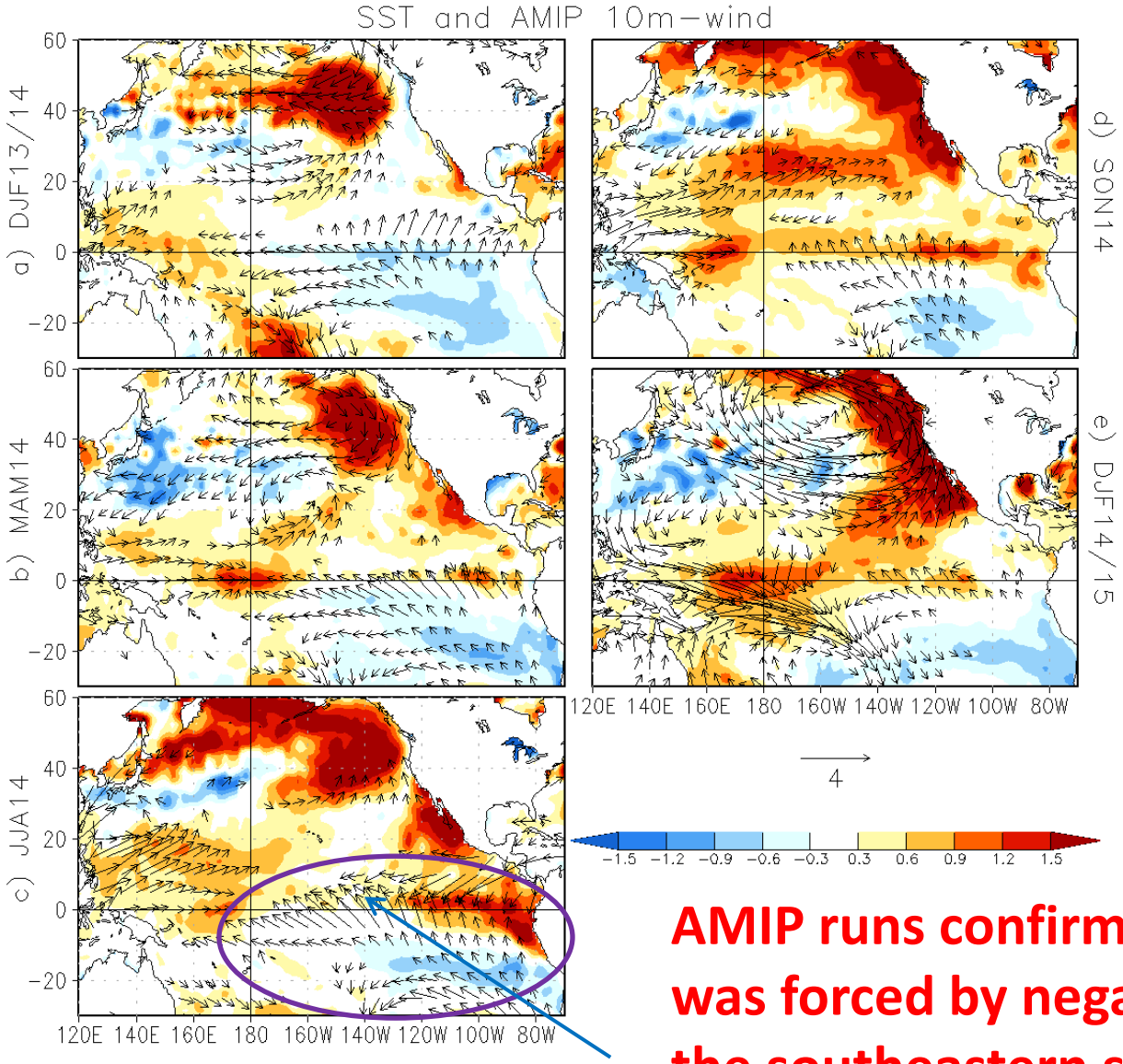
However, anomalous easterlies prevailed in AMJJA 2014, thus hindered El Nino development.

Where were the equatorial easterlies from?



The anomalous southeasterly seems related to the negative SST anomalies in the southeastern subtropical Pacific (Min et al 2015)

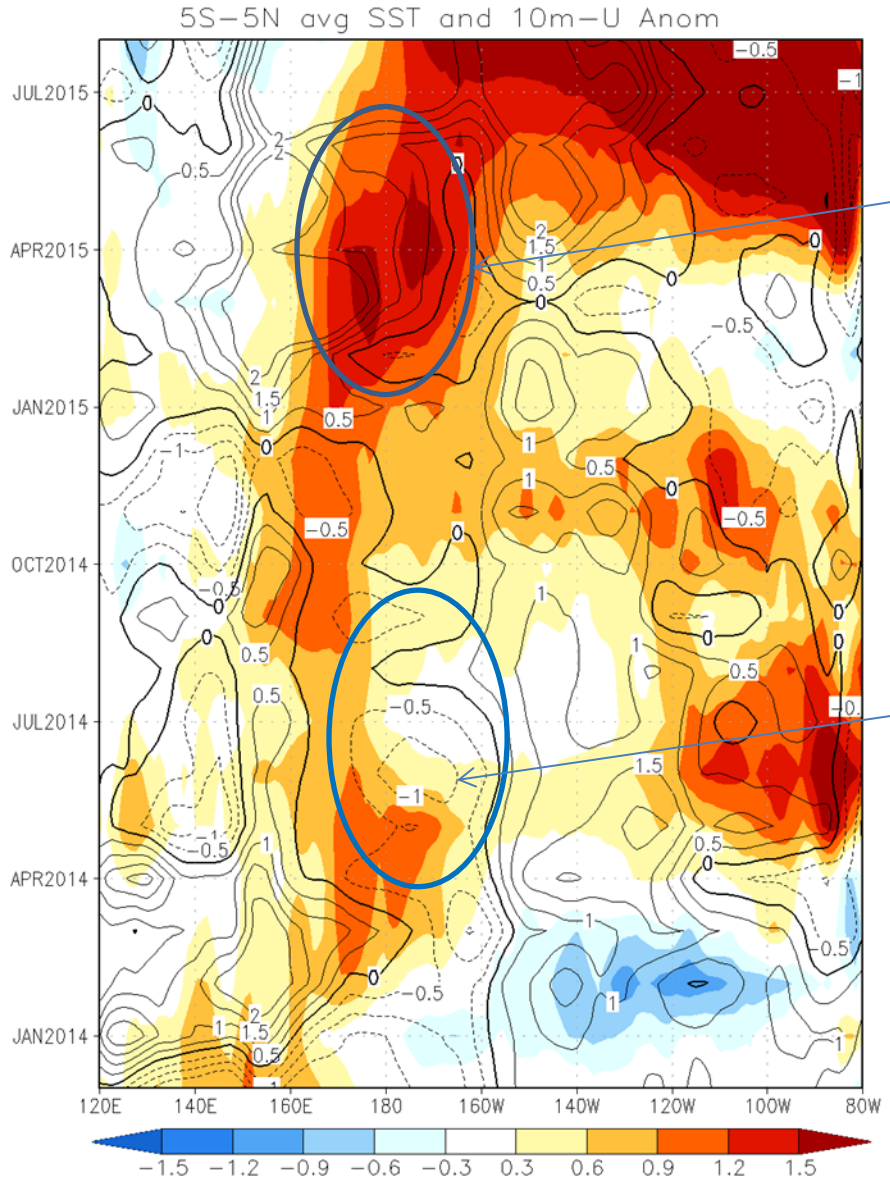
Evidence from AMIP Simulations



Model: atmospheric component of CFSv2
Forcing: observed SST (NOAA OI SST)
Member # = 18

AMIP runs confirms that southeasterly was forced by negative SST anomalies in the southeastern subtropical Pacific.

Equatorial Pacific Surface Wind and SST from Dec2013 to Aug2015



Westerlies helped ENSO development in 2015

Easterlies hindered ENSO development in 2014

Summary and conclusions

1. The east-west dipole structure of North America climate anomalies was consistent with NPM of Pacific SST;
2. Observed anomaly in the Pacific Ocean was dominated by NPM, and ENSO mode played an important, but secondary role.
3. In the presence of high NPM index in 2013/14 winter, an ENSO development was expected in 2014/15, but it was hindered by the easterly anomalies in the central equatorial Pacific, which was associated with the southeasterly caused by negative SST anomalies in the southeastern subtropical Pacific.