

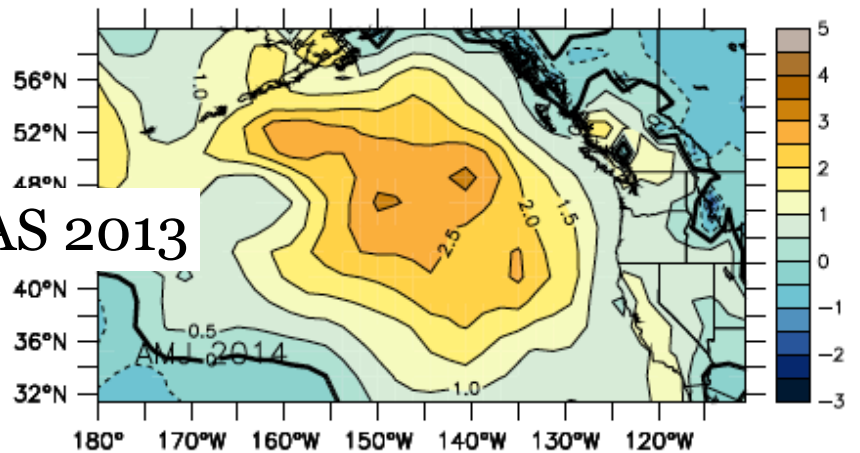
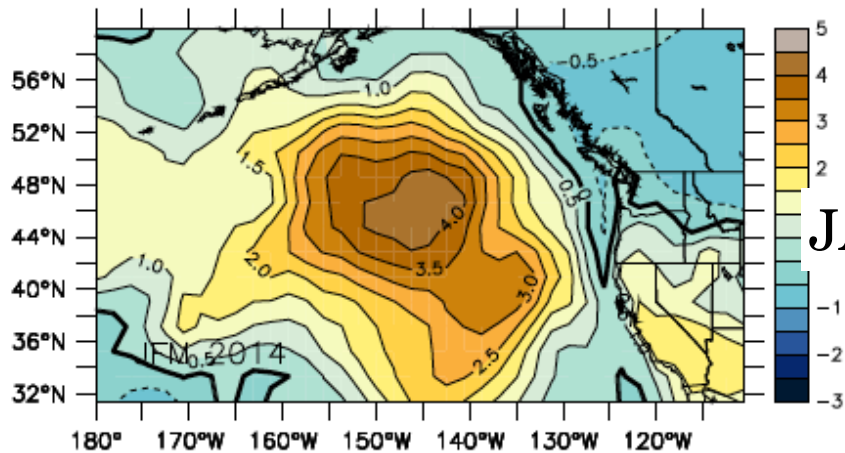
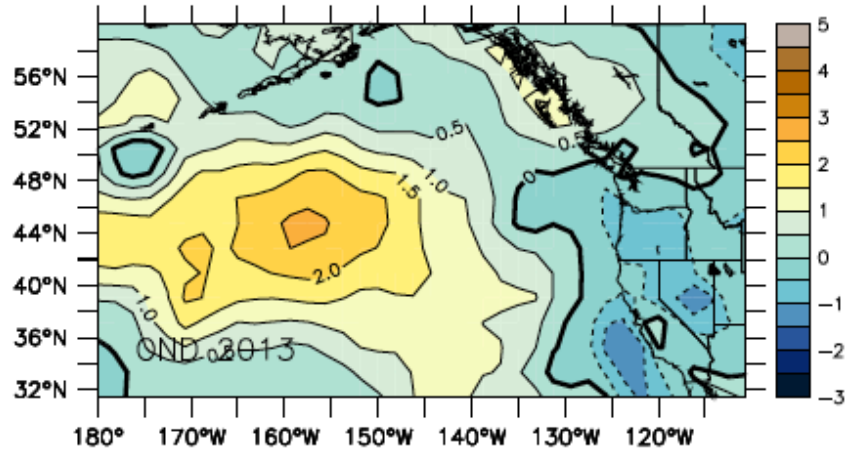
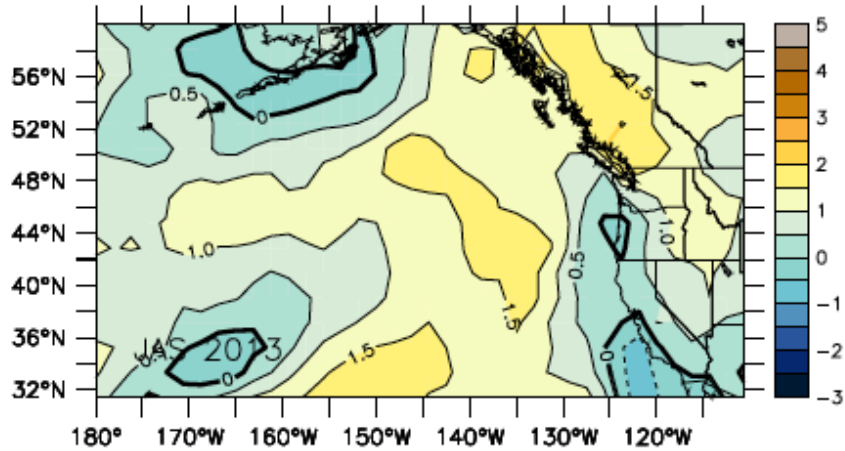
# Recent NE Pacific Warming or: How I Learned to Stop Worrying and Love the Blob

Nick Bond  
UW

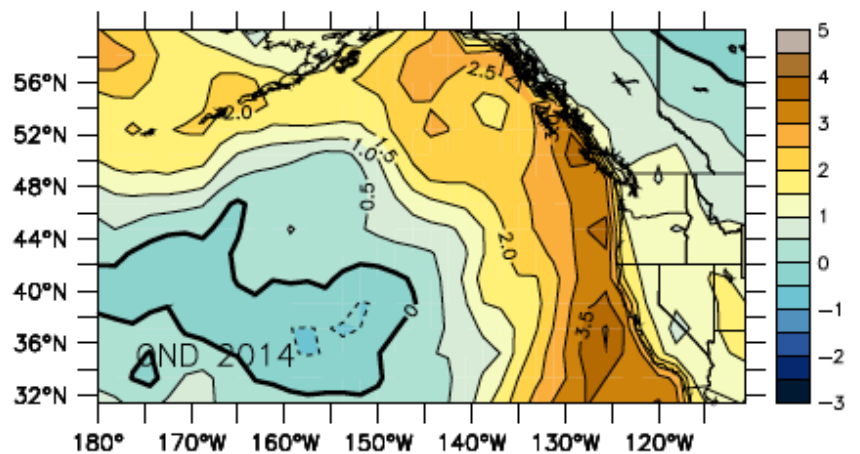
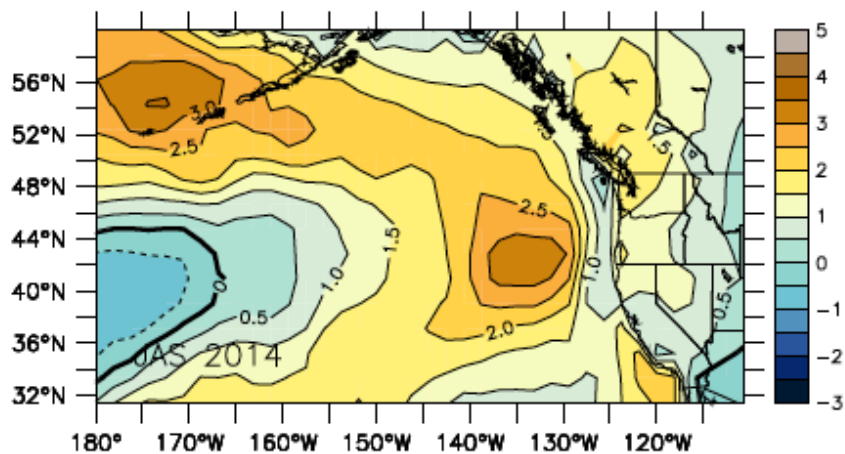


Manu Di Lorenzo  
Georgia Tech





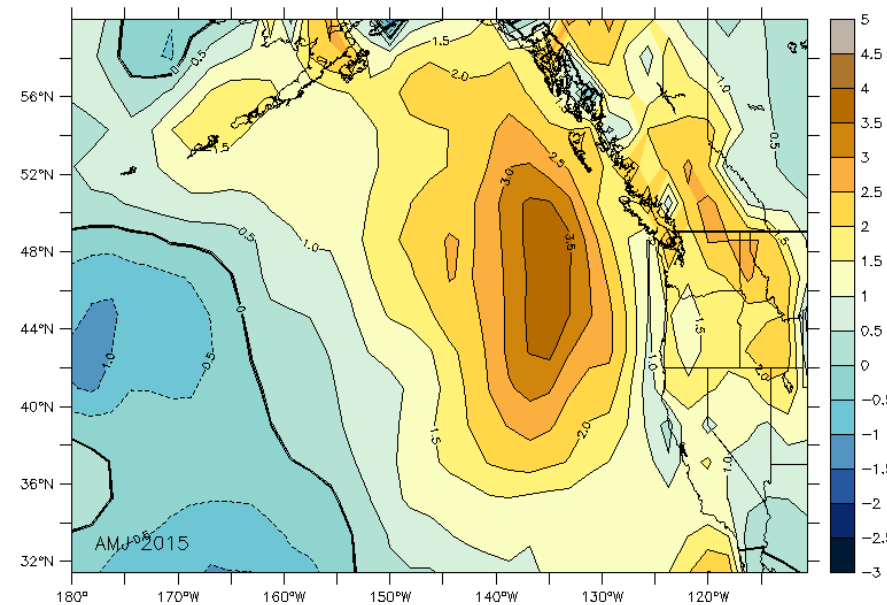
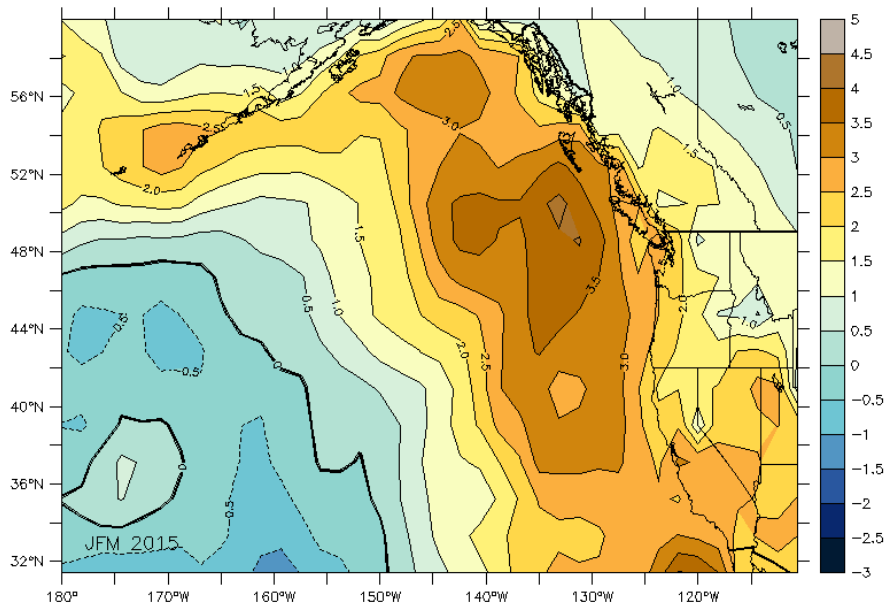
JAS 2013



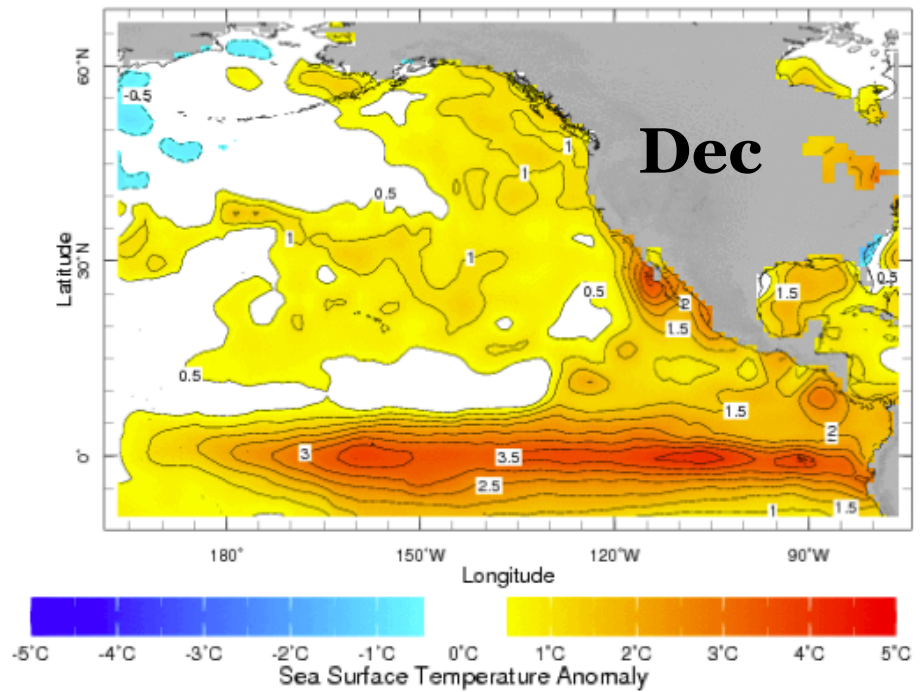
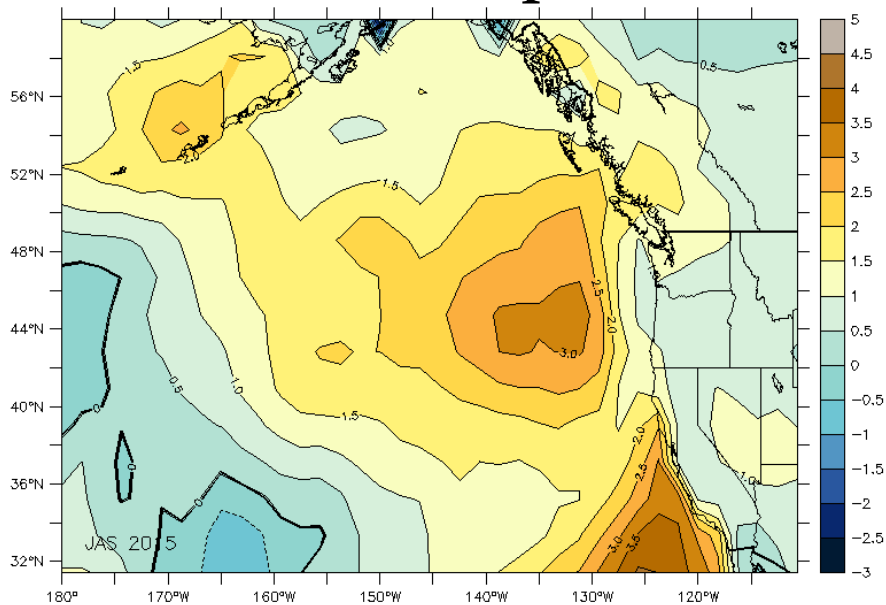
# Jan-Mar

# 2015




# Apr-Jun



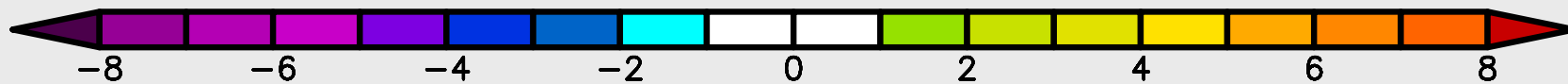
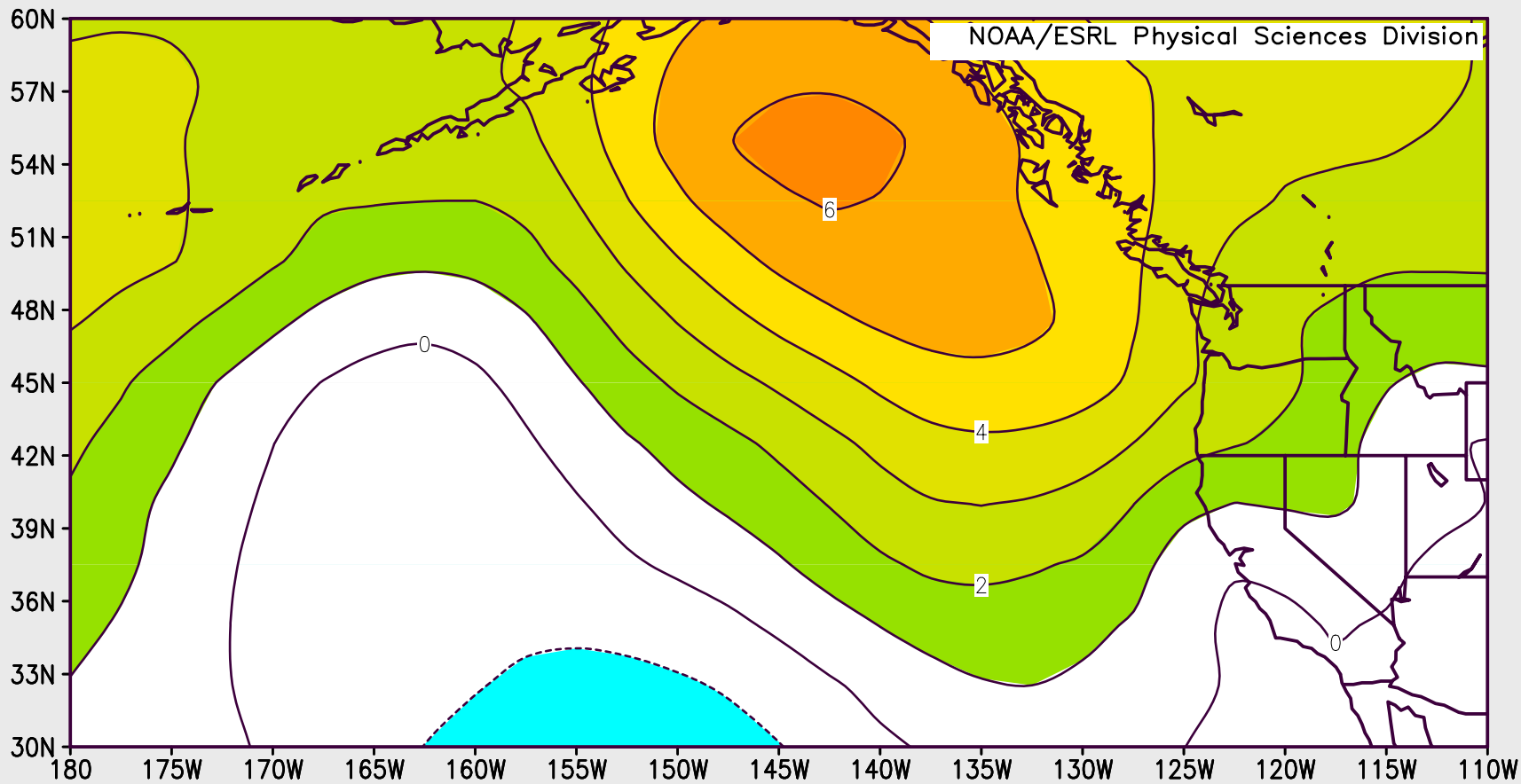
# Jun-Sep



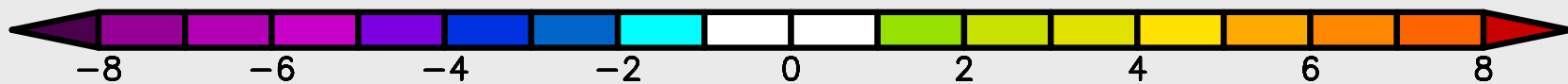
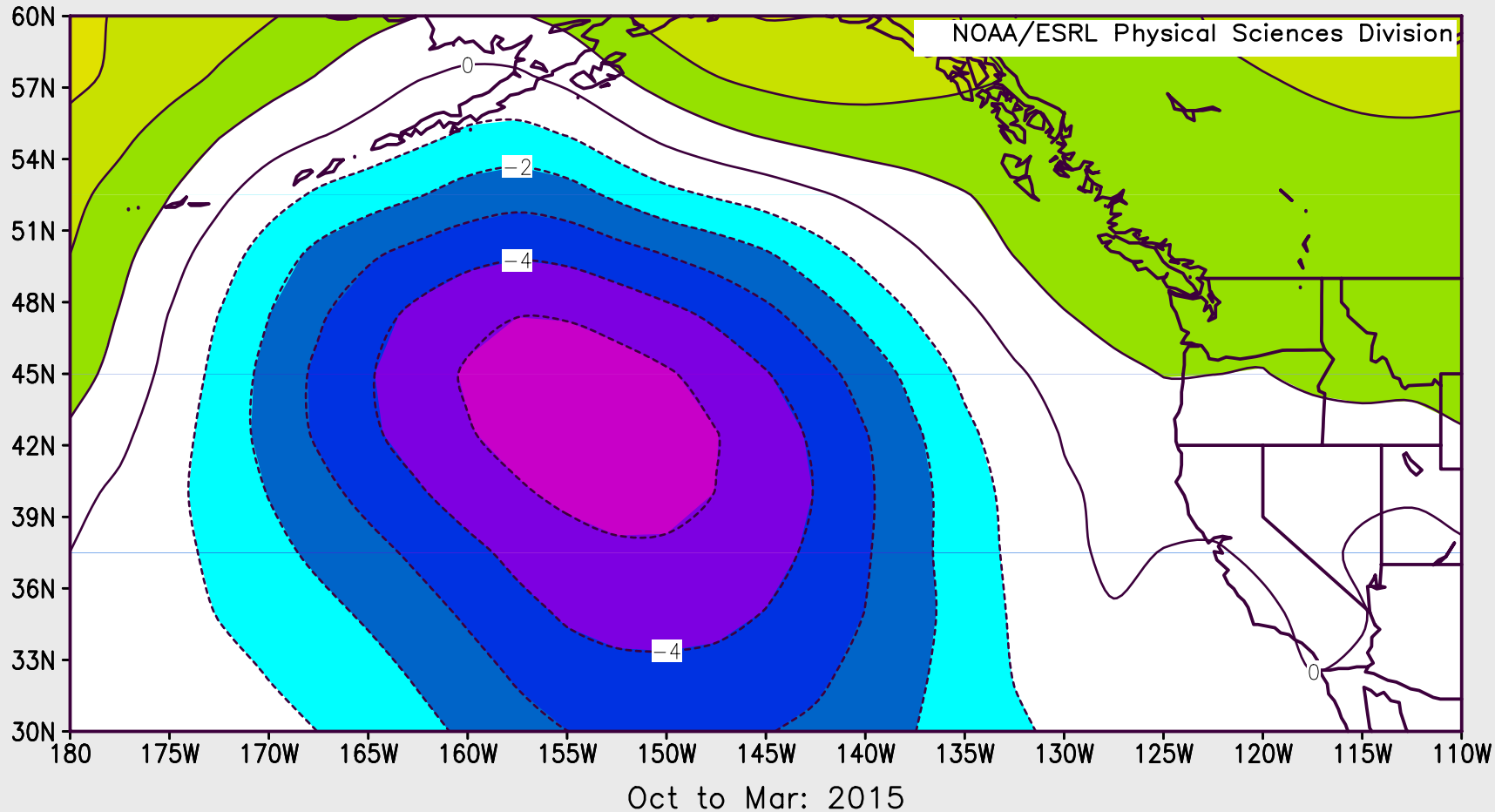
# Points for Discussion

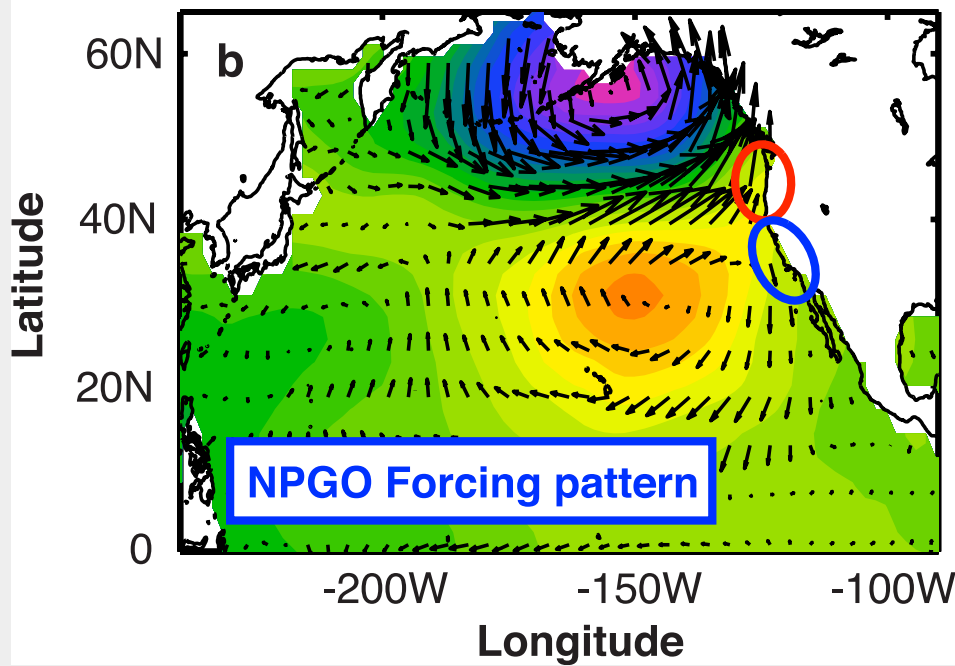
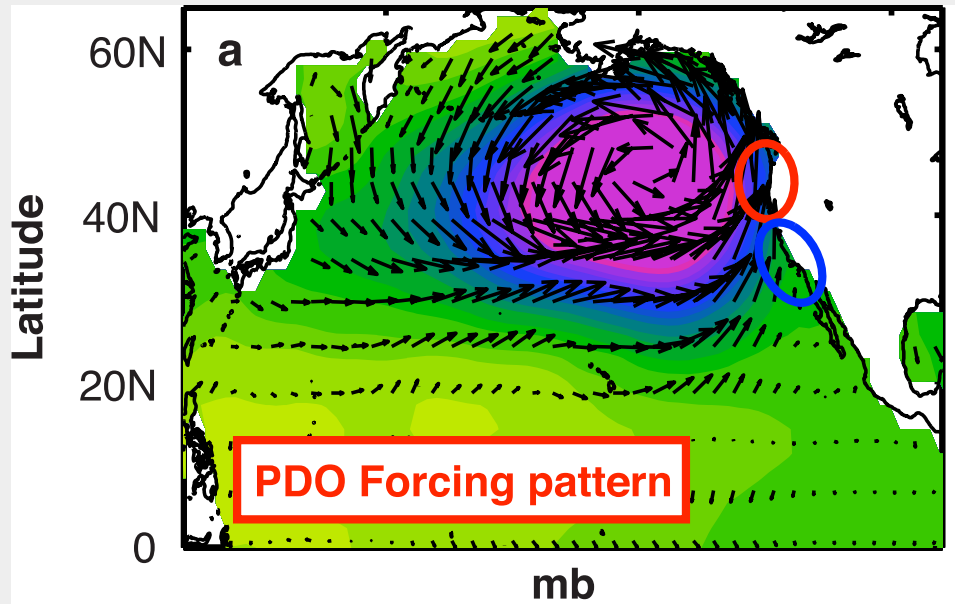
-  How well do we understand the source(s) of climate variability for the winters of 2013-14, 2014-15, 2015-16? How about the summers?
-  How do we assess the extent of the precedence for the current event (in terms of magnitudes)?
-  Does the current event have any relevance/connection to global climate change?

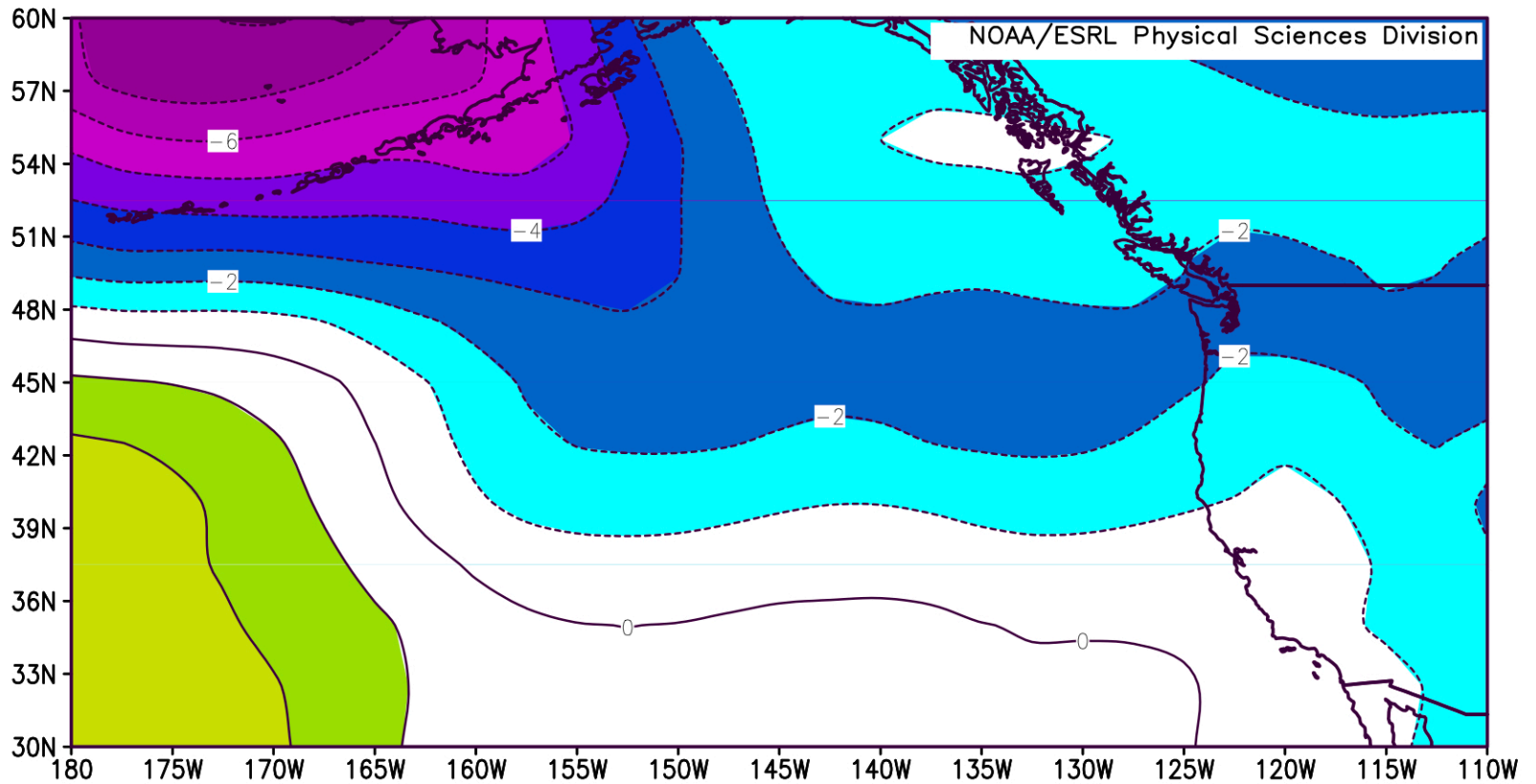
NCEP/NCAR Reanalysis  
Sea Level Pressure (mb) Composite Anomaly 1981–2010 climo



NCEP/NCAR Reanalysis  
Sea Level Pressure (mb) Composite Anomaly 1981–2010 climo





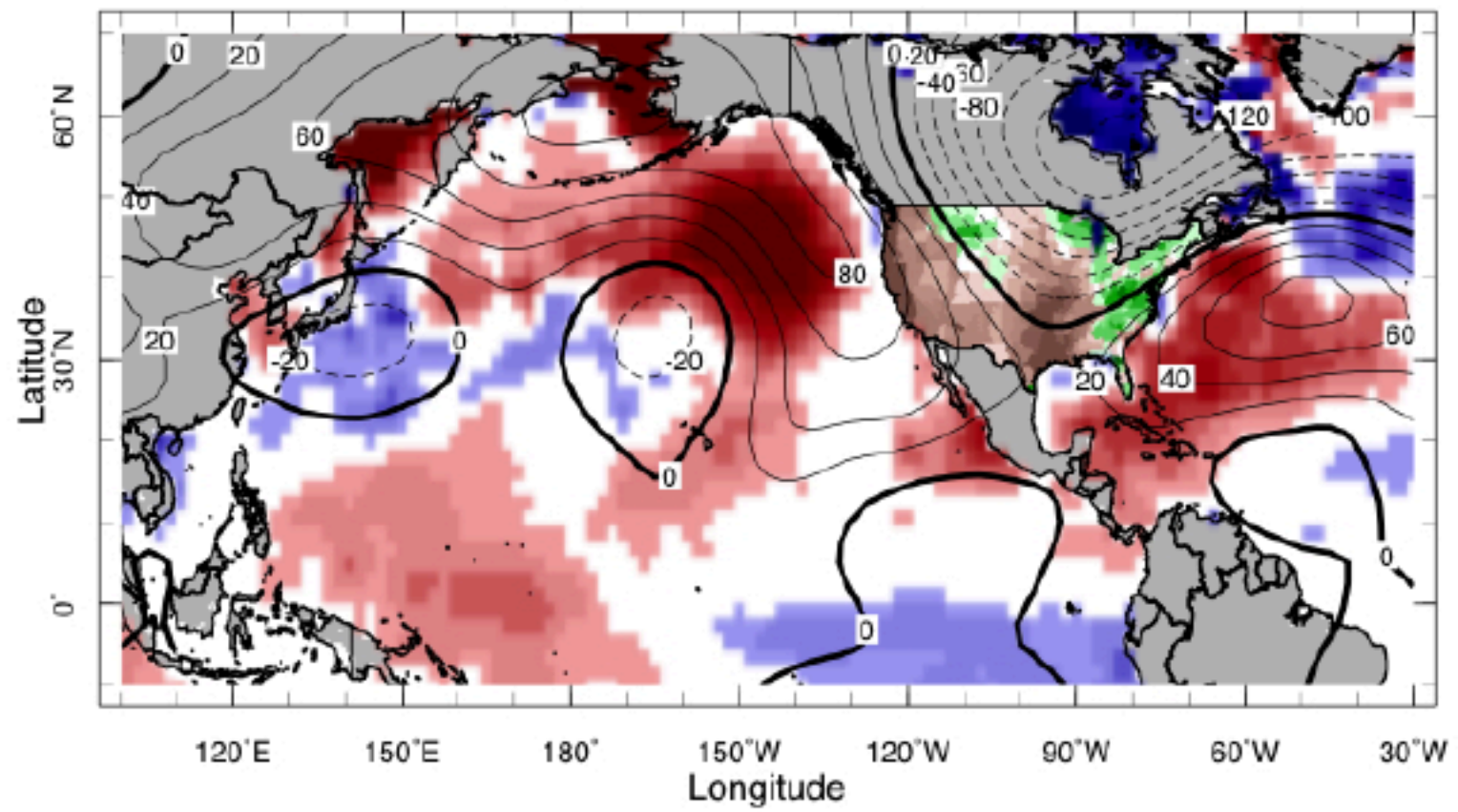




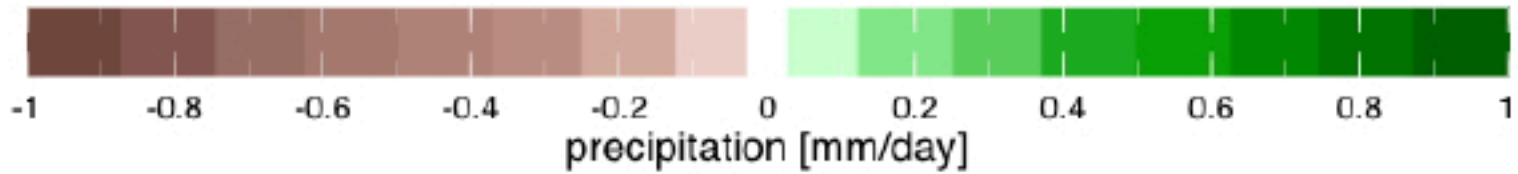
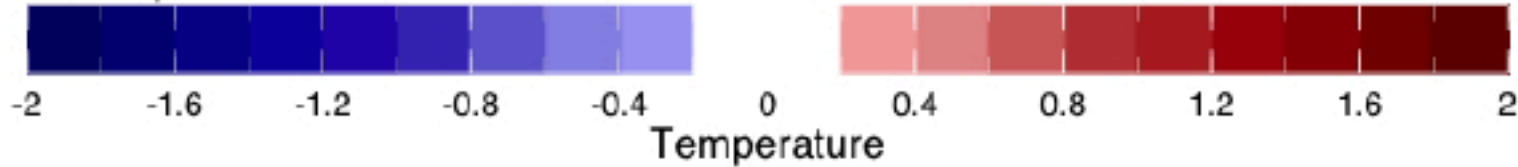
# Observed 200 hPa Z, SST & Precipitation Anomalies

(c) 2013-2014

Seager et al. (2015)



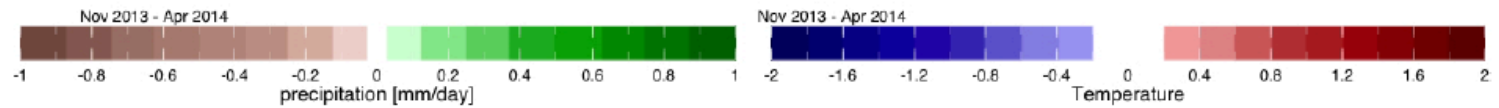
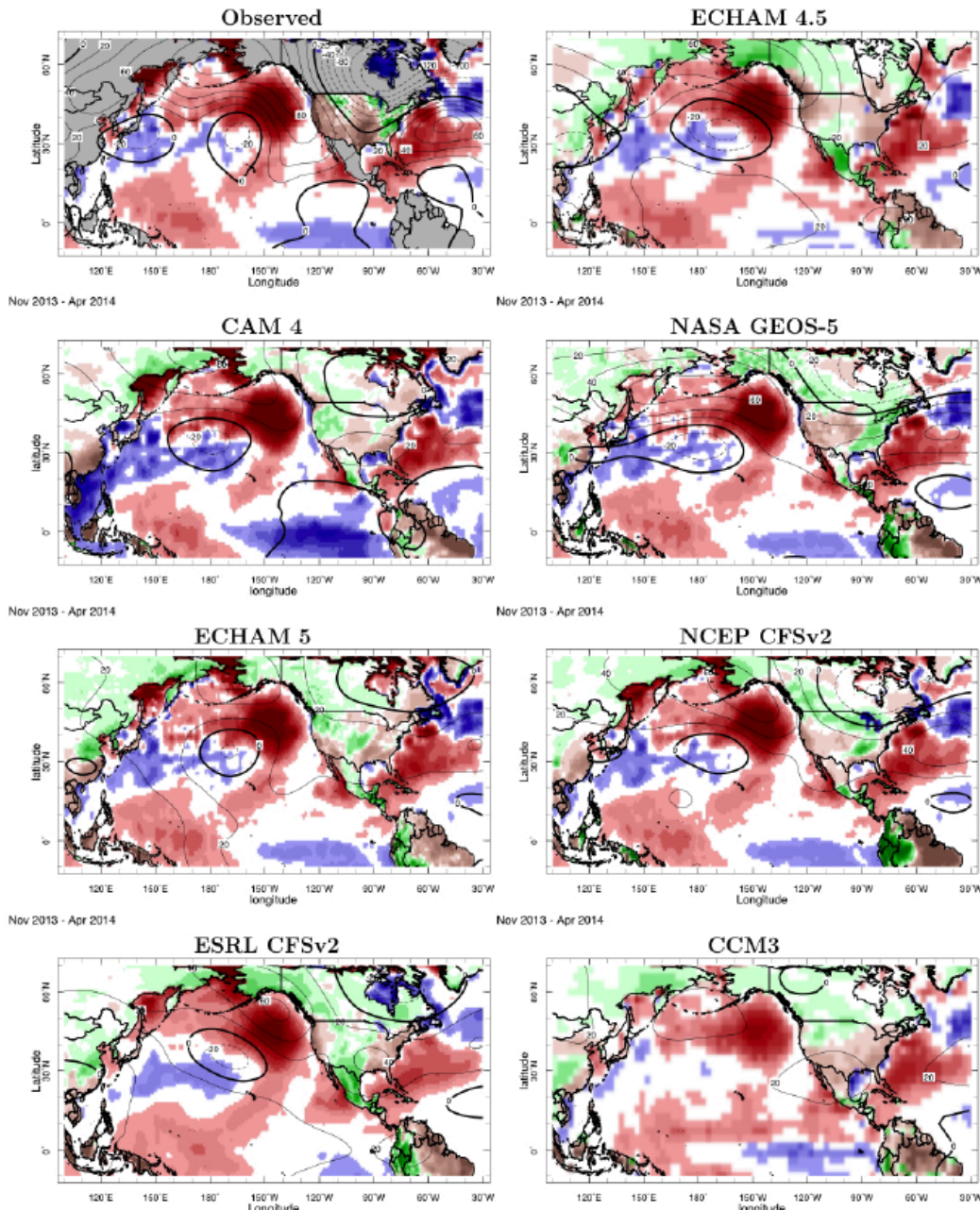
Nov 2013 - Apr 2014



**FIGURE 9**

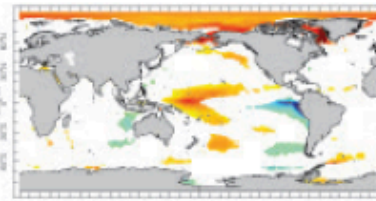
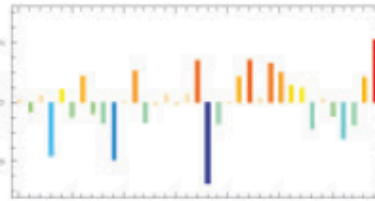
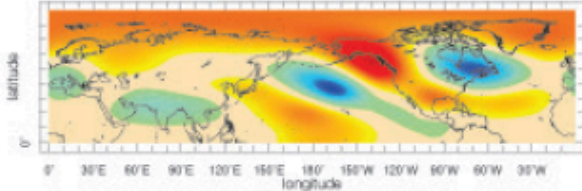
**Winter 2013-14 SSTA  
(ocean), Precip (land), 200  
mb Height (contour)**

Same as Figure 6 but for the winter of  
November 2013 to April 2014.

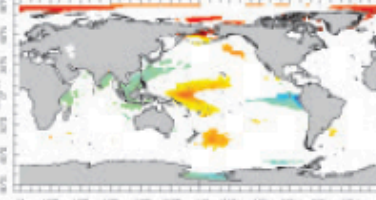


# Model Anomalies w/ EOF3 SST

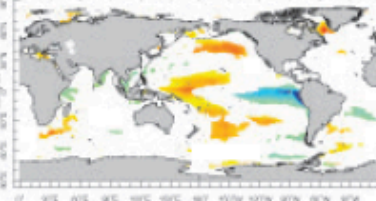
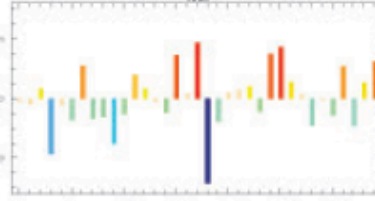
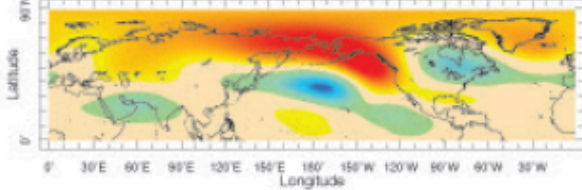
## ECHAM 4.5



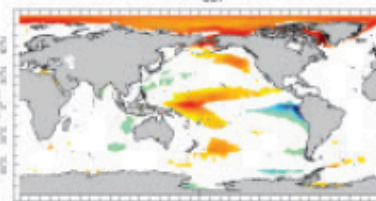
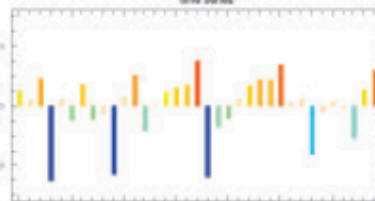
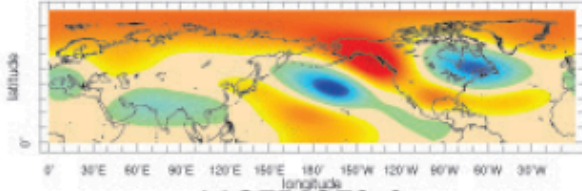
## CAM4



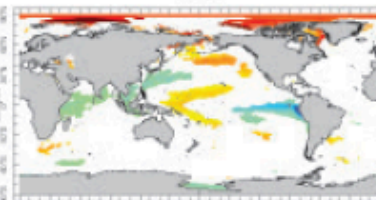
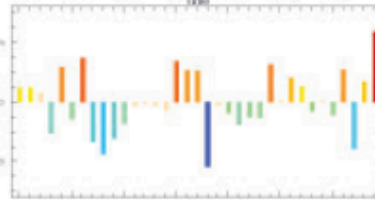
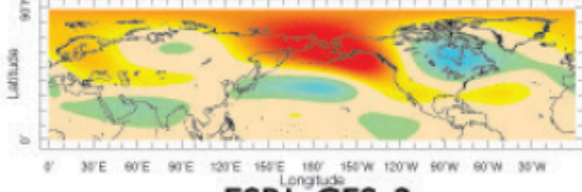
## NASA GEOS-5



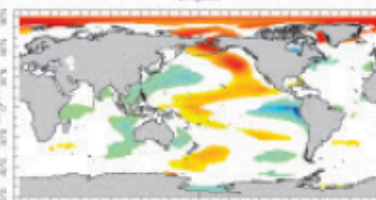
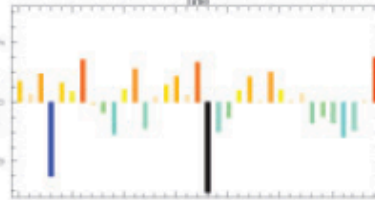
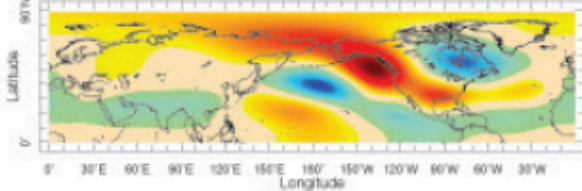
## ECHAM 5



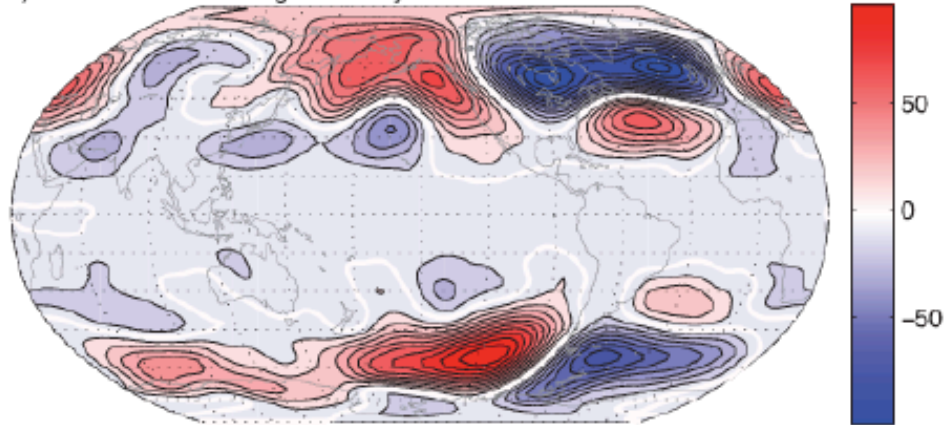
## NCEP CFSv2



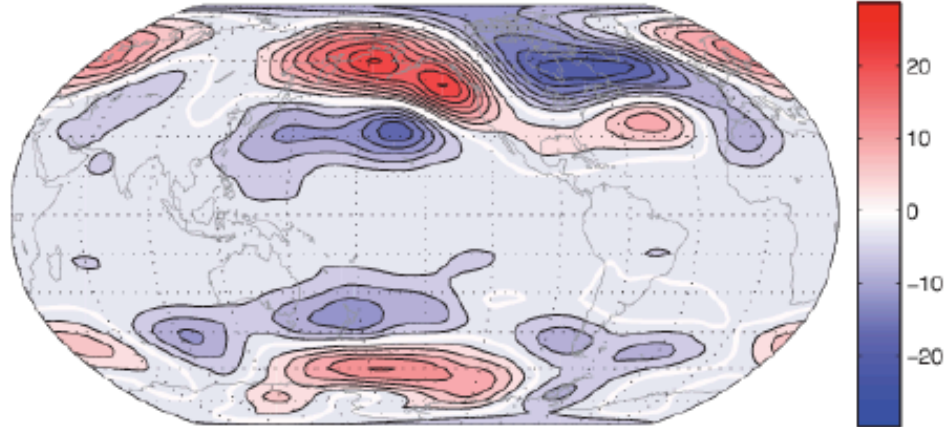
## ESRL CFSv2



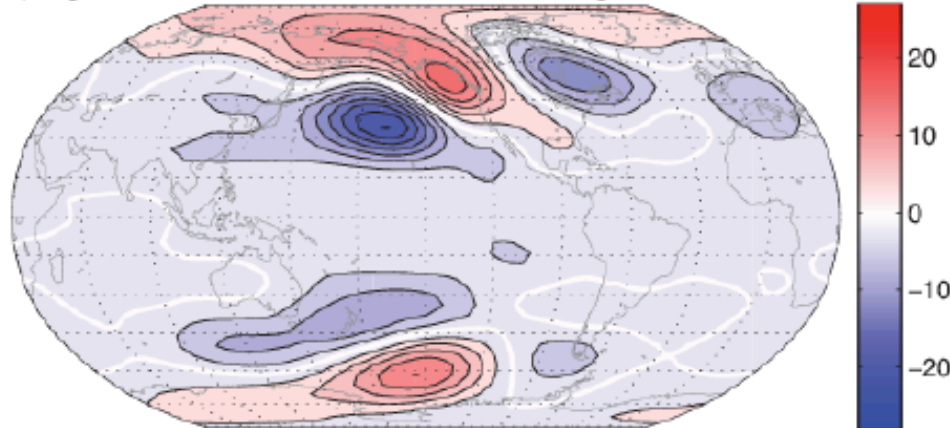
a) Observed 500 hPa Height Anomaly Nov-March 2013-14

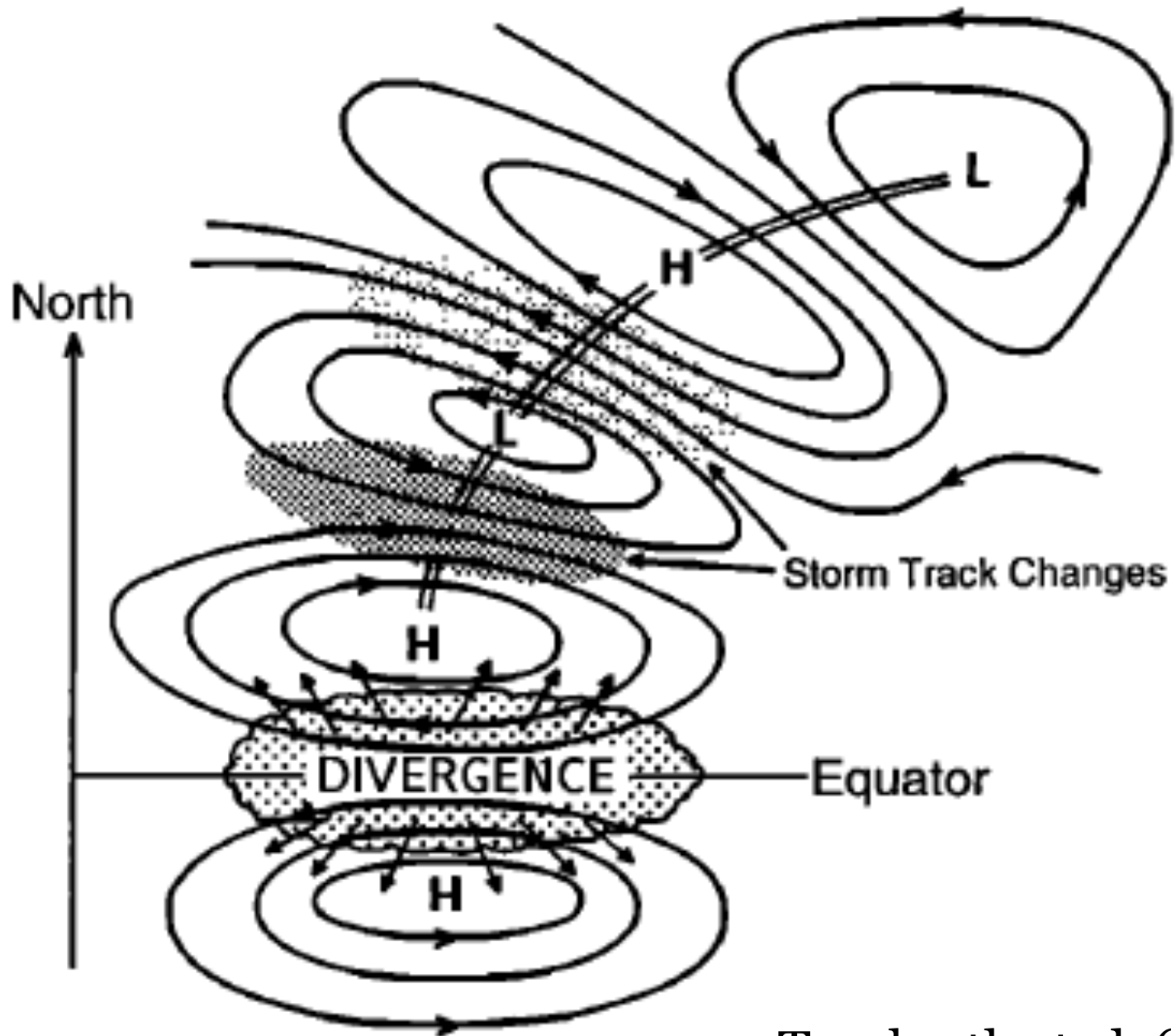


b) Regression of NCEP/NCAR Reanalysis onto EOF2 of global SST 1979-2014



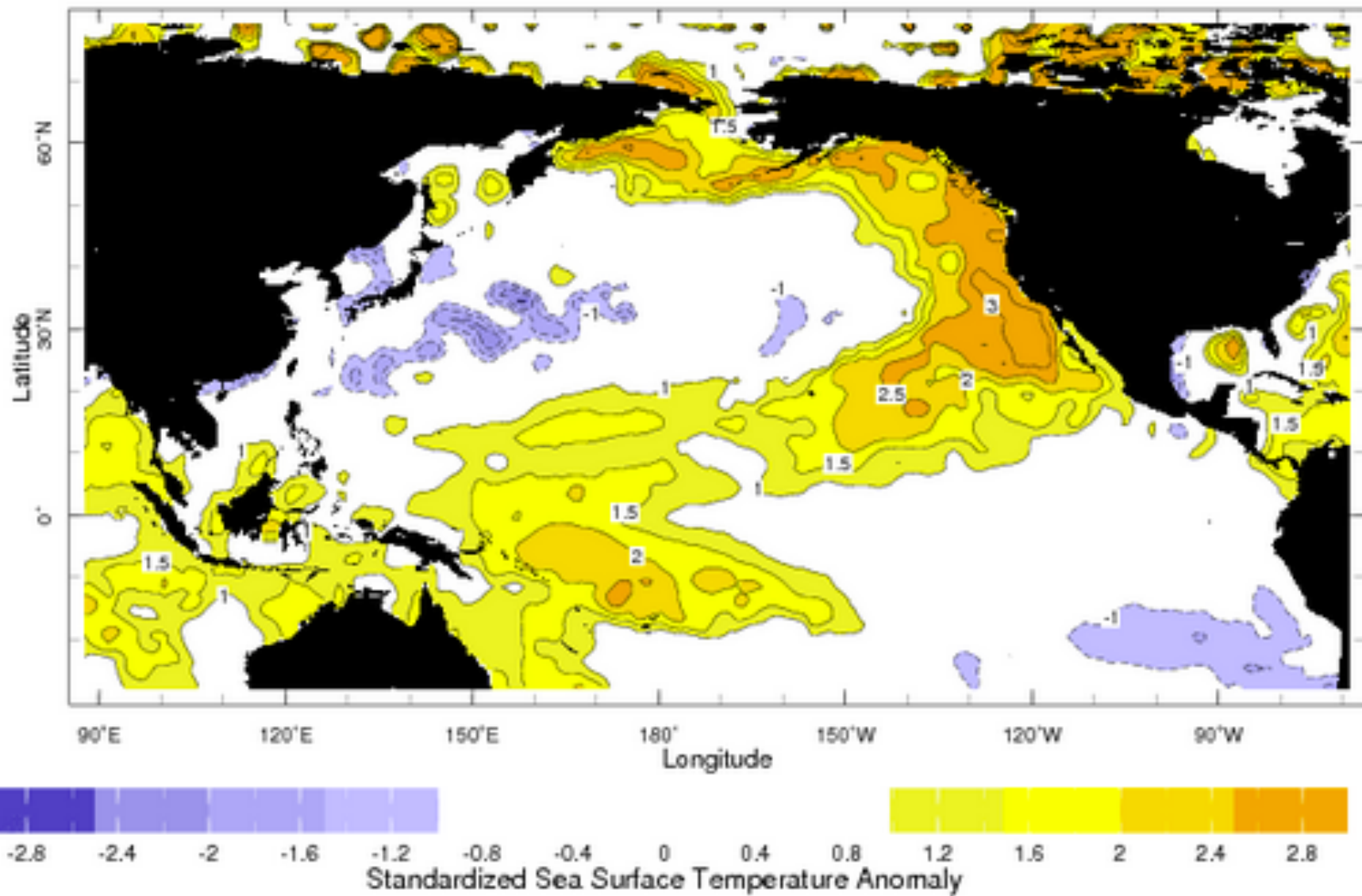
c) Regression of ESRL-GFSv2 Ensemble onto EOF2 of global SST 1979-2014





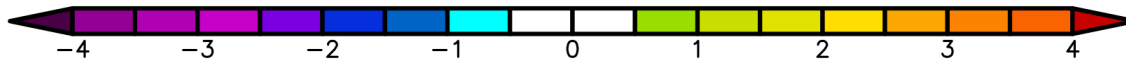
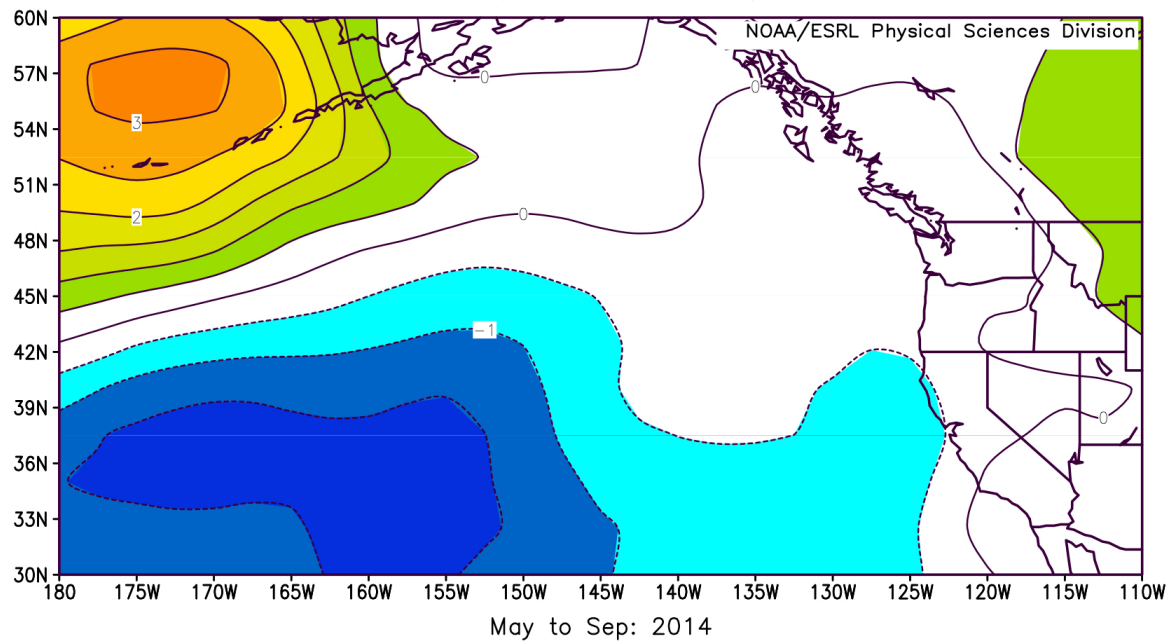
Trenberth et al. (1998)

Dec 2014 - Feb 2015



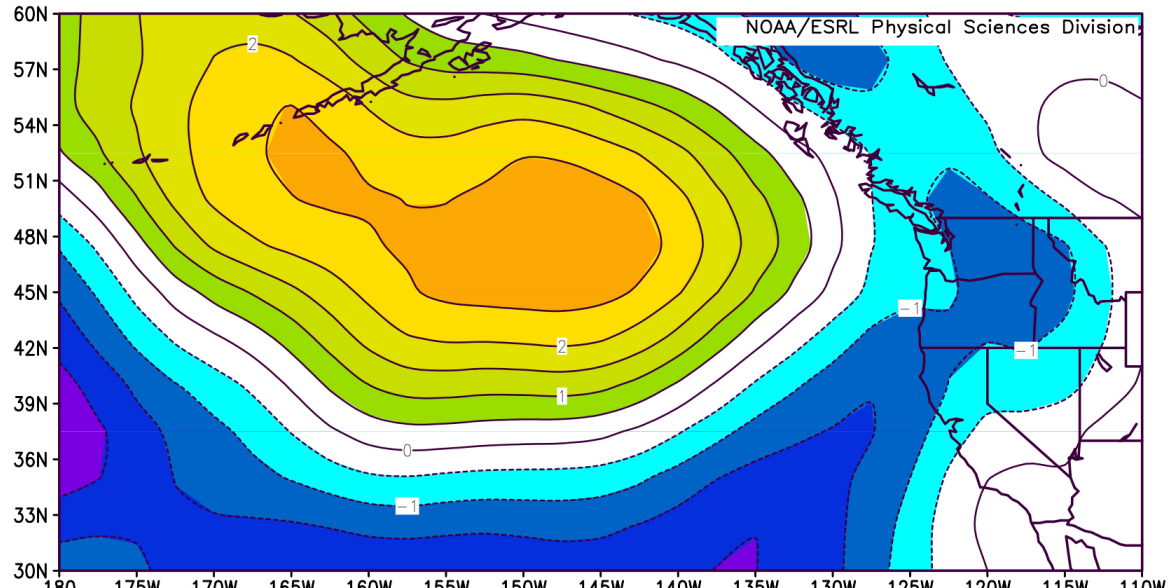
# SLP Anomalies

## May-Sep 2014



NCEP/NCAR Reanalysis

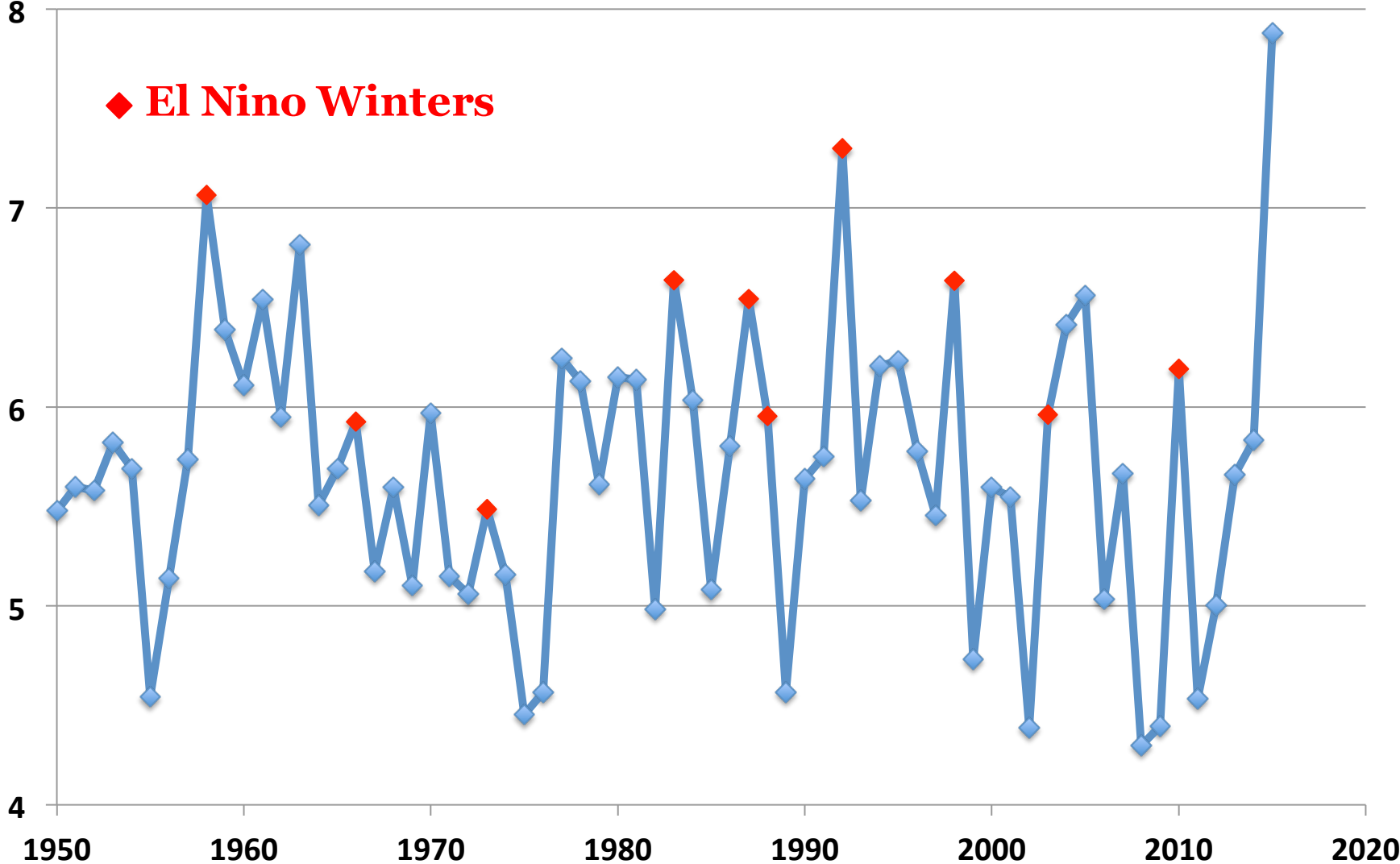
Sea Level Pressure (mb) Composite Anomaly 1981–2010 climo



## May-Sep 2015

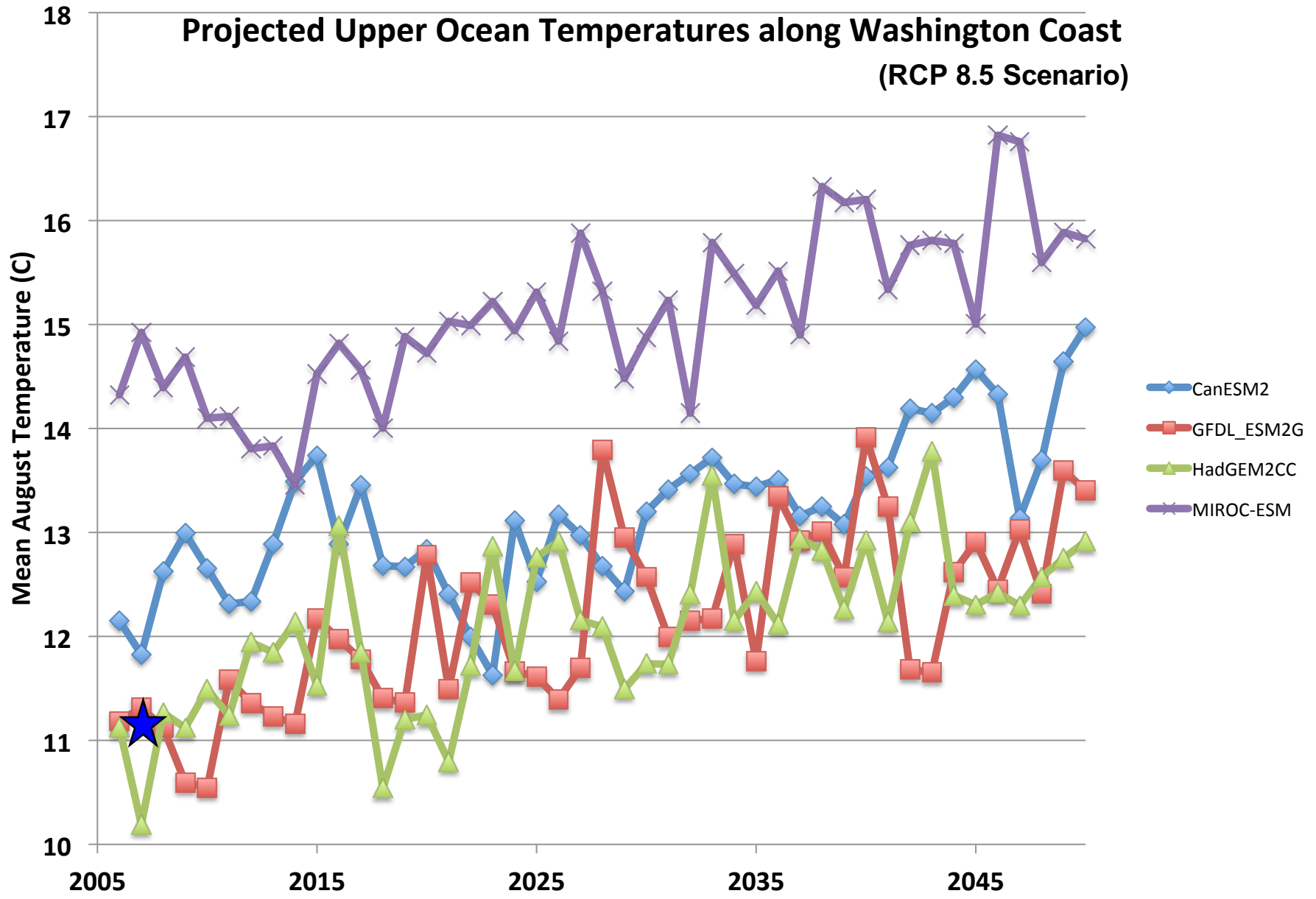
# Pacific NW Near Coastal SST (Feb-Apr)

◆ El Nino Winters








# Projected Upper Ocean Temperatures along Washington Coast (RCP 8.5 Scenario)



# Points for Discussion

-  How well do we understand the source(s) of climate variability for the winters of 2013-14, 2014-15, 2015-16? How about the summers?
-  How do we assess the extent of the precedence for the current event (in terms of magnitudes)?
-  Does the current event have any relevance/ connection to global climate change?

Puget Sound, 2045...



YEAH, I MISS THE SALMON, TOO, BUT YOU GOTTA ADMIT GLOBAL WARMING HAS BROUGHT US SOME COOL NEW SPECIES!

© 2005  
HORSEY  
PULLMAN, WA  
WWW.HORSEY.COM

WARMING OCEANS



MONSTER EL NIÑO

BAKED ALASKA

BURNING RAIN FORESTS!

TOXIC RED TIDE

BIGGEST EVER

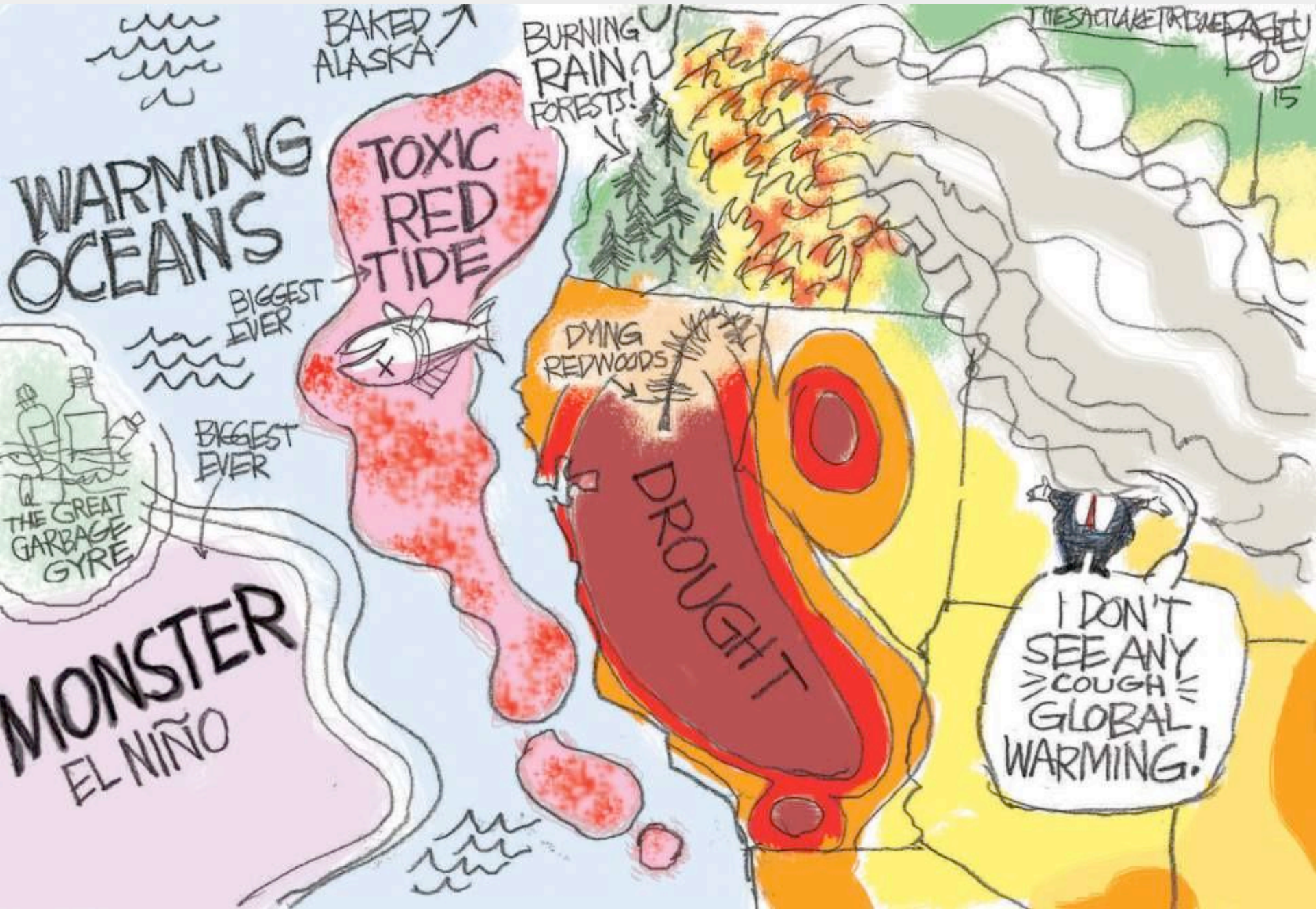
BIGGEST EVER

DYING REDWOODS

DROUGHT

I DON'T SEE ANY COUGH GLOBAL WARMING!

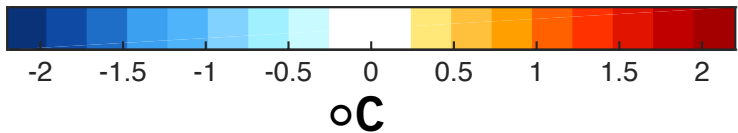
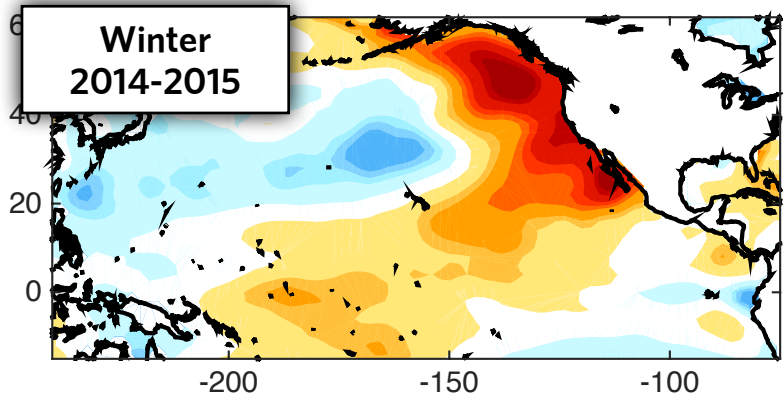
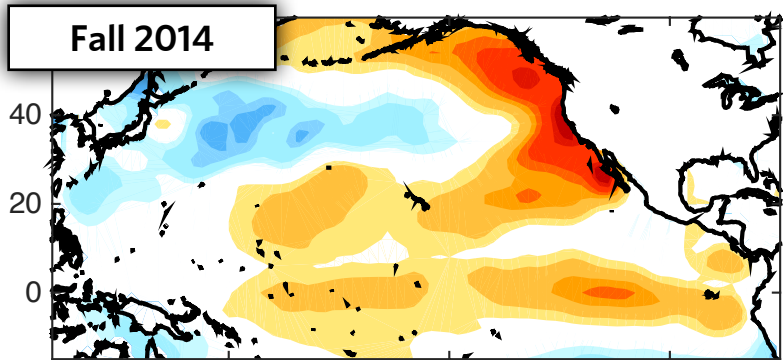
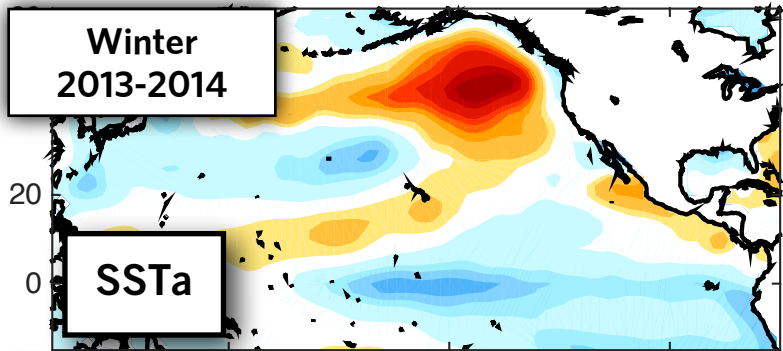
THE SACTAKE TRIMES ACTU 15





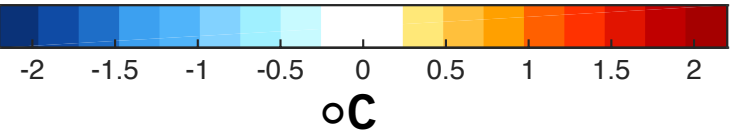
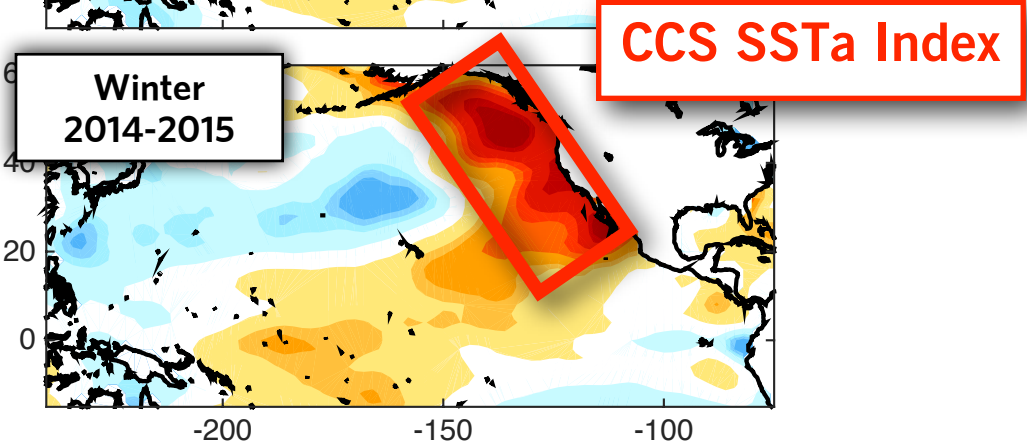
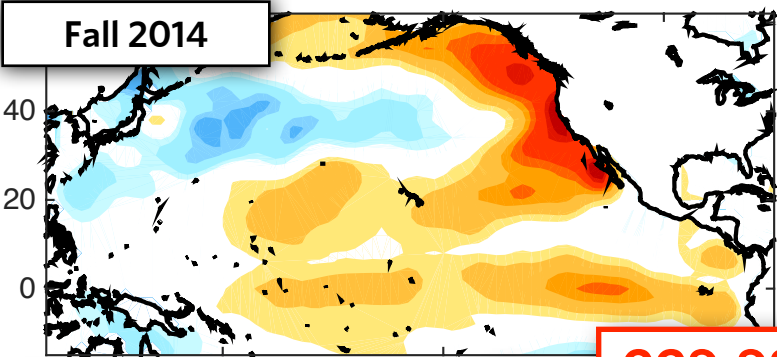
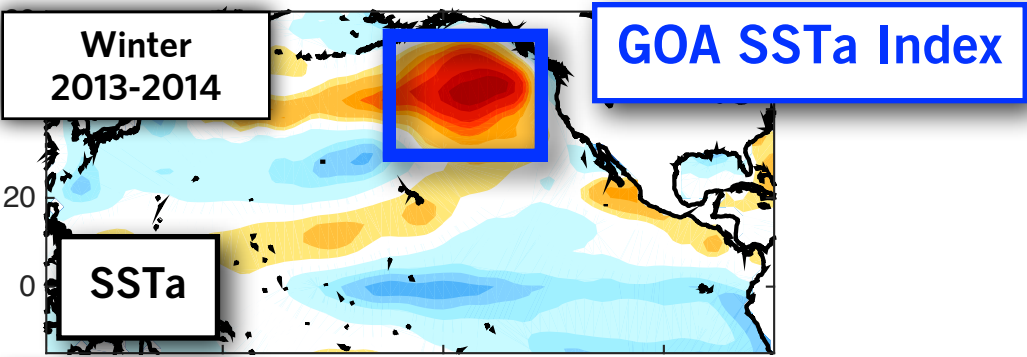
## QUESTION

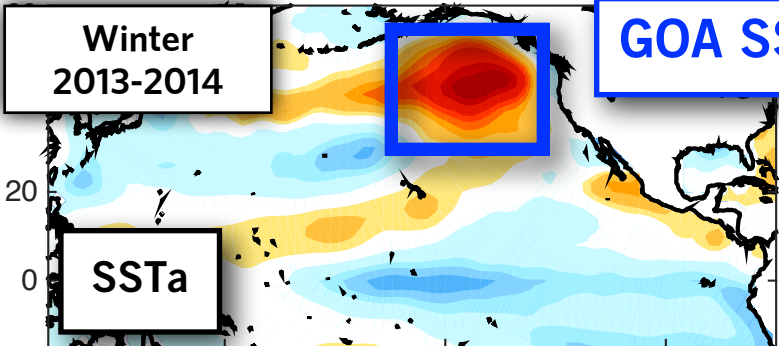
What are the precedents for this prolonged warming event?



Warm Blob

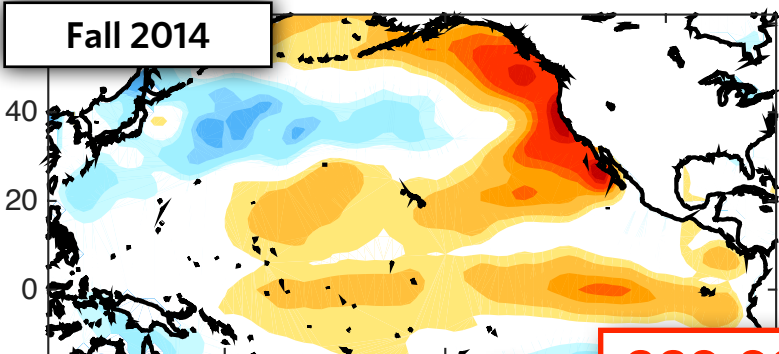
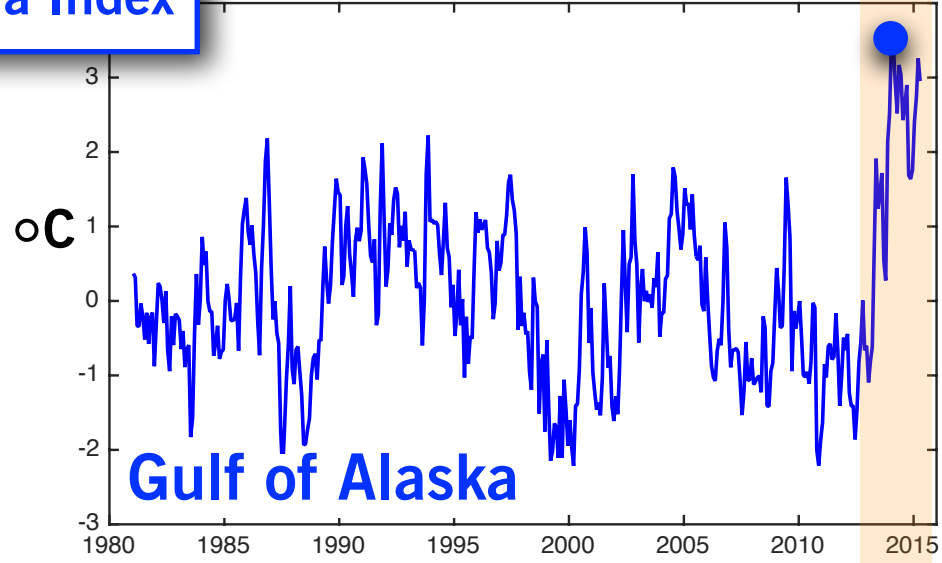
Evolution and persistence





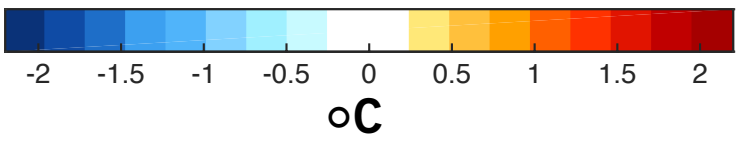
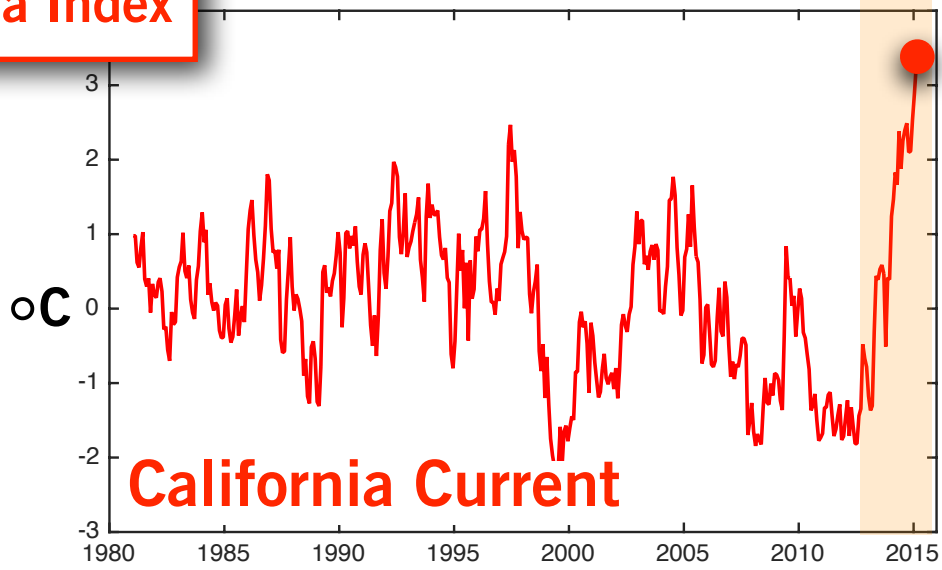
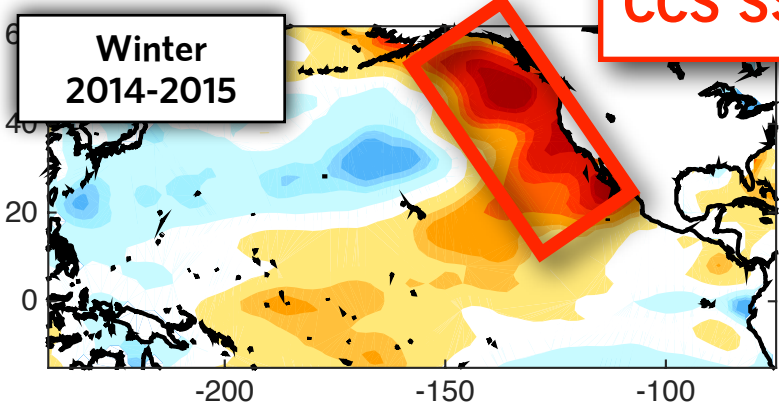
**GOA SSTa Index**

**JFM 2014**



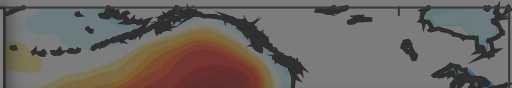
**CCS SSTa Index**

**JFM 2015**

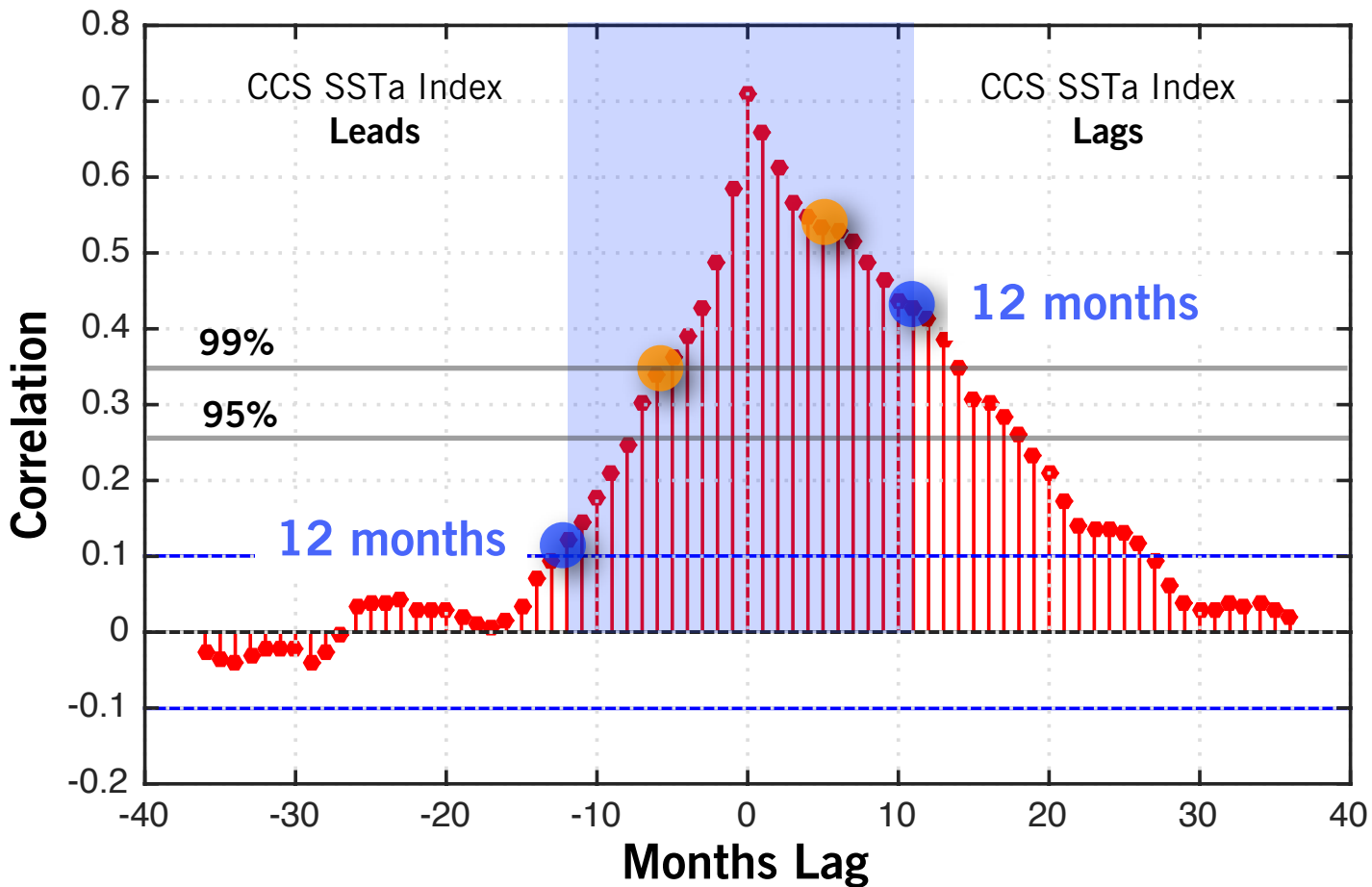




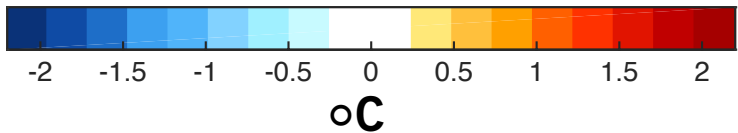
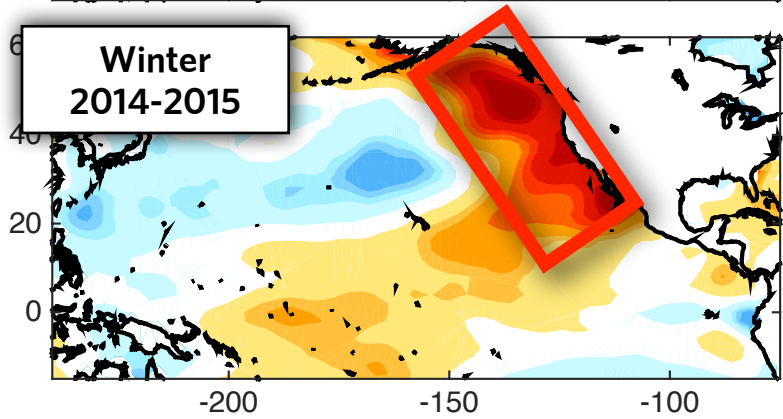
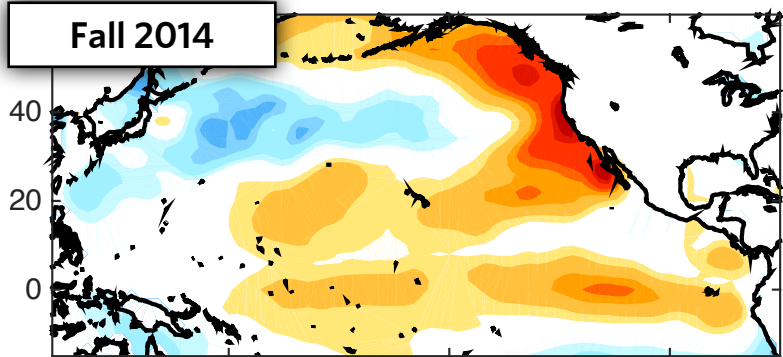
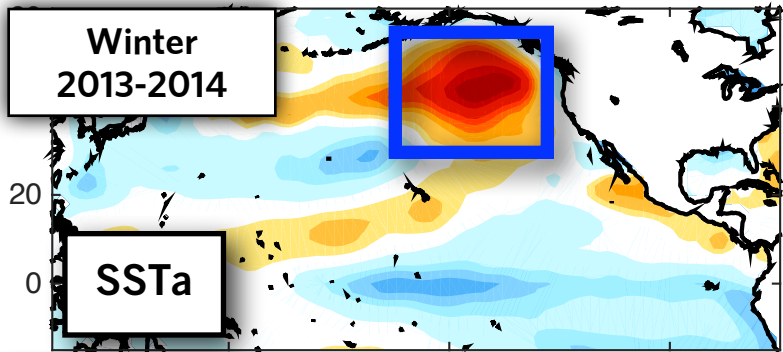
Winter  
2013-2014



## Cross Correlation GOA SSTa vs. CCS SSTa



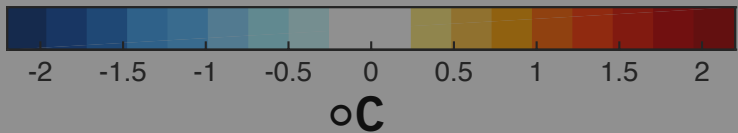
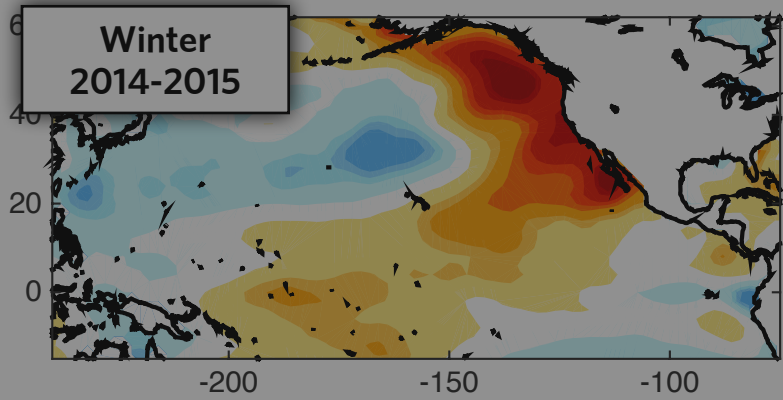
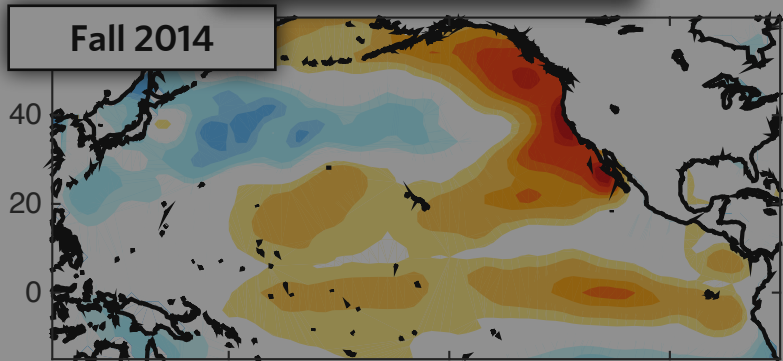
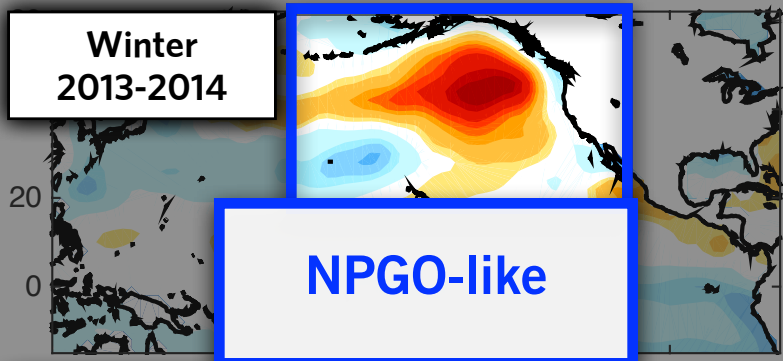
°C



Warm Blob

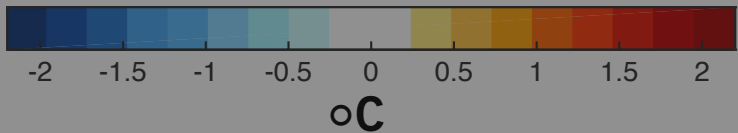
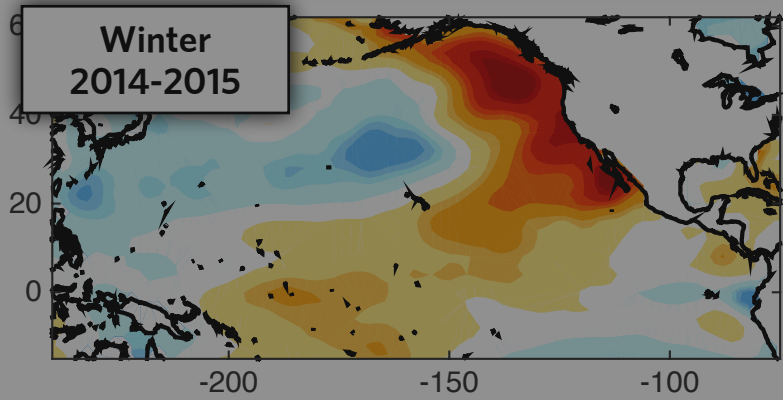
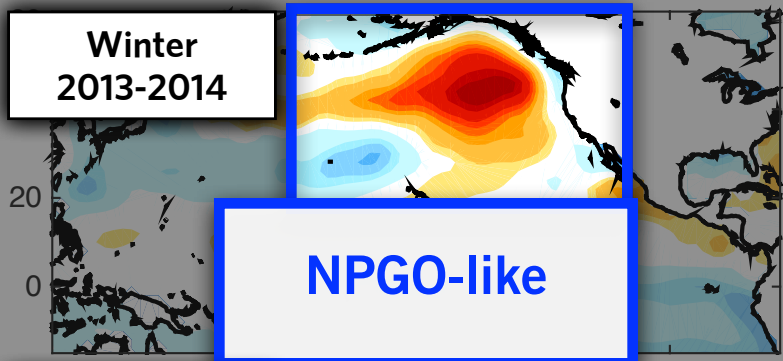
Evolution and persistence





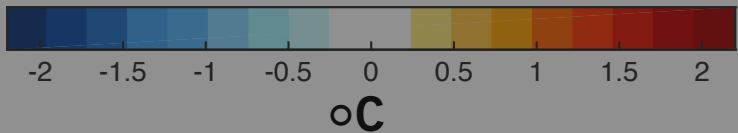
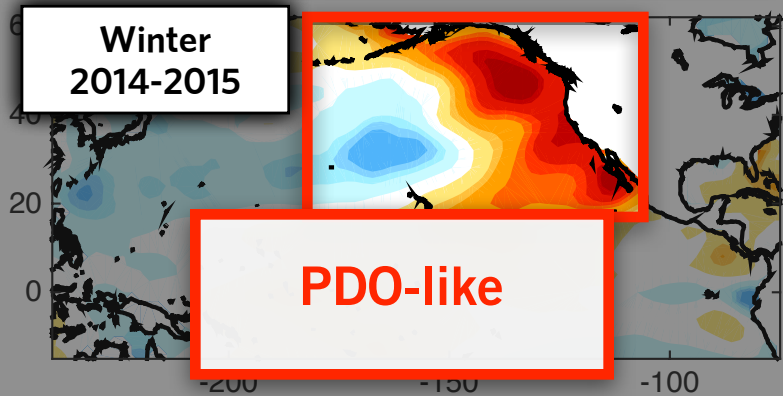
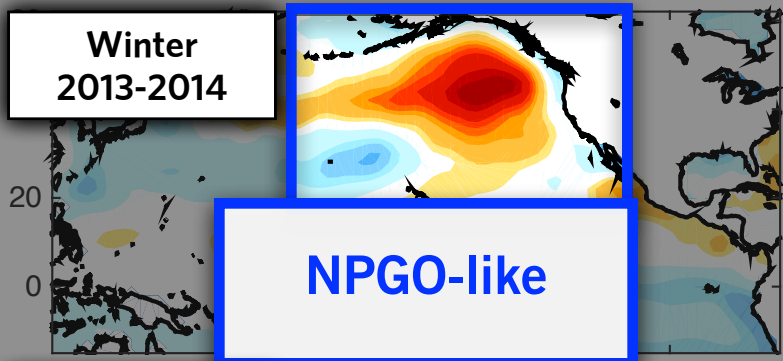
Warm Blob

Evolution and persistence



Warm Blob

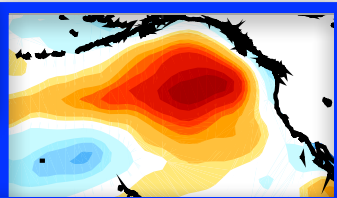
Evolution and persistence



Warm Blob

Evolution and persistence

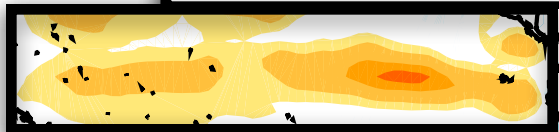
Winter  
2013-2014



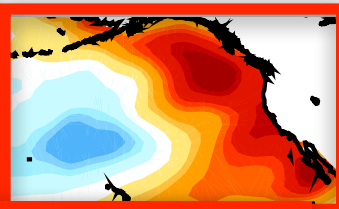
NPGO-like

Fall 2014

ENSO-like



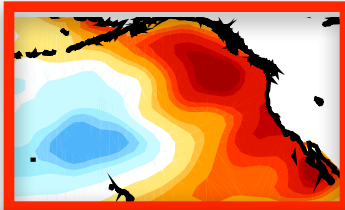
Winter  
2014-2015



PDO-like

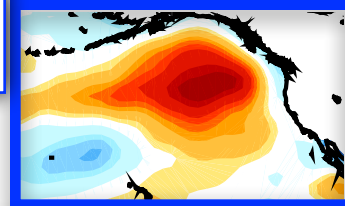
# A Climate Hypothesis (Interpretation)

Winter  
2014-2015



PDO-like

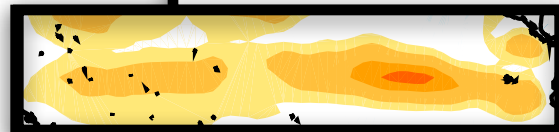
Winter  
2013-2014



NPGO-like

Fall 2014

ENSO-like

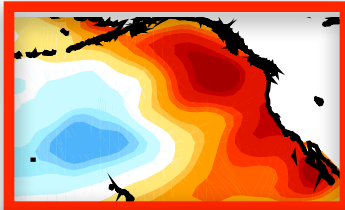




# A Climate Hypothesis (Interpretation)

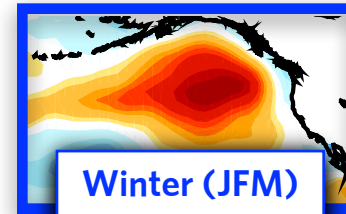
Strong in Winter 2013/2014

Winter  
2014-2015



PDO-like

North Pacific  
Oscillation  
ATMOSPHERE



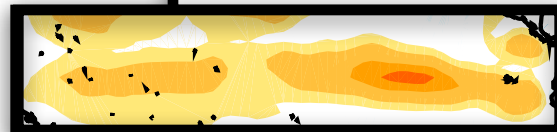
Winter (JFM)  
2014

North Pacific  
Gyre Oscillation  
OCEAN



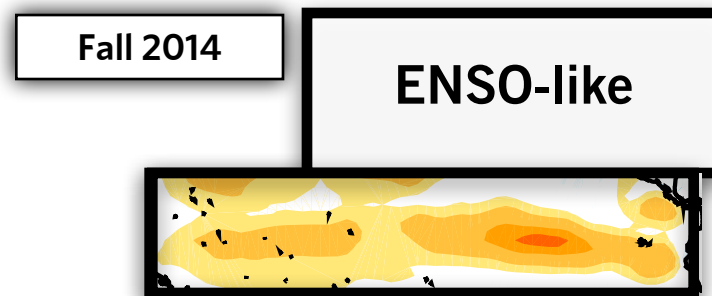
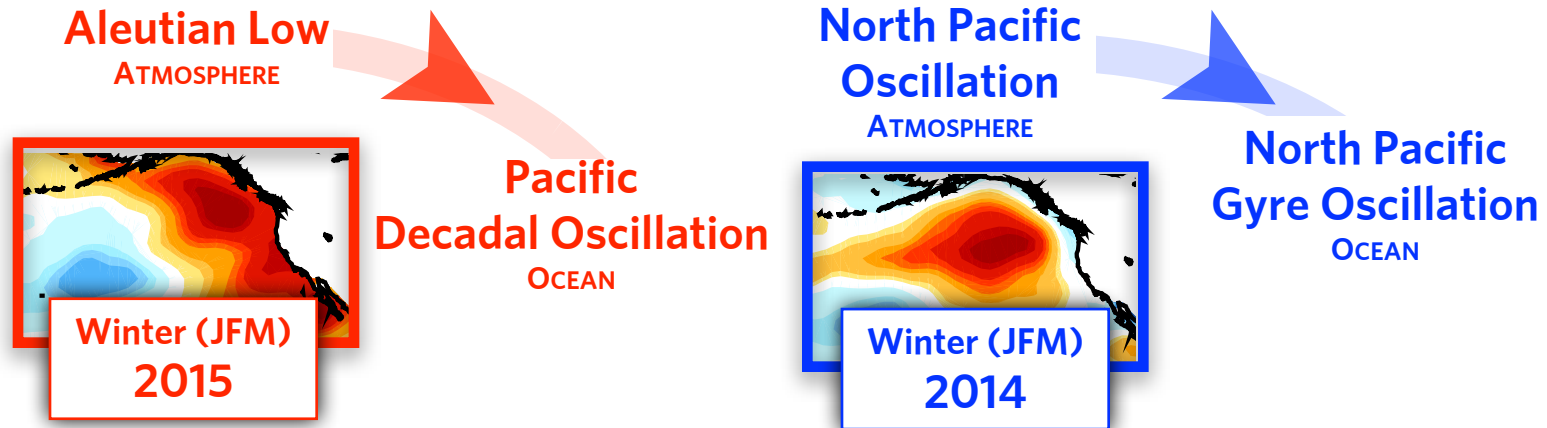
Fall 2014

ENSO-like



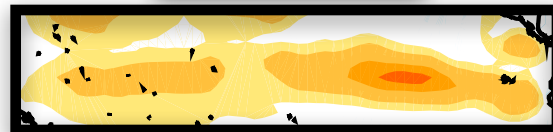
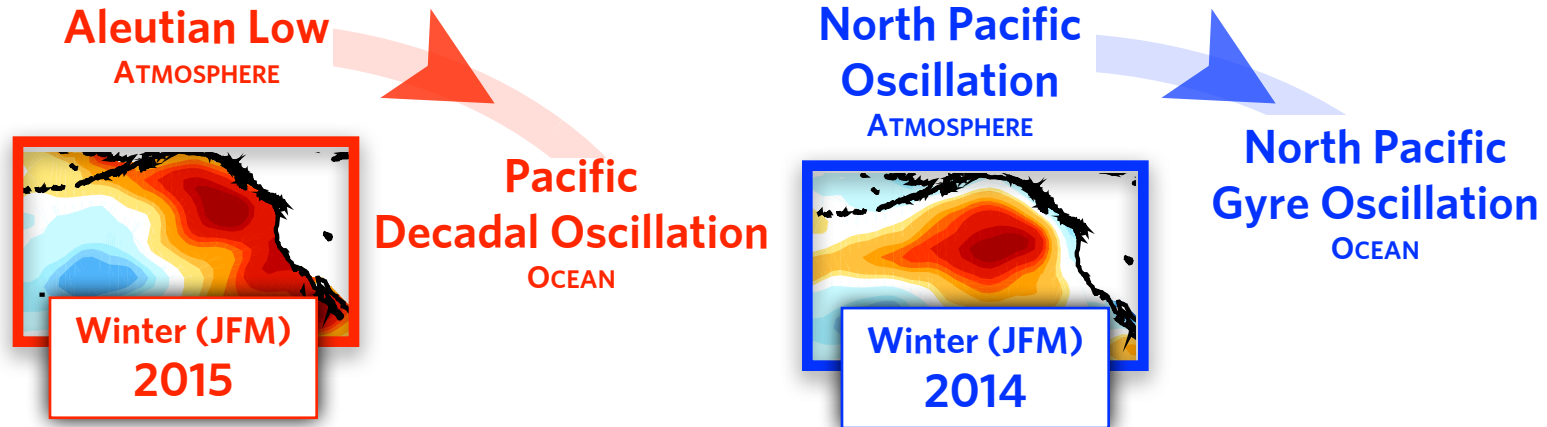
# A Climate Hypothesis (Interpretation)

Strong in Winter 2013/2014

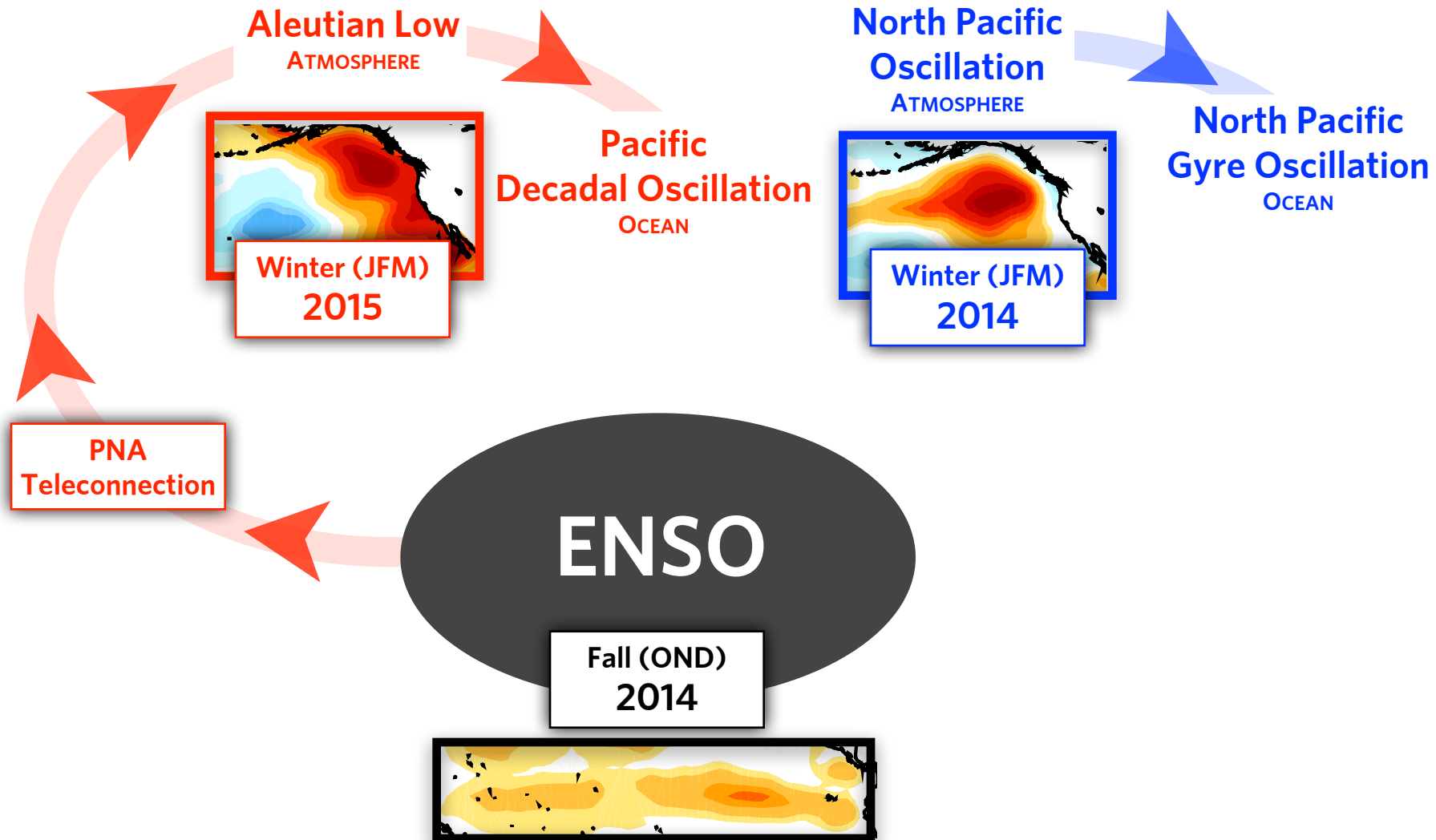


# A Climate Hypothesis (Interpretation)

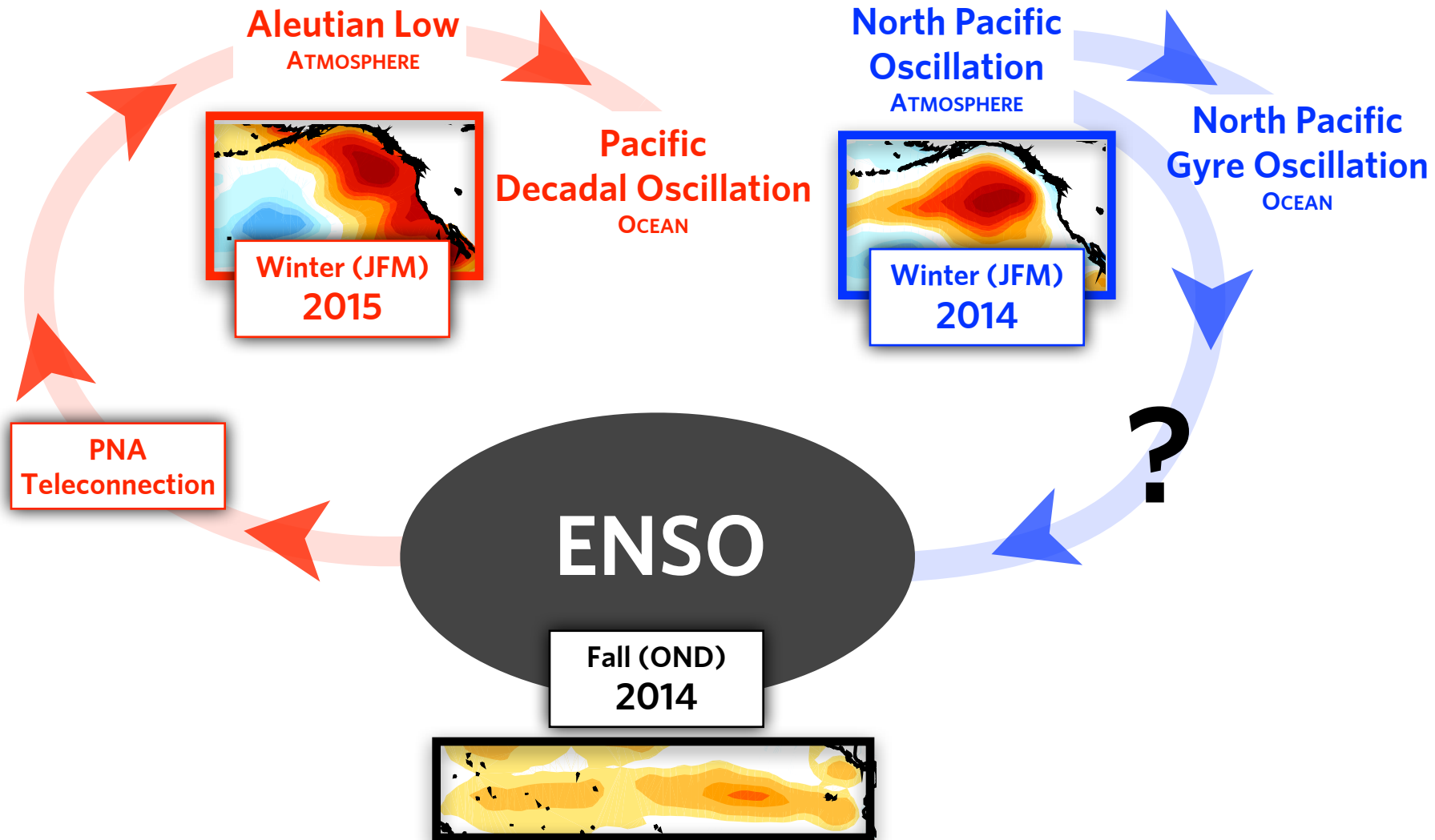
Strong in Winter 2013/2014



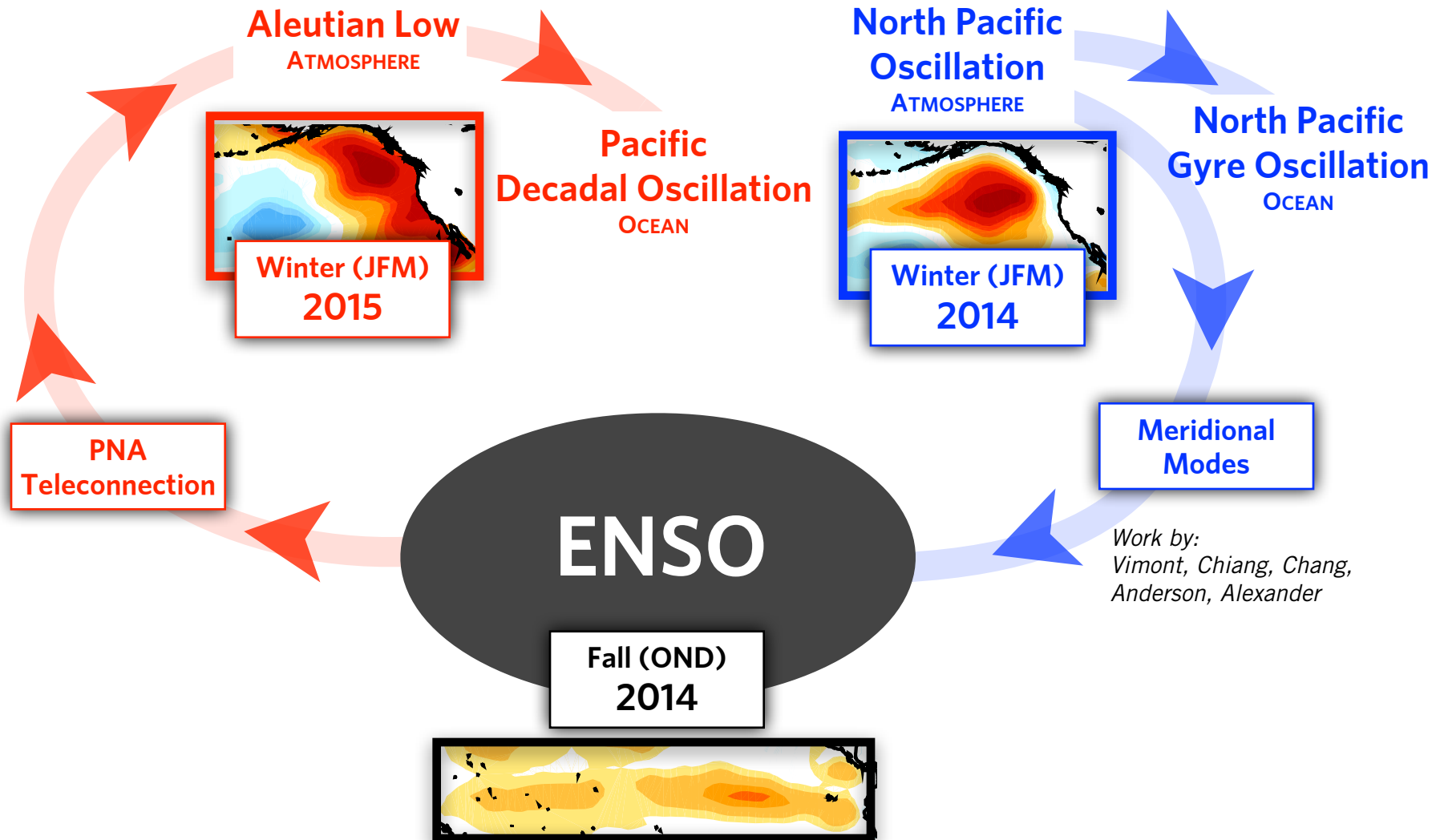
# A Climate Hypothesis (Interpretation)



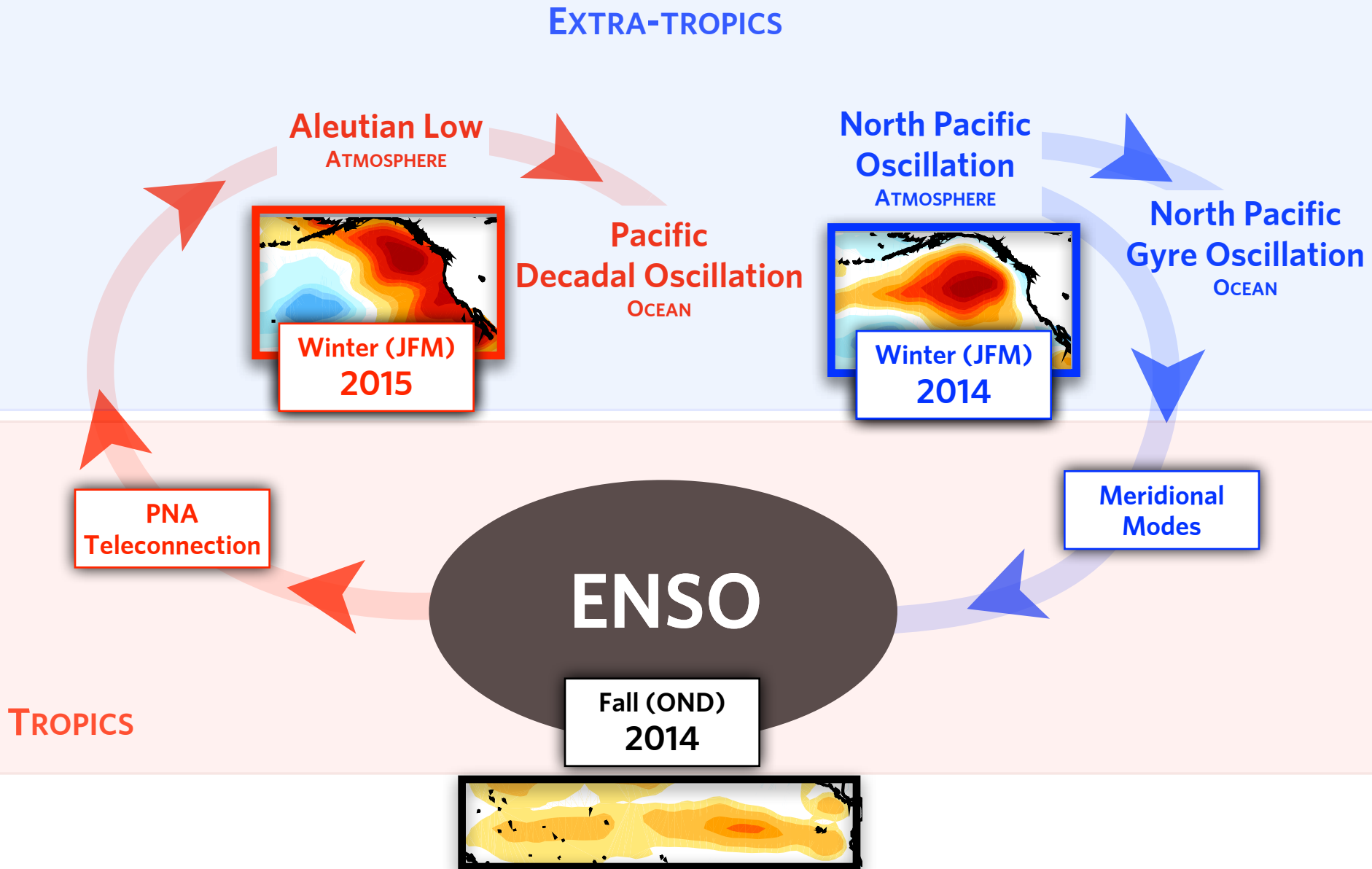
# A Climate Hypothesis (Interpretation)



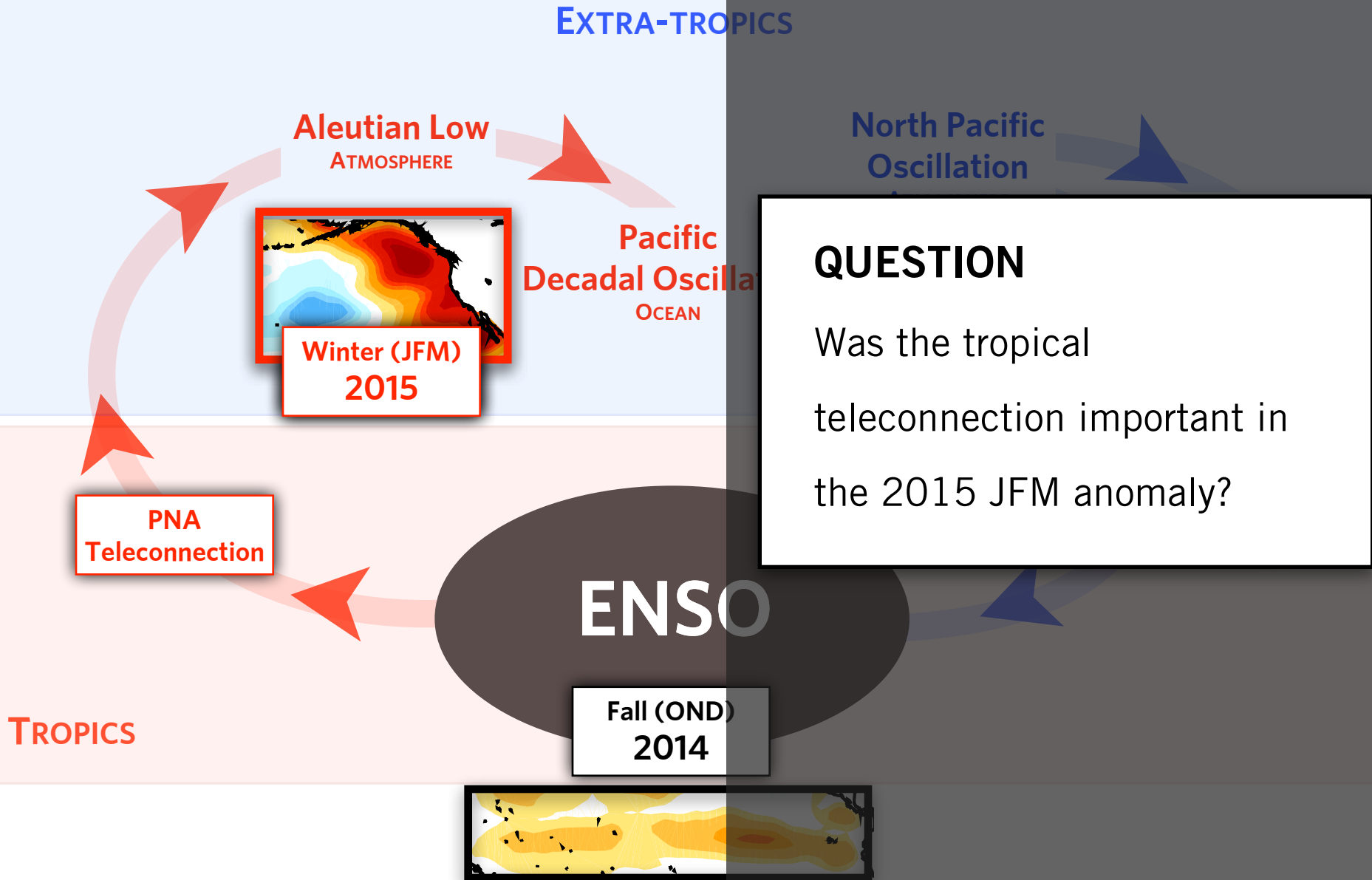
# A Climate Hypothesis (Interpretation)



# Evolution of the North Pacific Warm Anomaly 2014-2015



# A Climate Hypothesis (Interpretation)

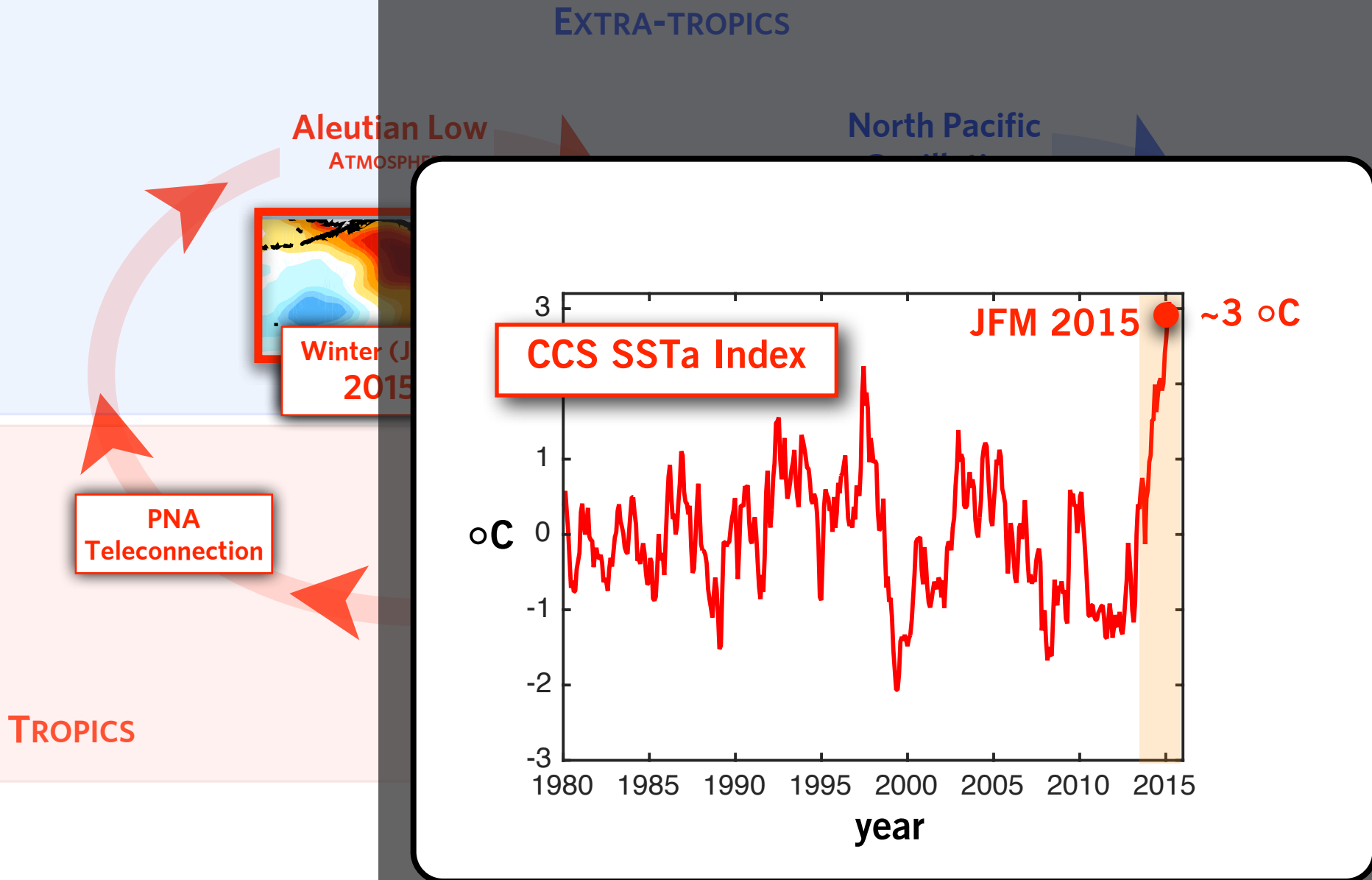


## QUESTION

Was the tropical teleconnection important in the 2015 JFM anomaly?



# A Climate Hypothesis (Interpretation)

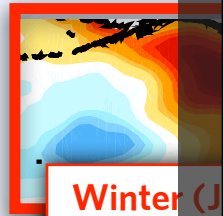


# A Climate Hypothesis (Interpretation)

EXTRA-TROPICS

Aleutian Low  
ATMOSPHERIC

North Pacific

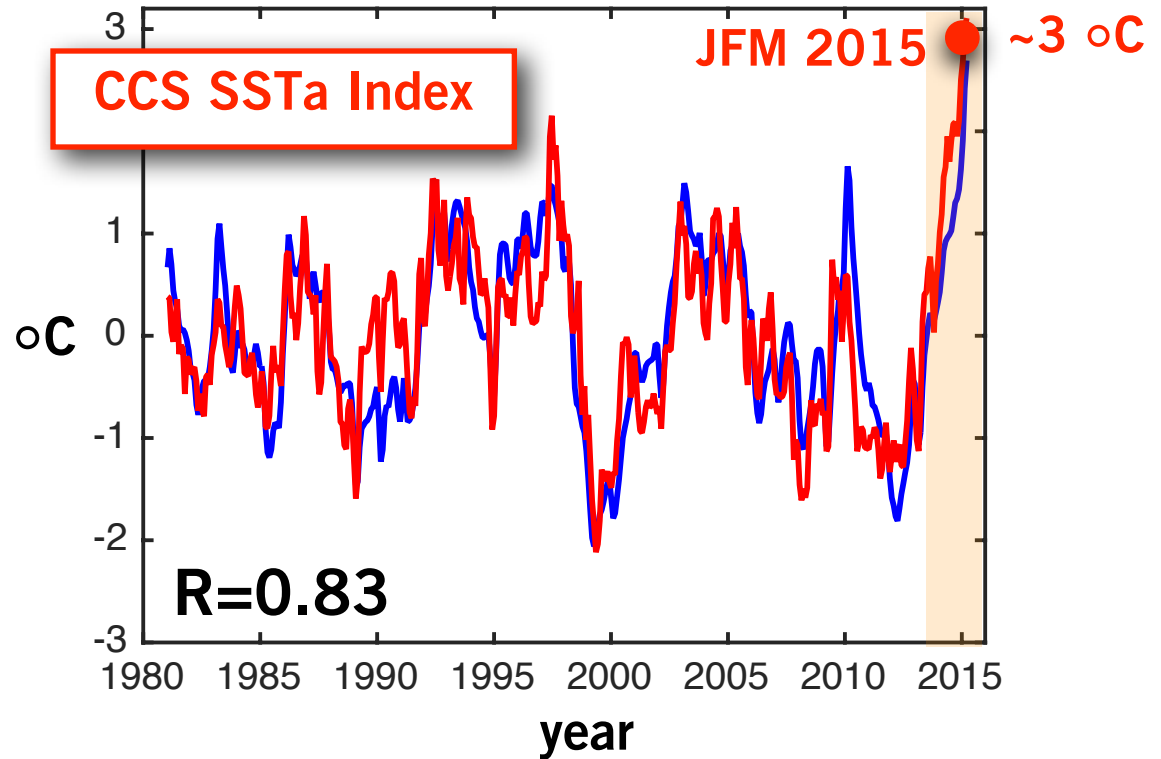


Winter (JFM)  
2015

PNA  
Teleconnection

TROPICS

## NORTH PACIFIC SLPa Atmospheric Forcing (AR-1)



# A Climate Hypothesis (Interpretation)

EXTRA-TROPICS

Aleutian Low  
ATMOSPHERIC

North Pacific

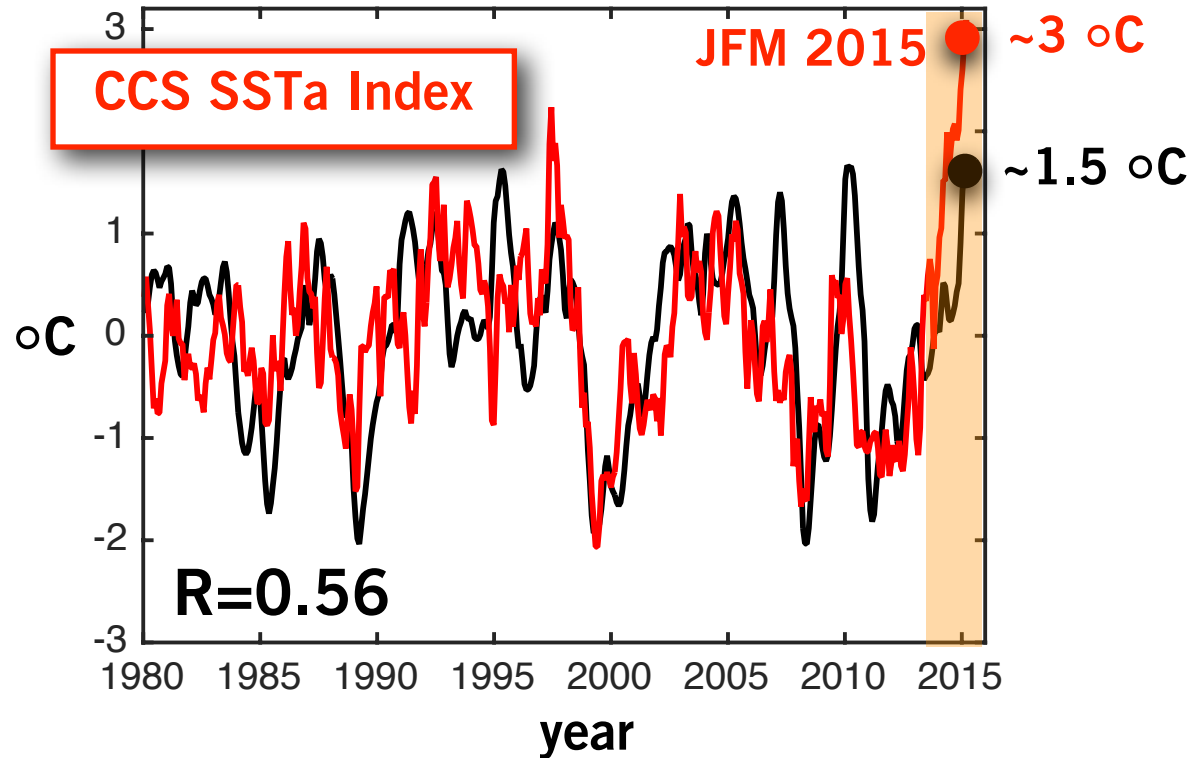


Winter (JFM)  
2015

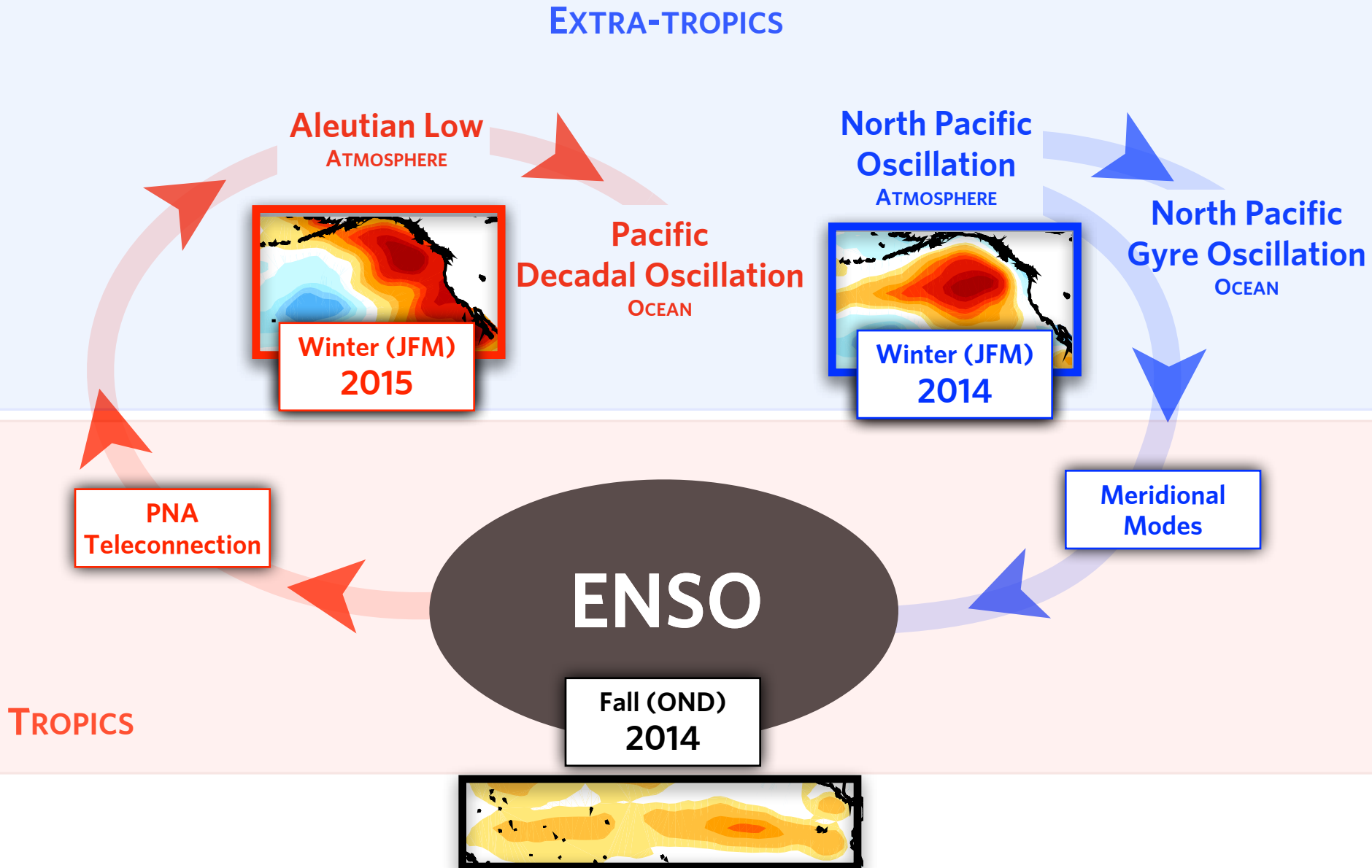
PNA  
Teleconnection

TROPICS

## NORTH PACIFIC SLPa Atmospheric Forcing (AR-1)



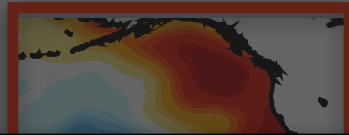
# A Climate Hypothesis (Interpretation)



# A Climate Hypothesis (Interpretation)

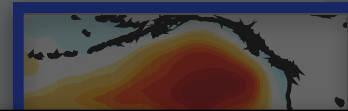
EXTRA-TROPICS

Aleutian Low  
ATMOSPHERE



Pacific  
Decadal Oscillation

North Pacific  
Oscillation  
ATMOSPHERE



North Pacific  
Gyre Oscillation  
OCEAN

## QUESTION

Are these extreme climate events becoming more frequent under greenhouse forcing?

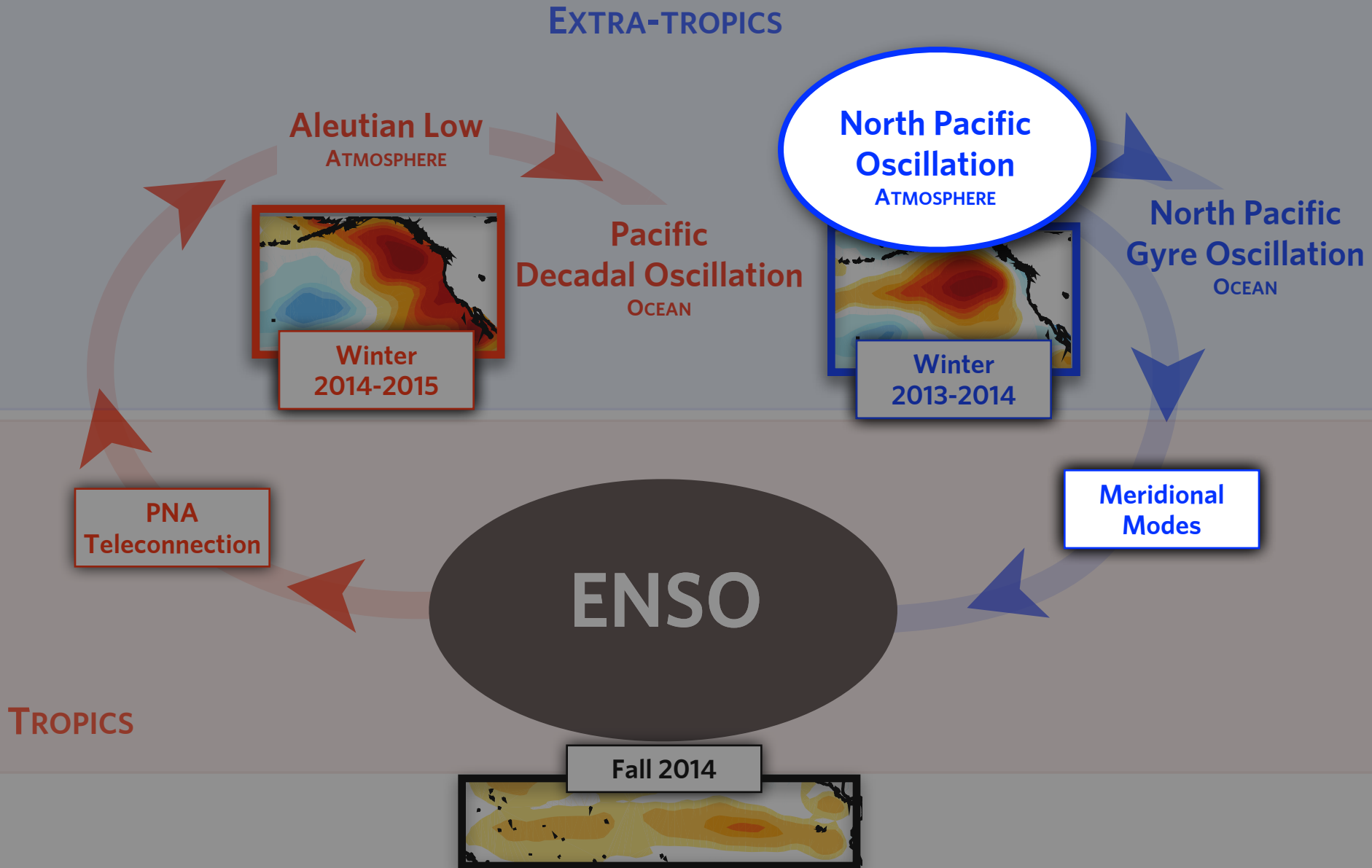
ENSO

TROPICS

Fall 2014



# A Climate Hypothesis (Interpretation)

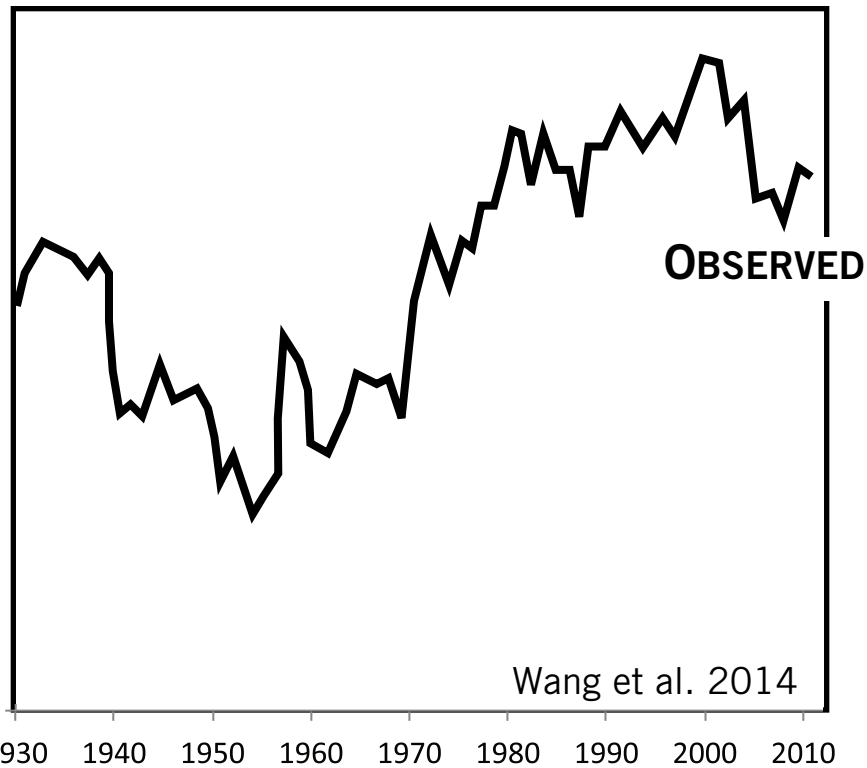


# A Climate Hypothesis (Interpretation)

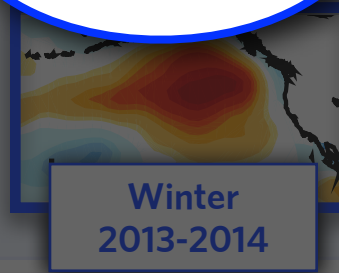
## EXTRA-TROPICS

### STRENGTH

of tropical/extra-tropical coupling



North Pacific  
Oscillation  
ATMOSPHERE



North Pacific  
Gyre Oscillation  
OCEAN

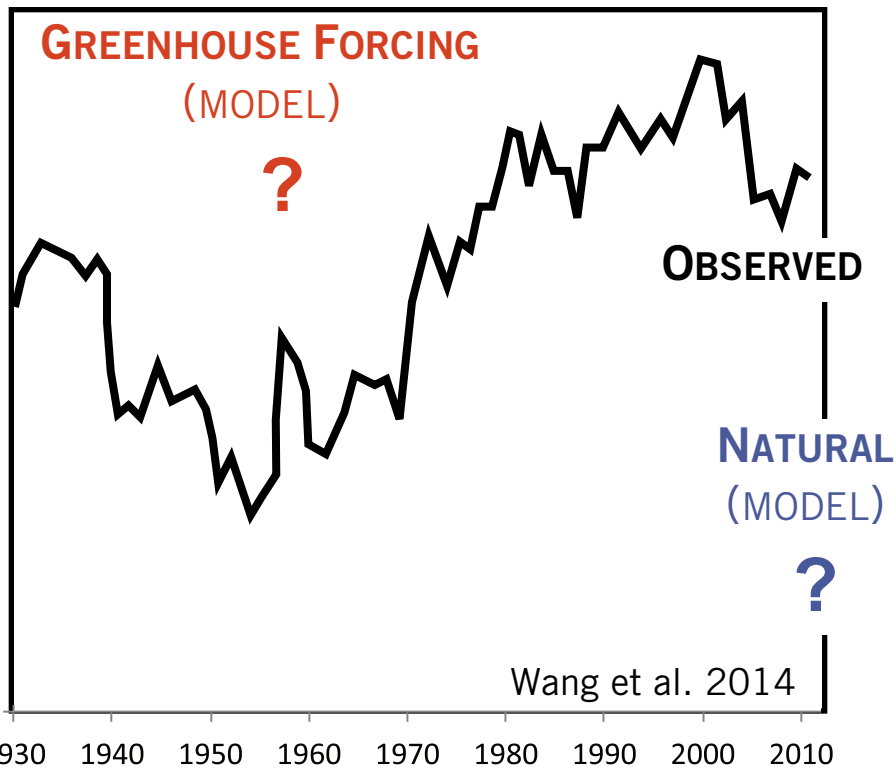
Meridional  
Modes

# A Climate Hypothesis (Interpretation)

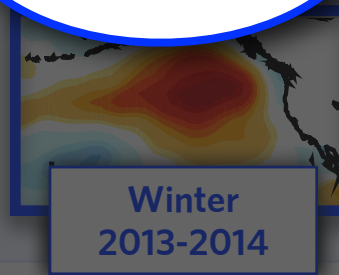
## EXTRA-TROPICS

### STRENGTH

of tropical/extra-tropical coupling



**North Pacific Oscillation**  
ATMOSPHERE



**North Pacific Gyre Oscillation**  
OCEAN

**Meridional Modes**

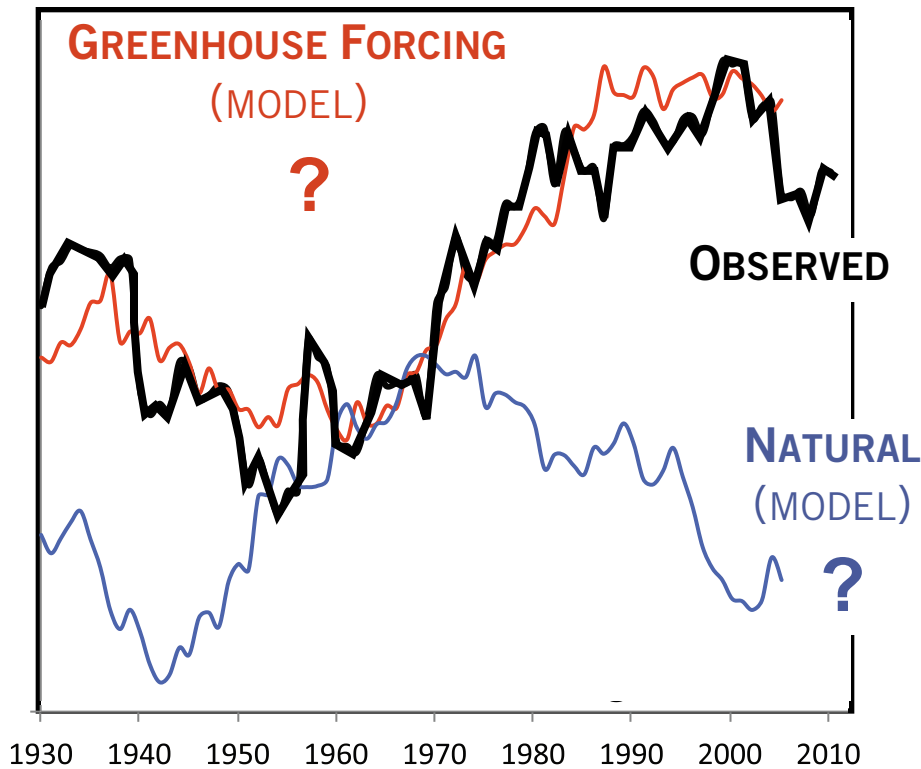


# A Climate Hypothesis (Interpretation)

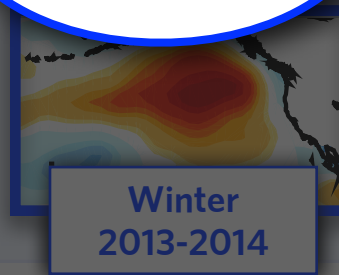
## EXTRA-TROPICS

### STRENGTH

of tropical/extra-tropical coupling



North Pacific  
Oscillation  
ATMOSPHERE



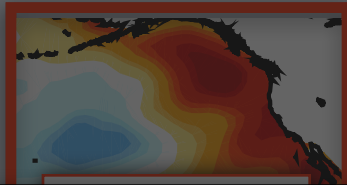
North Pacific  
Gyre Oscillation  
OCEAN

Meridional  
Modes

# A Climate Hypothesis (Interpretation)

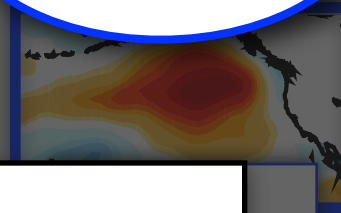
EXTRA-TROPICS

Aleutian Low  
ATMOSPHERE



Pacific  
Decadal Oscillation  
OCEAN

North Pacific  
Oscillation  
ATMOSPHERE



North Pacific  
Gyre Oscillation  
OCEAN



Meridional  
Modes

## QUESTION

Why would this connection become stronger?

ENSO

TROPICS

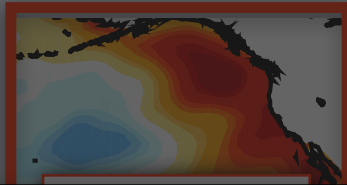
Fall 2014



# A Climate Hypothesis (Interpretation)

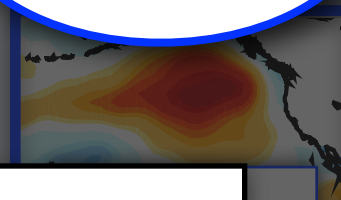
EXTRA-TROPICS

Aleutian Low  
ATMOSPHERE



Pacific  
Decadal Oscillation  
OCEAN

North Pacific  
Oscillation  
ATMOSPHERE



North Pacific  
Gyre Oscillation  
OCEAN



Meridional  
Modes

## QUESTION

Why would this connection become stronger?

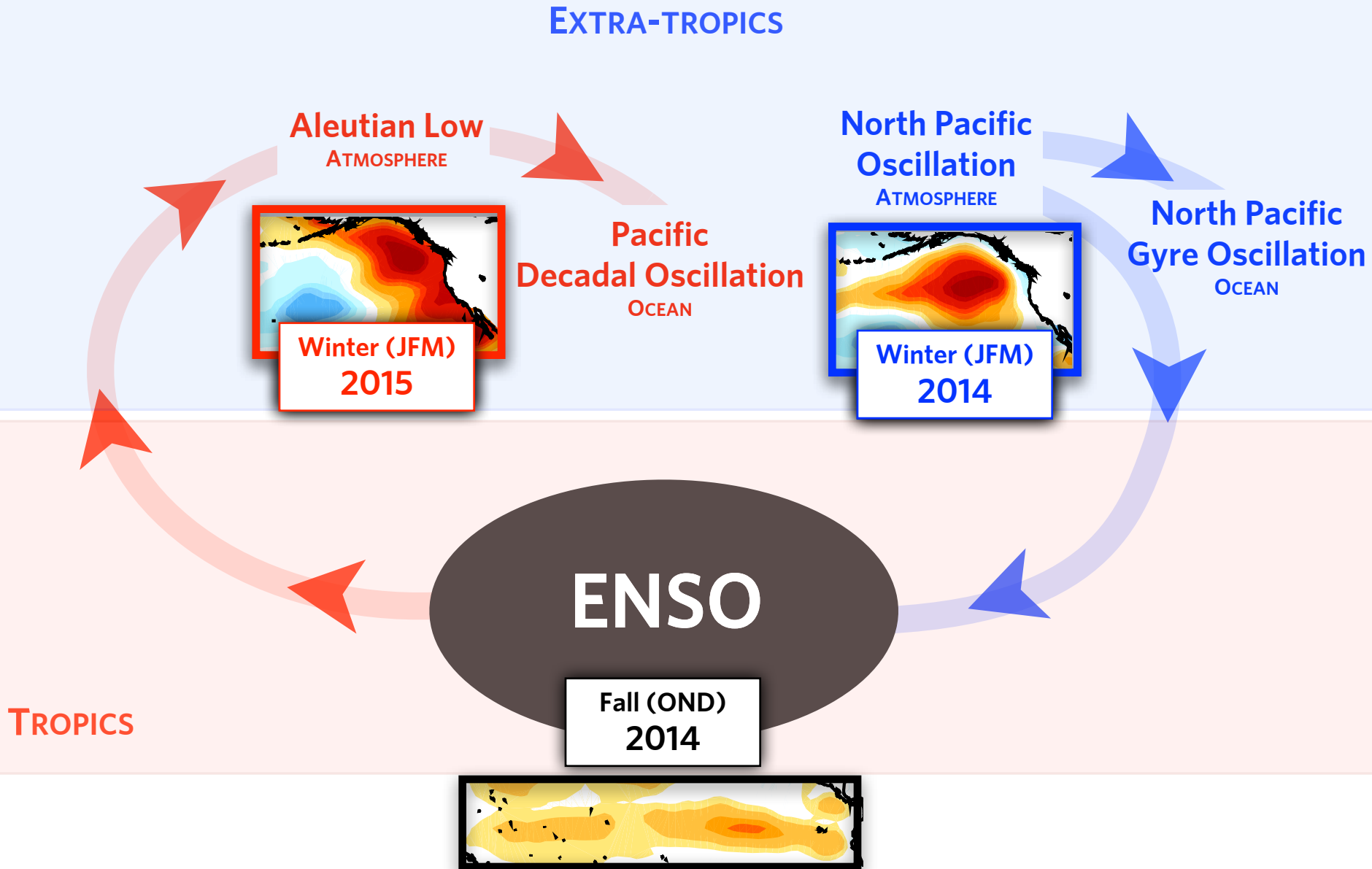
## Hypothesis:

*Thermodynamic ocean-atmosphere  
coupling is stronger*

TROPICS

ENSO

# A Climate Hypothesis (Interpretation)



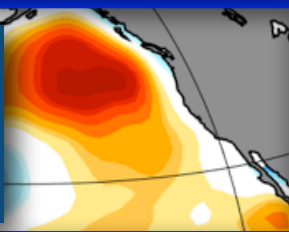
# CLIMATE HYPOTHESIS for the WARM BLOB in 2014/15

WIN 2014

WIN 2015

1

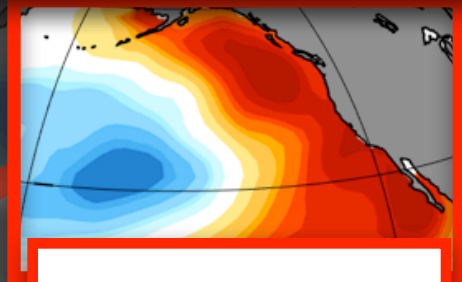
ATMOSPHERIC RIDGE  
GENERATES WARM BLOB  
WINTER



NPGO-like

2

ENSO TELECONNECTIONS  
REINFORCE AND ADD PERSISTENCE  
TO BLOB NEXT WINTER



PDO-like

ENSO  
Teleconnection  
Pattern

SUMMER  
& FALL

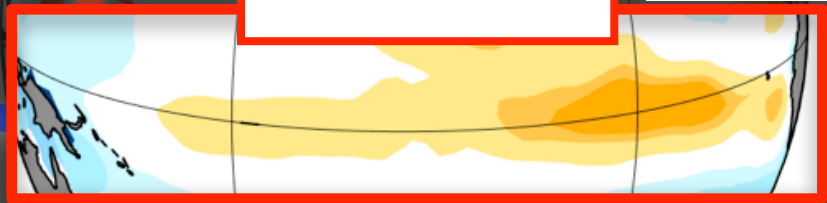
Meridional  
Modes

3

THERMODYNAMIC FEEDBACKS  
MAY AMPLIFY UNDER  
GREENHOUSE FORCING

ENSO-like

FALL 2015



# CLIMATE HYPOTHESIS for the WARM BLOB in 2014/15

1  
ATMOSPHERIC RIDGE  
GENERATES WARM BLOB  
WINTER

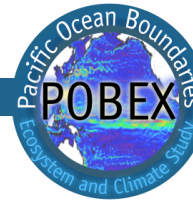
2013

Di Lorenzo, E., Combes, V., Keister, J.E., Strub, T.P., Thomas, A.C., Franks, P.J.S., Ohman, M.D., Furtado, J., Bracco, A., Bograd, S.J., Peterson, W.T., Schwing, F.B., Chiba, S., Taguchi, B., Hormazabal, S., Parada, C., 2013.

*Synthesis of Pacific Ocean climate and ecosystem dynamics*

*Oceanography*, Vol. 26 (4).

## Synthesis of Pacific Ocean Climate & Ecosystem Variability



BY EMANUELE DI LORENZO, VINCENT COMBES, JULIE KEISTER, TED STRUB, ANDREW THOMAS, PETER J.S. FRANKS, ANNALISA BRACCO,

STEVEN BOGRAD, WILLIAM PETERSON, FRANK SCHWING, SANA E CHIBA, BUNMEI TAGUCHI, SAMUEL HORMAZABAL AND CAROLINA PARADA

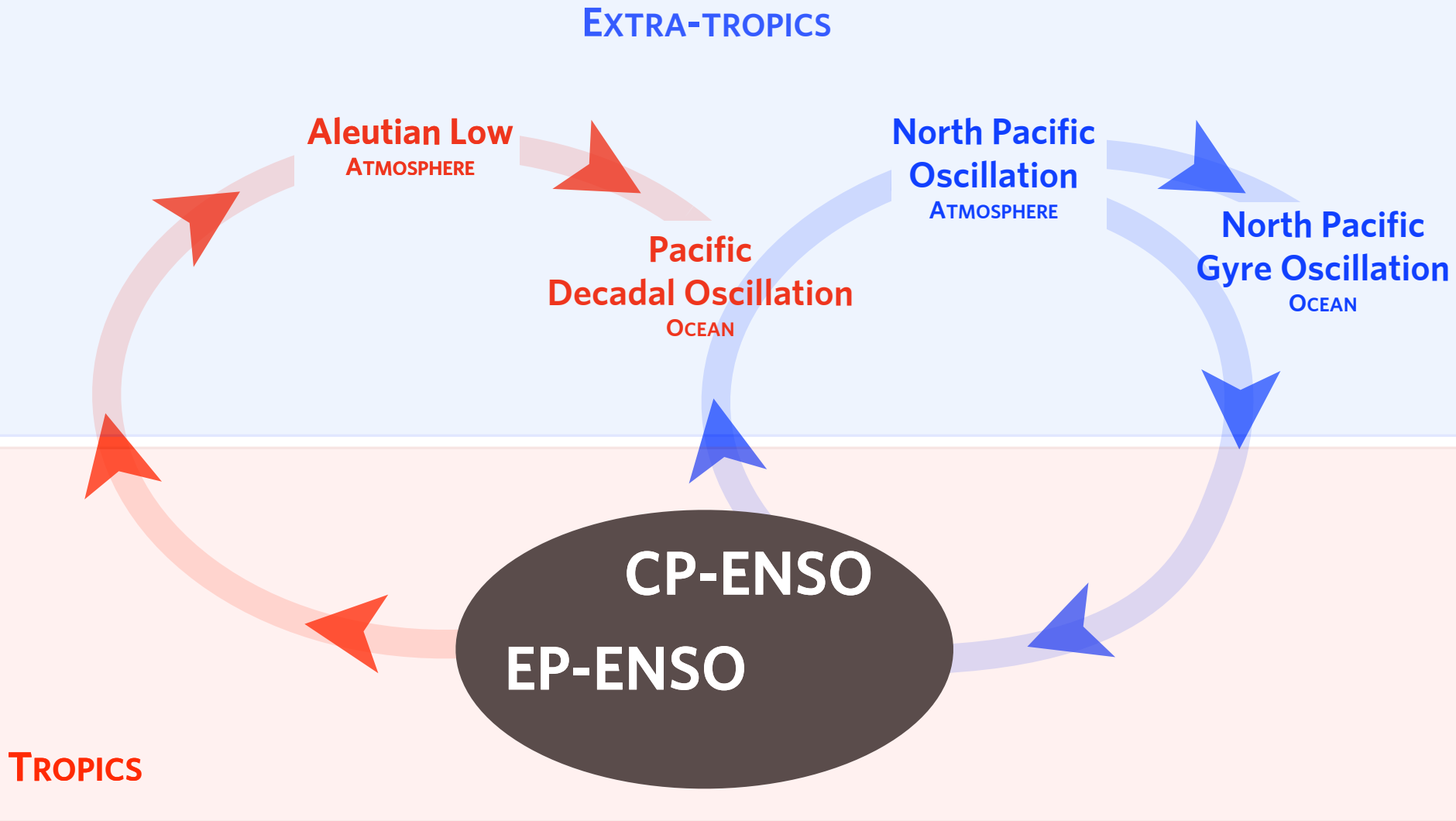
3  
THANK YOU

3  
THERMODYNAMIC FEEDBACKS  
MAY AMPLIFY UNDER  
GREENHOUSE FORCING

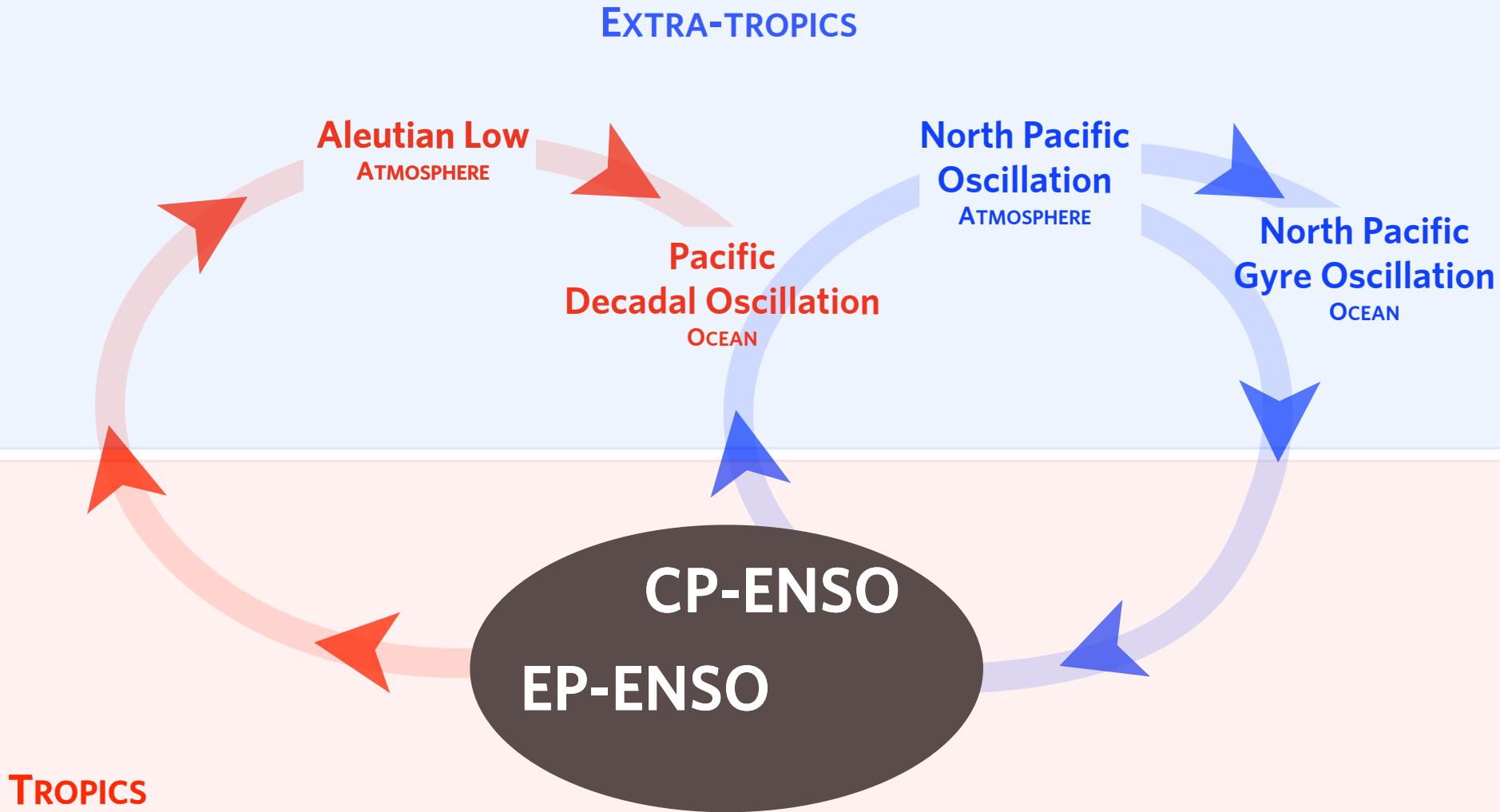
Teleconnec  
Pattern

Meridional

# A Climate Hypothesis (Interpretation)



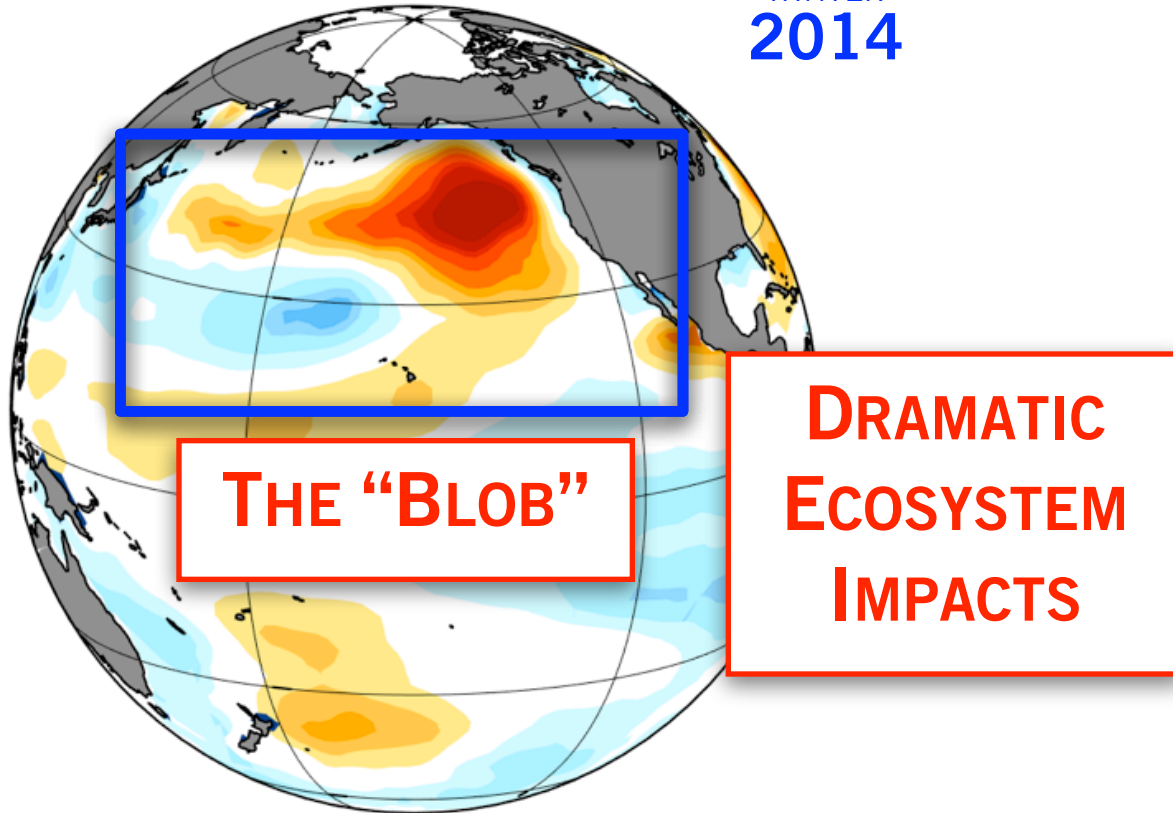
# Hypothesis Pacific Climate Variability



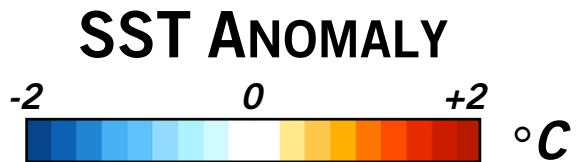




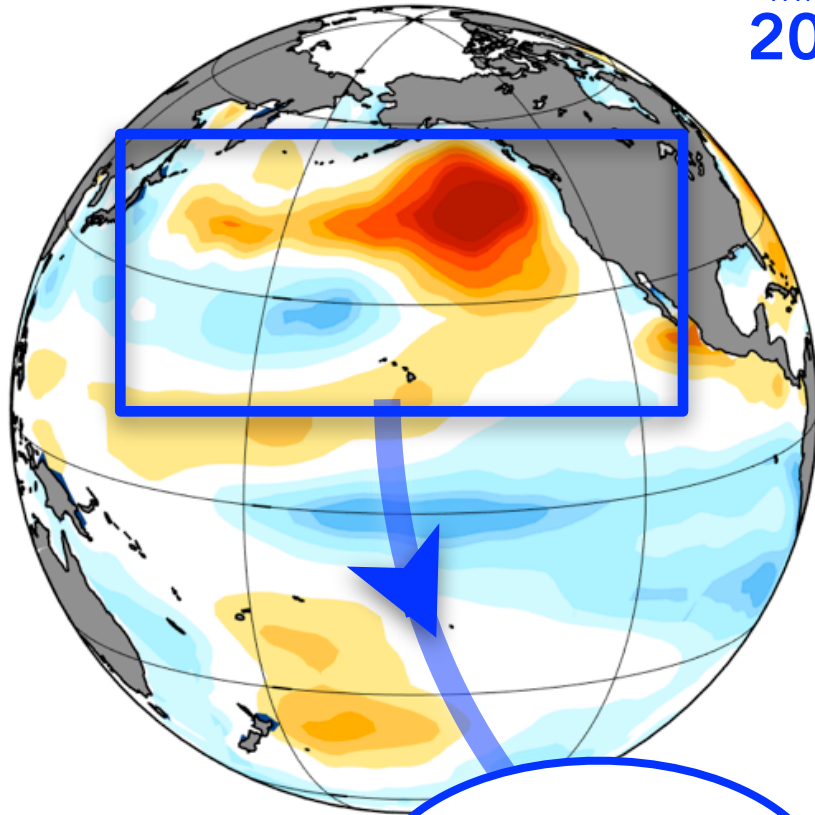
WINTER  
2014



*Bond et al. 2014*



WINTER  
2014



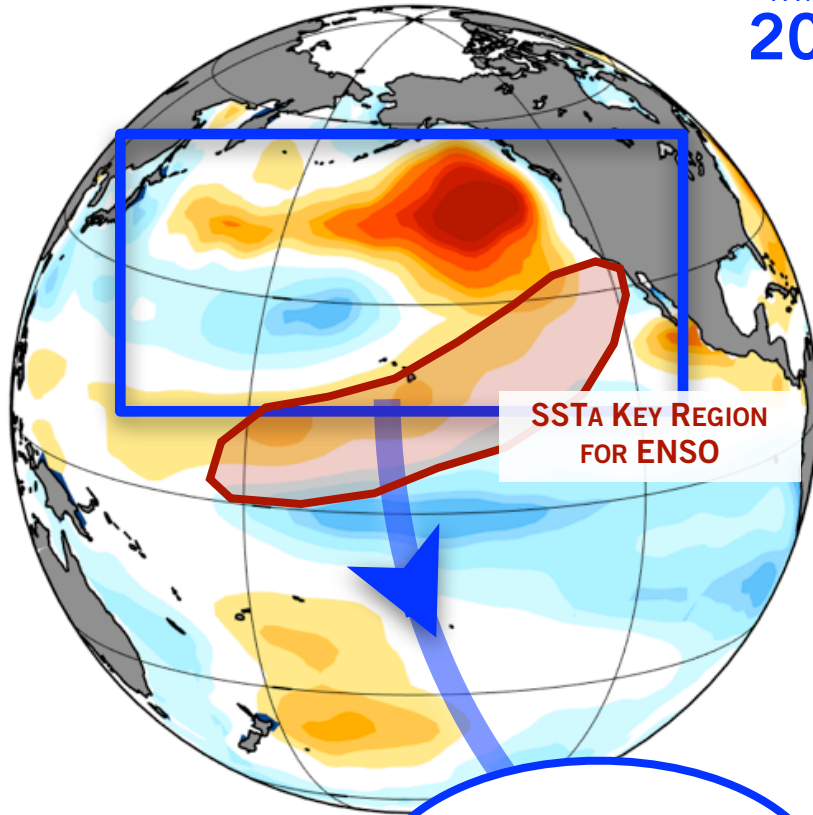
*North Pacific  
Ocean Dynamics*



**SST ANOMALY**



WINTER  
2014



**SSTA KEY REGION  
FOR ENSO**

*North Pacific  
Ocean Dynamics*

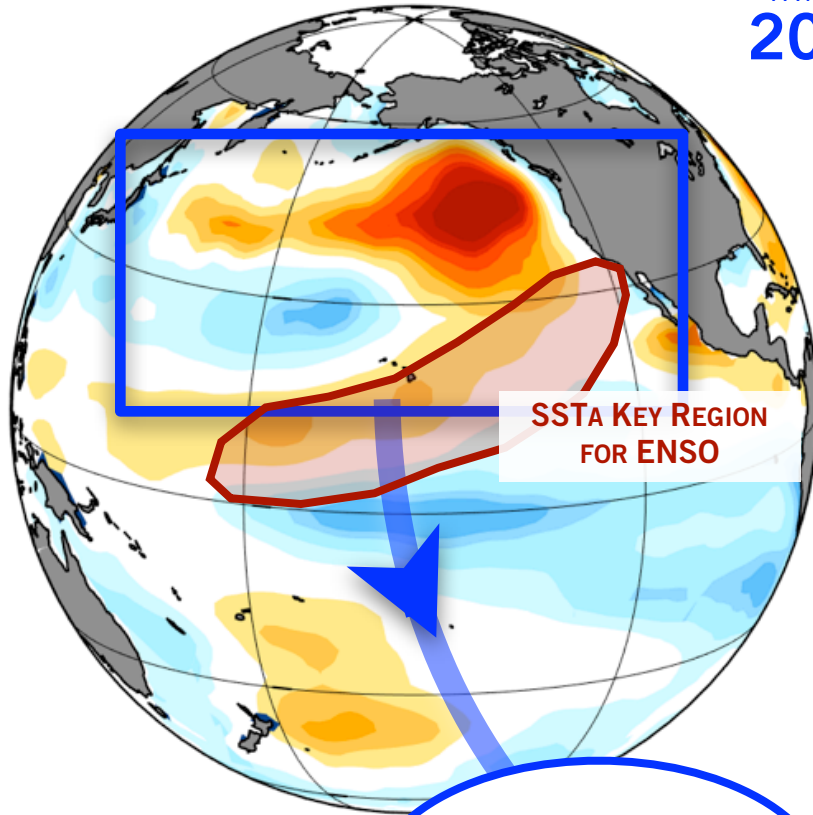


**STRONG 2014  
EL NIÑO ?**

**SSTA ANOMALY**



WINTER  
2014



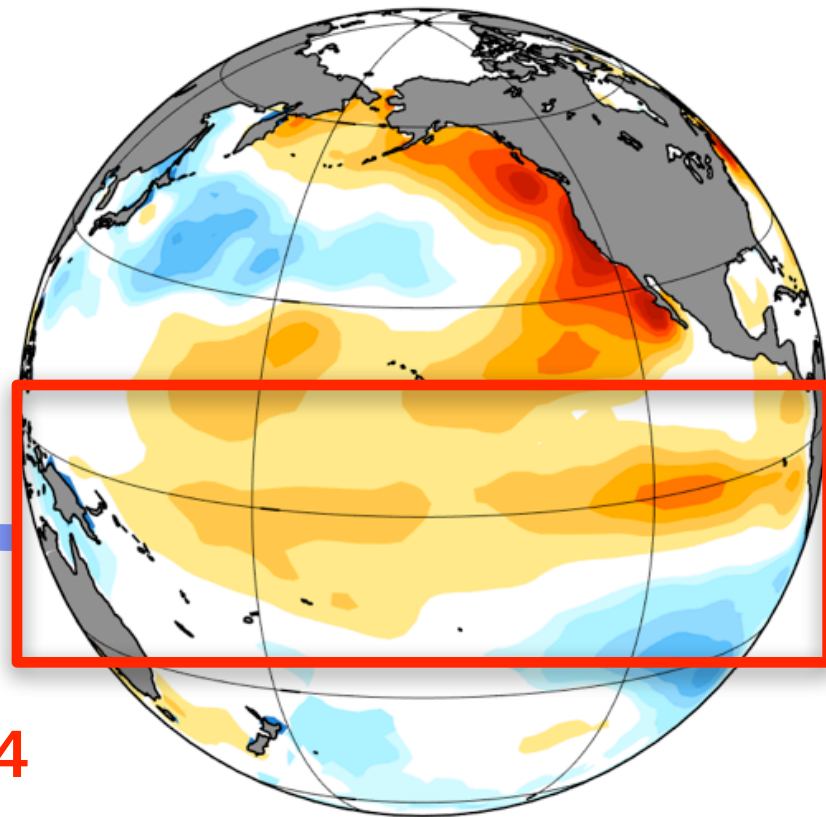
SSTA KEY REGION  
FOR ENSO

*North Pacific  
Ocean Dynamics*

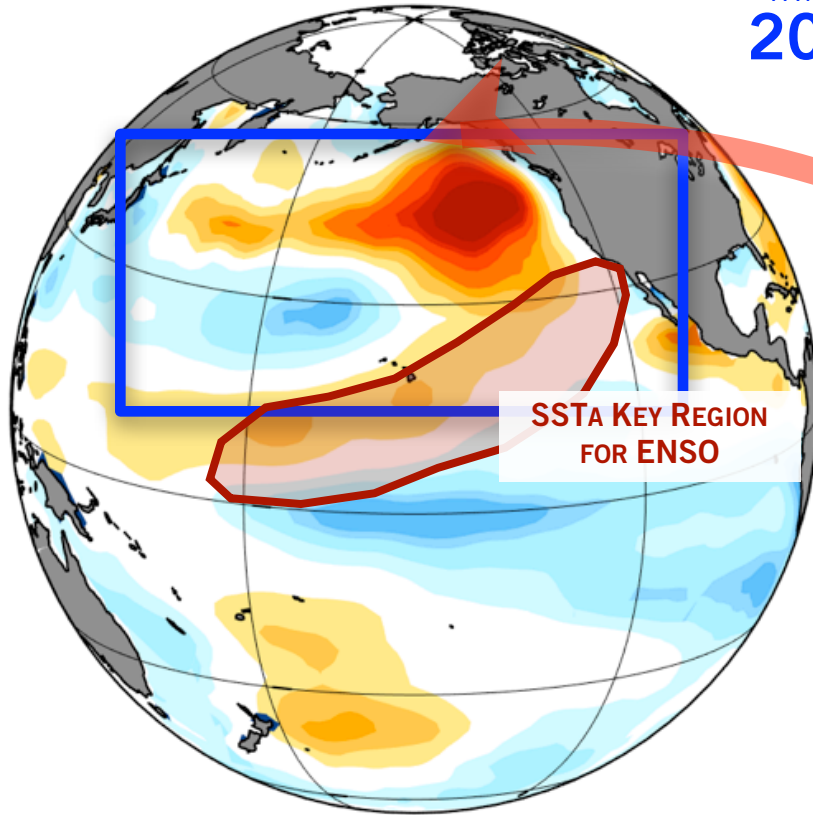
SSTA ANOMALY



FALL  
2014



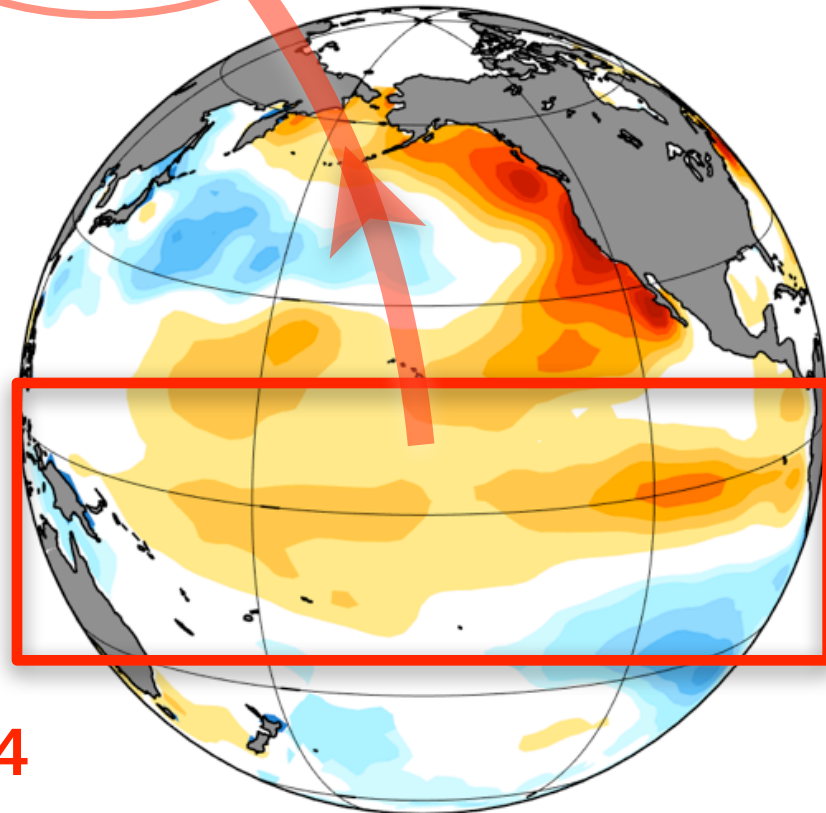
WINTER  
2014



SSTA KEY REGION  
FOR ENSO

SIGNIFICANT

*Atmospheric  
Teleconnections*

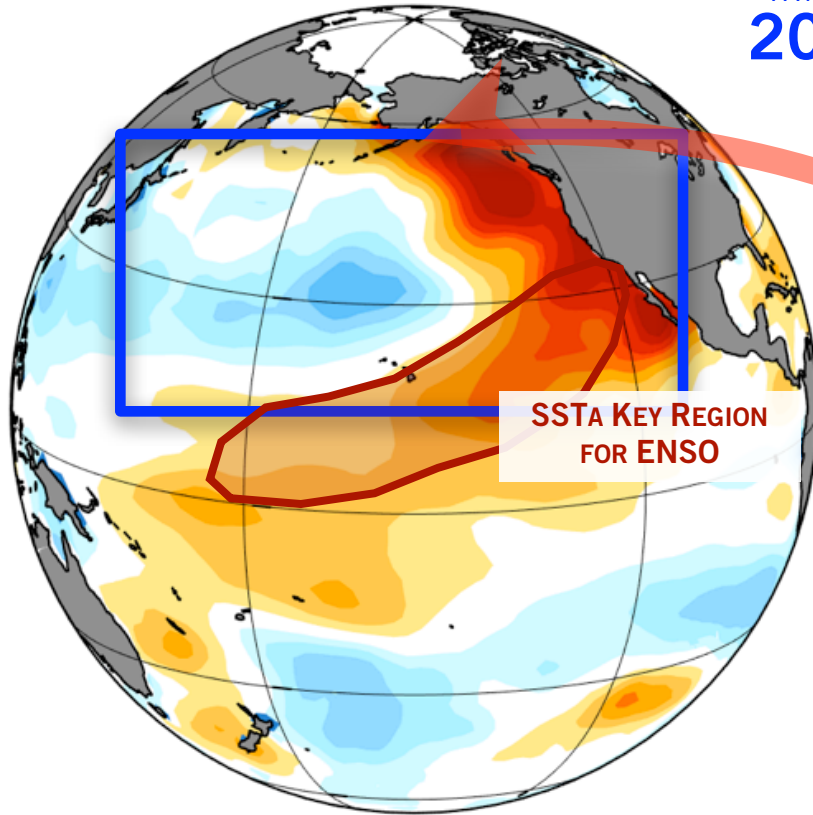


FALL  
2014

SST ANOMALY

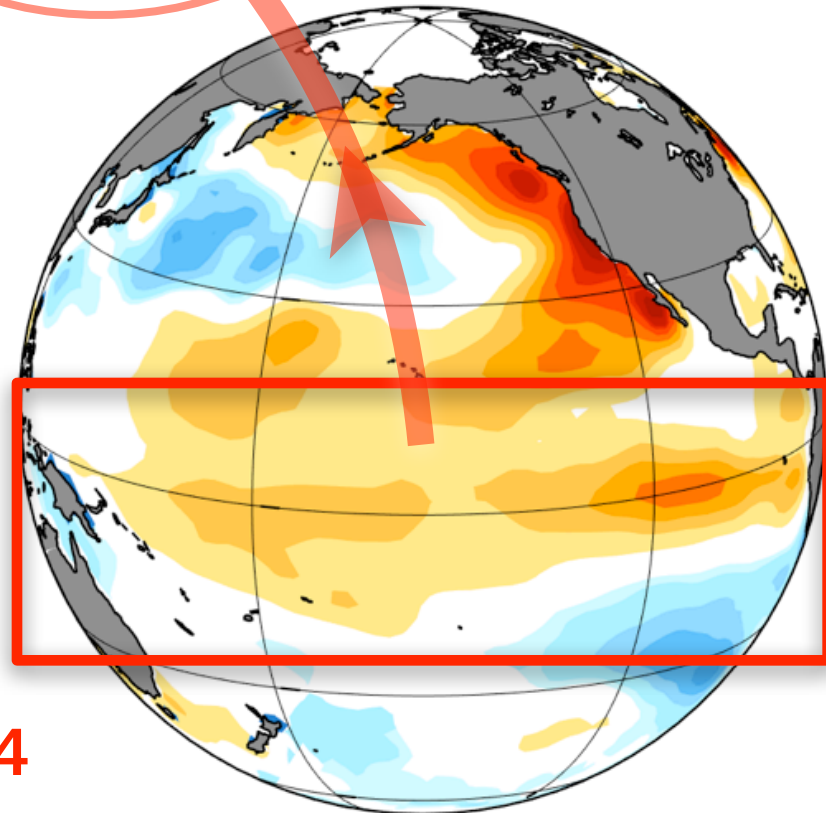


WINTER  
2015



SIGNIFICANT

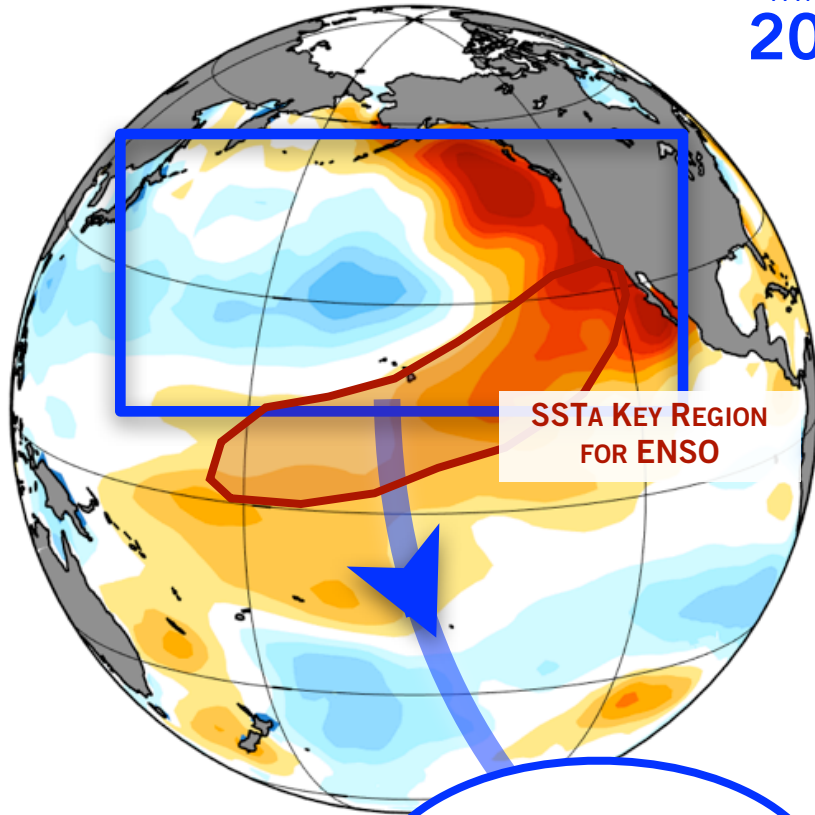
*Atmospheric  
Teleconnections*



SST ANOMALY

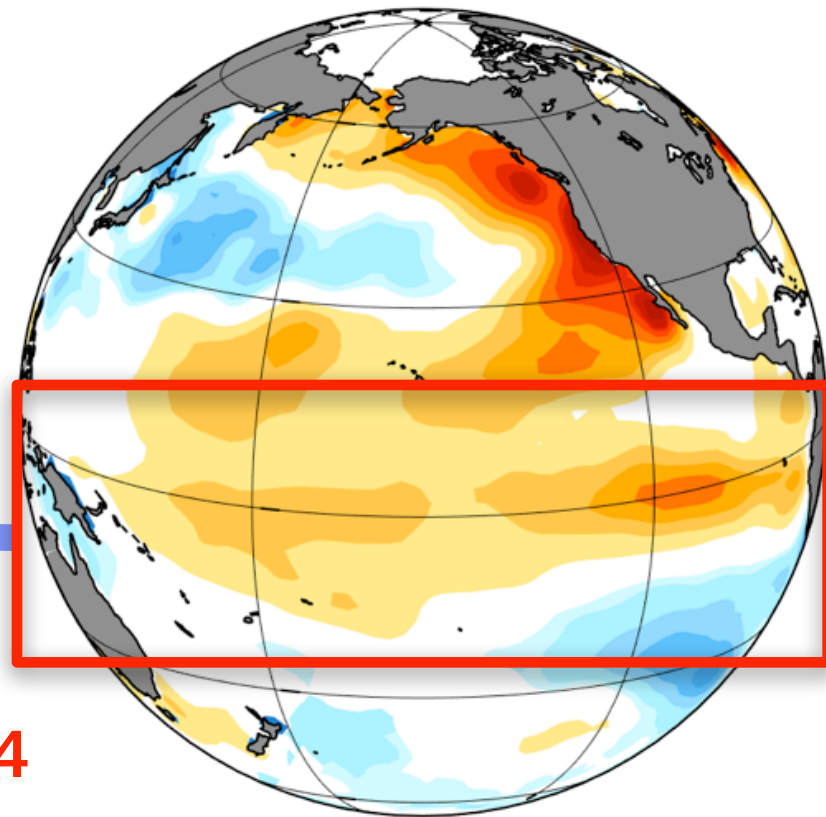


WINTER  
2015



SSTA KEY REGION  
FOR ENSO

*North Pacific  
Ocean Dynamics*



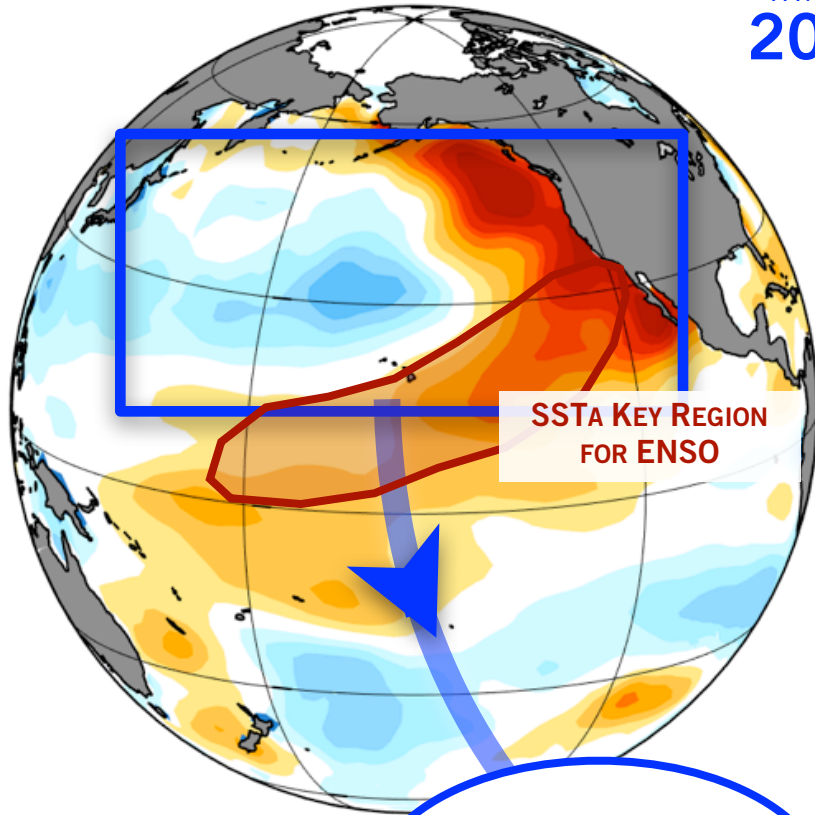
FALL  
2014

SSTA ANOMALY





WINTER  
2015



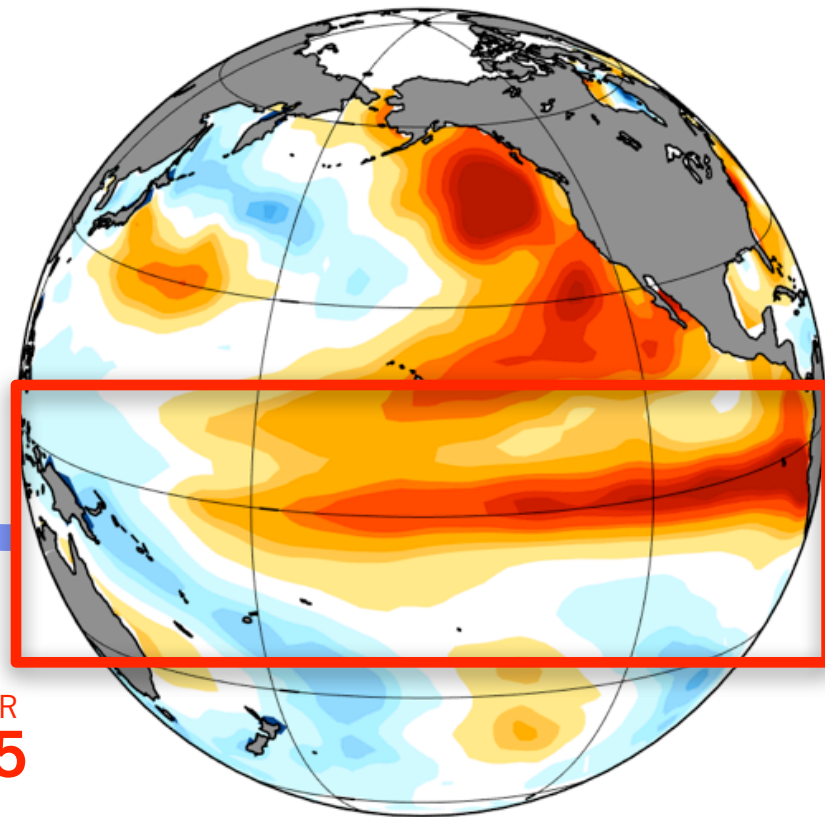
SSTA KEY REGION  
FOR ENSO

*North Pacific  
Ocean Dynamics*

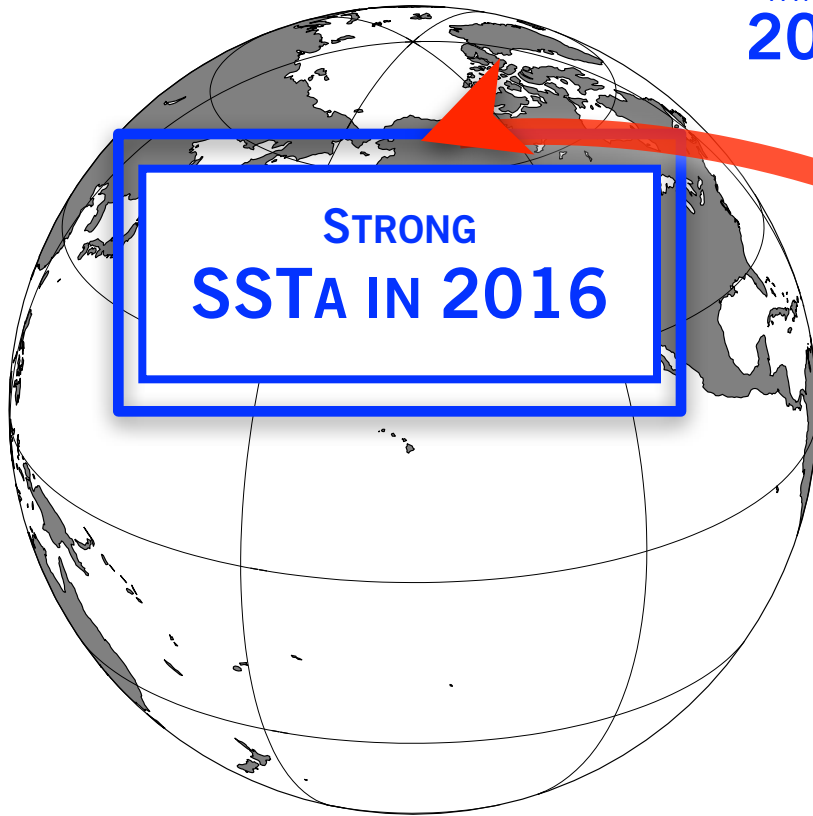
SSTA ANOMALY



SUMMER  
2015

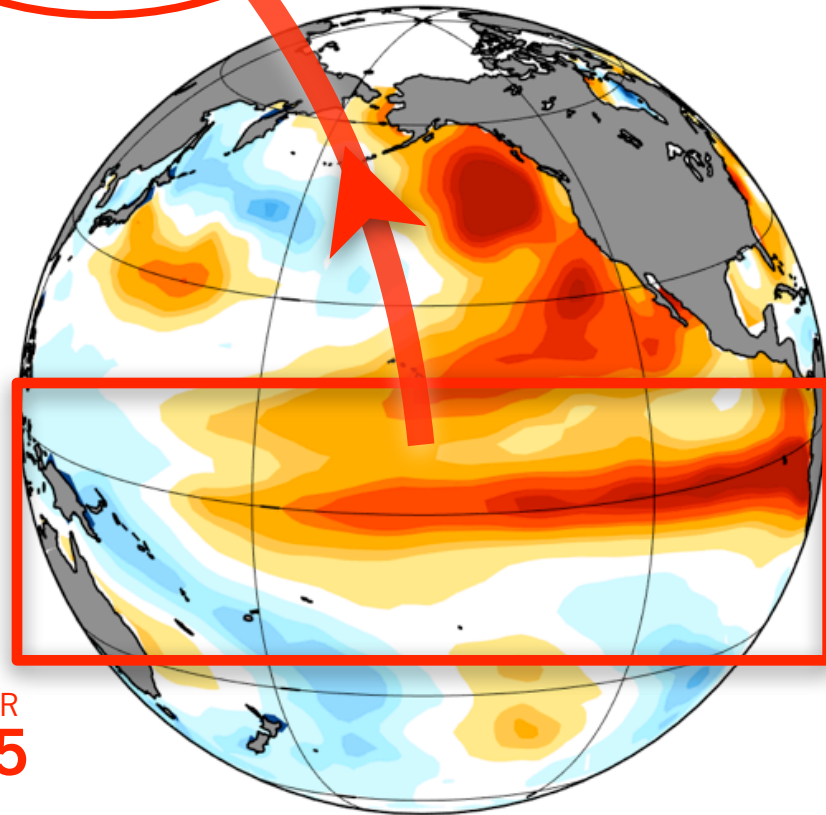


WINTER  
2016



**STRONG**

*Atmospheric  
Teleconnections*

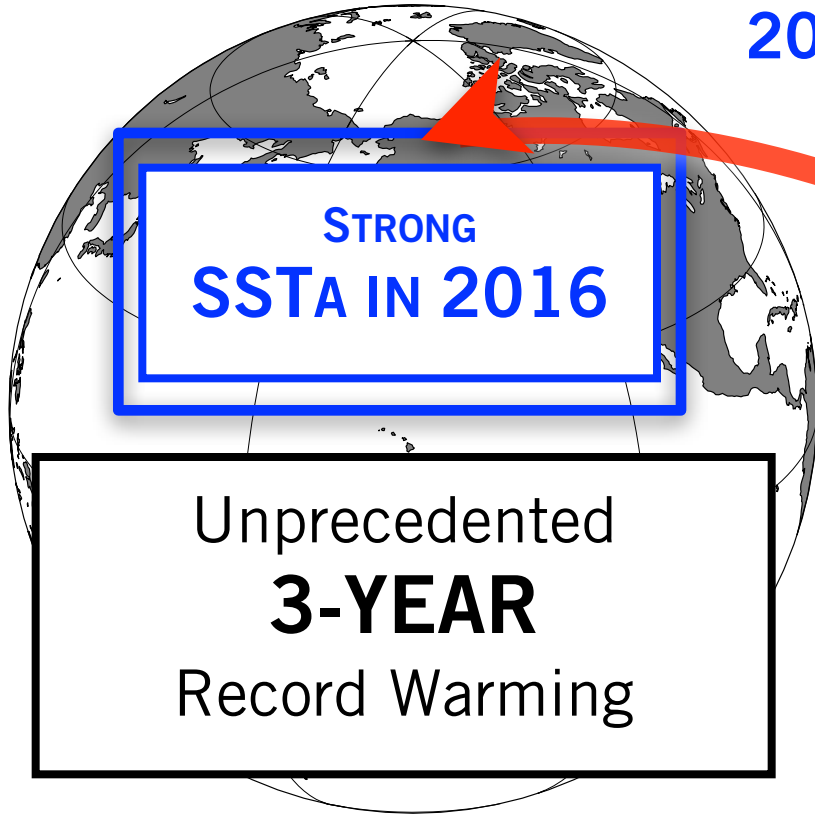


SUMMER  
2015

**SST ANOMALY**

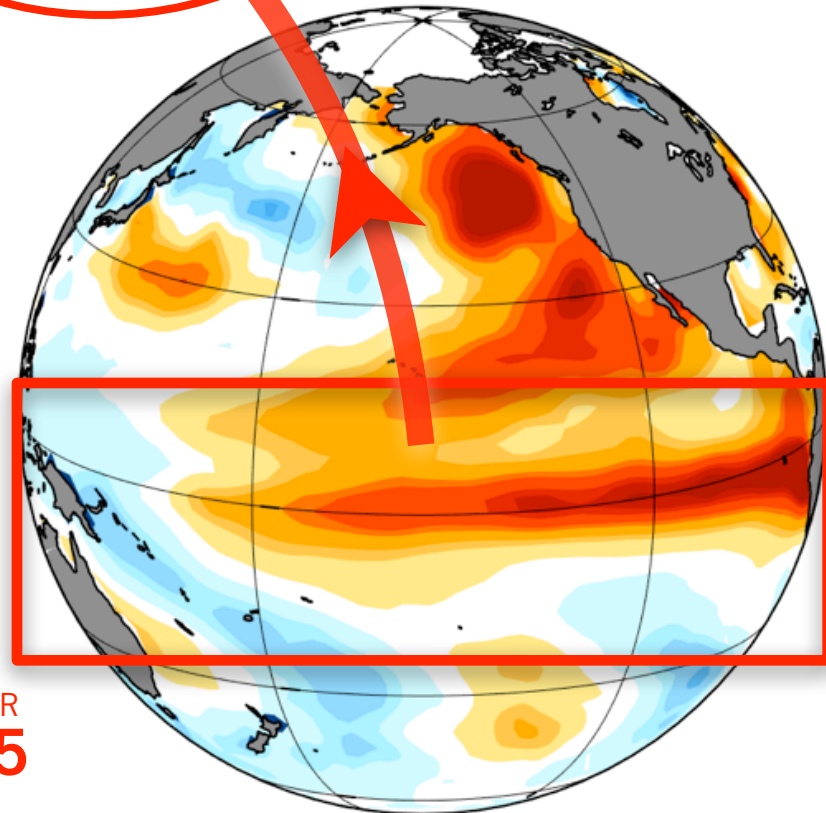


WINTER  
2016



**STRONG**

*Atmospheric  
Teleconnections*



SUMMER  
2015

