*Changes in character of **North Pacific variability** and ecosystem implications*

by E. Di Lorenzo

Collaborators: J. Furtado, K. Cobb, I. Nurhati

PICES S2 Session, October 2013

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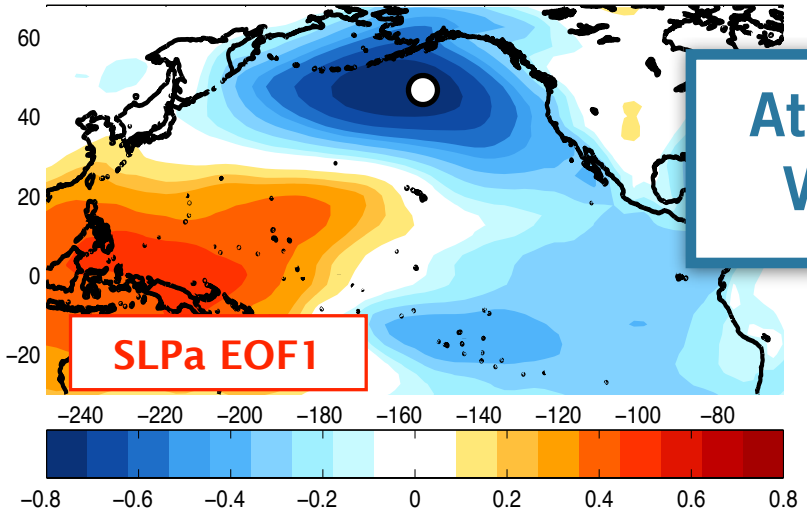
QUESTION:

What drives the surface ocean variance in the North Pacific?

Aleutian Low (AL)



Atmospheric Variability

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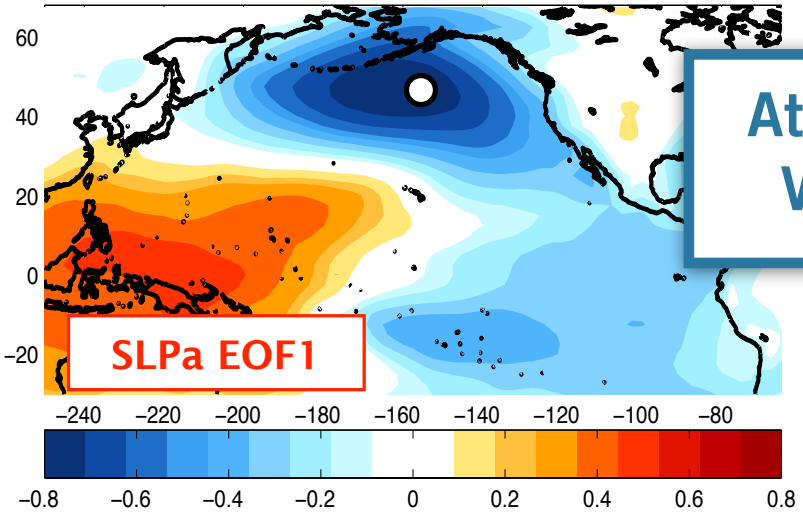
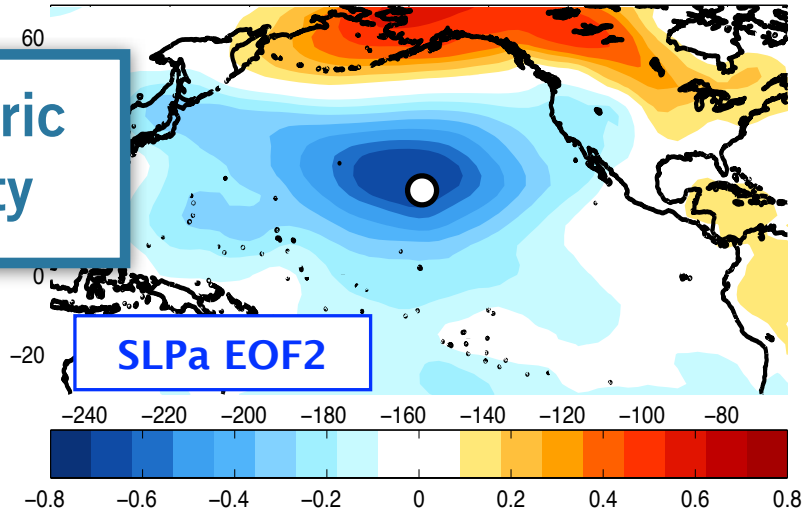


Atmospheric Variability

North Pacific Oscillation (NPO)



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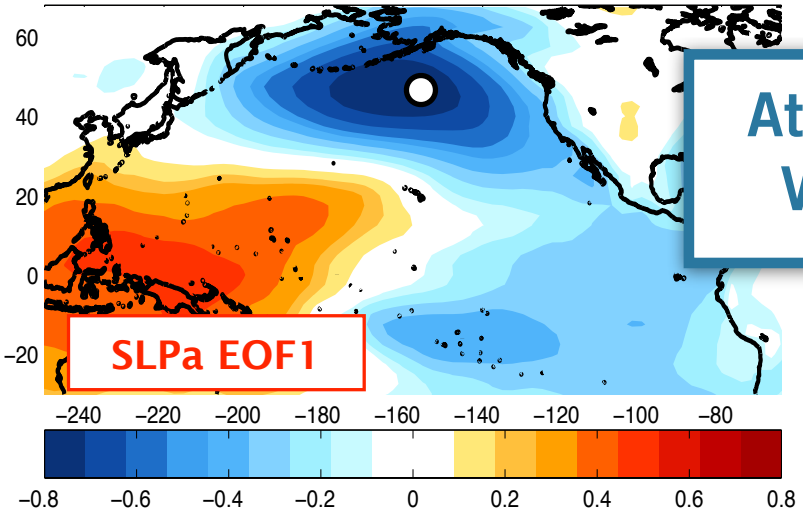

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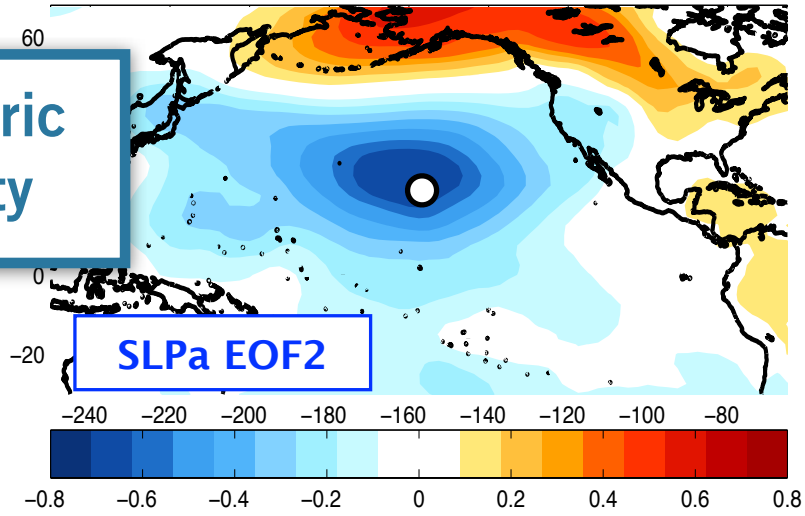

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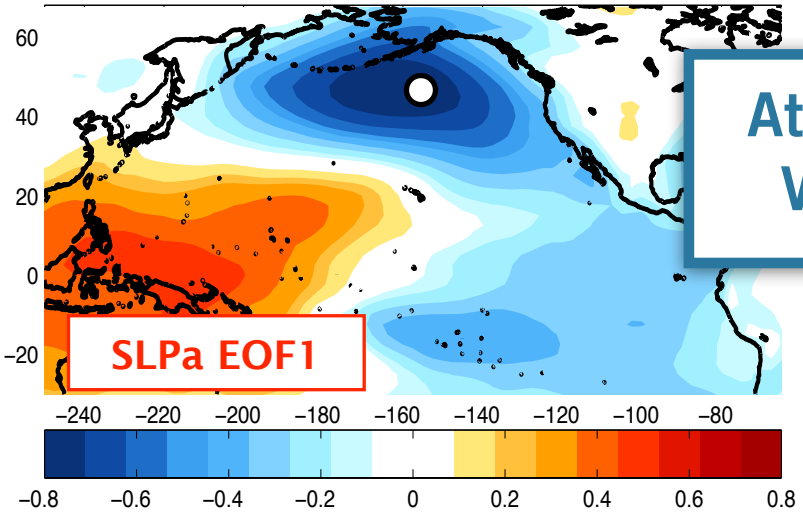

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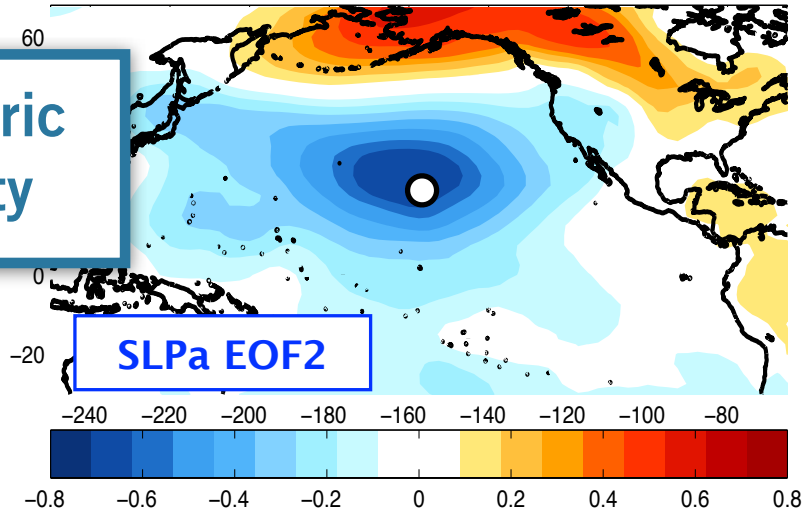

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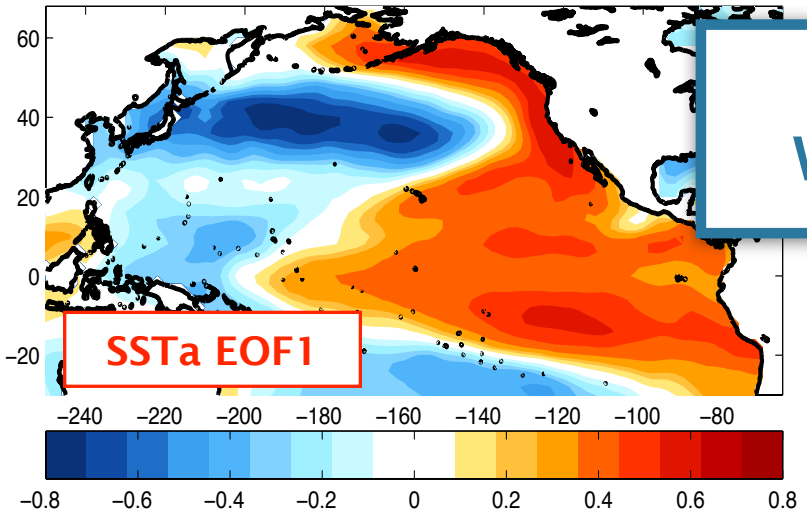

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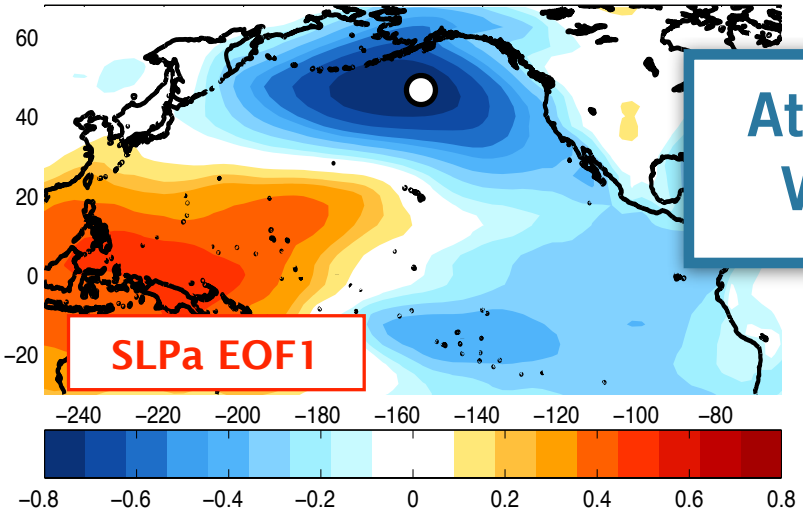

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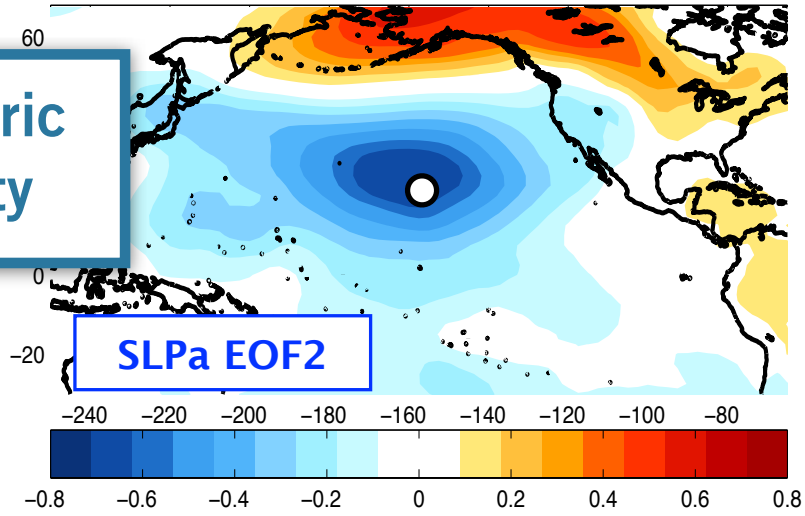

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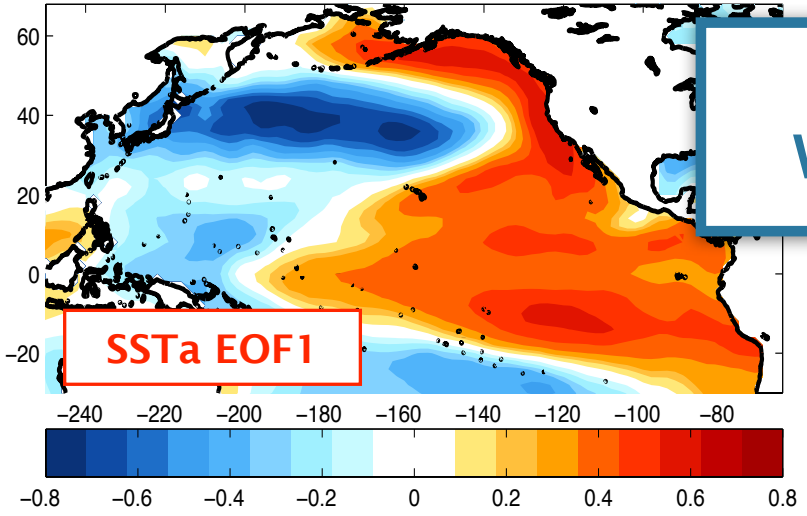

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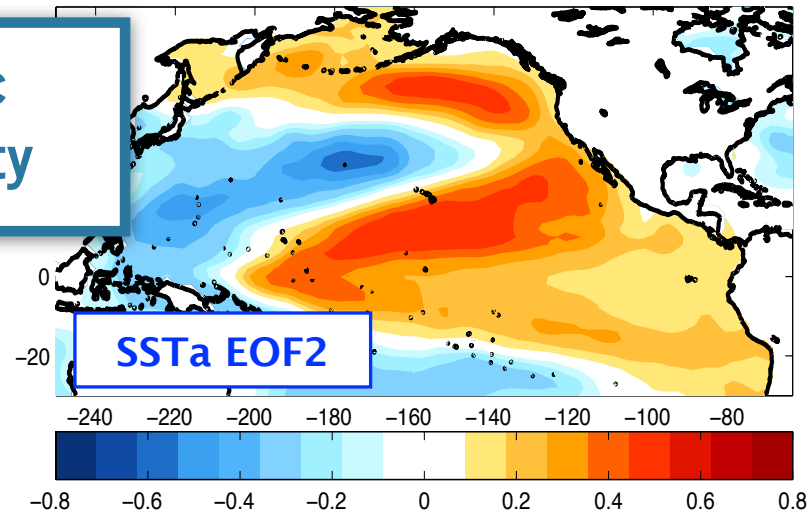

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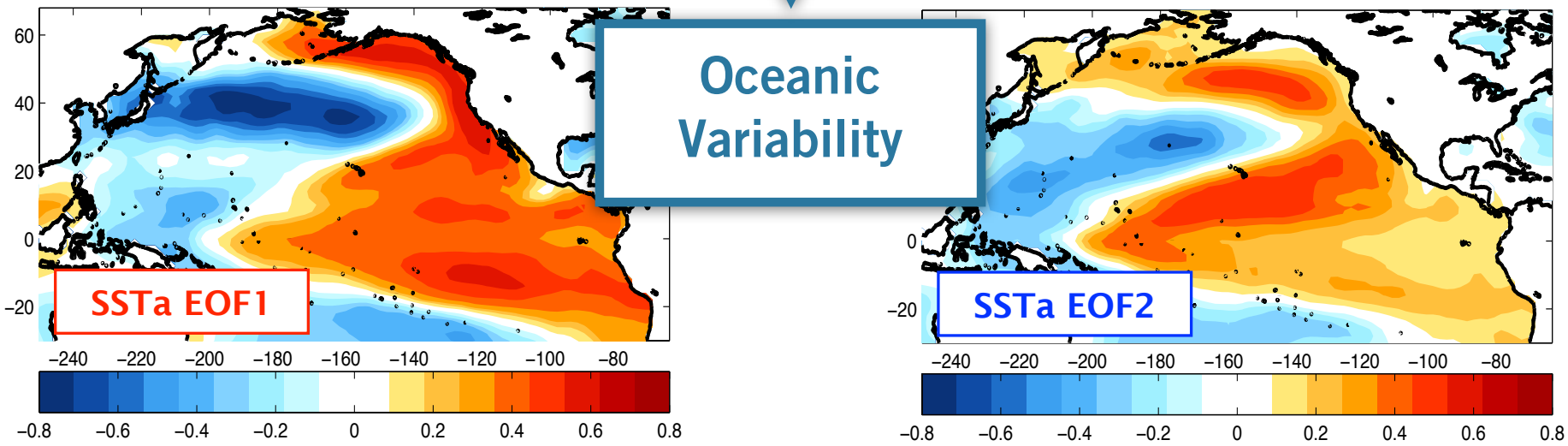

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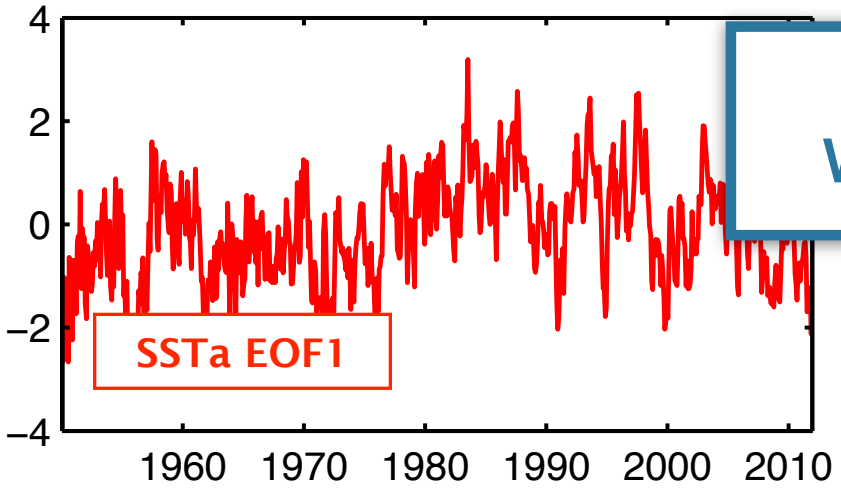

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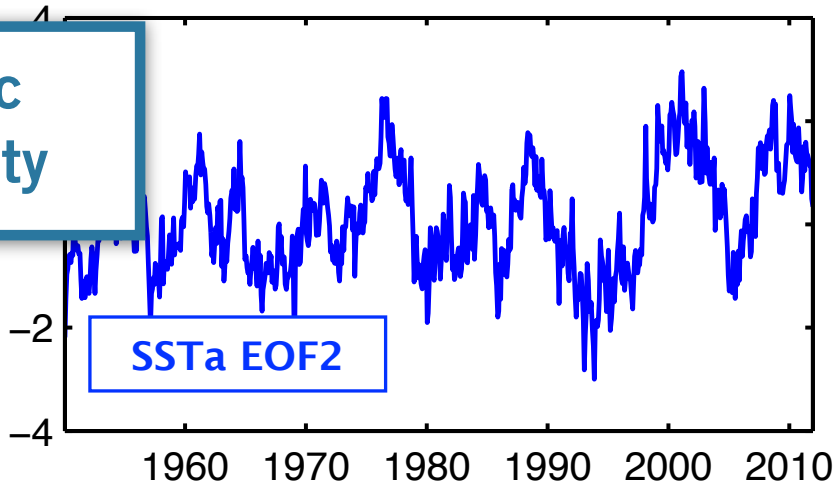

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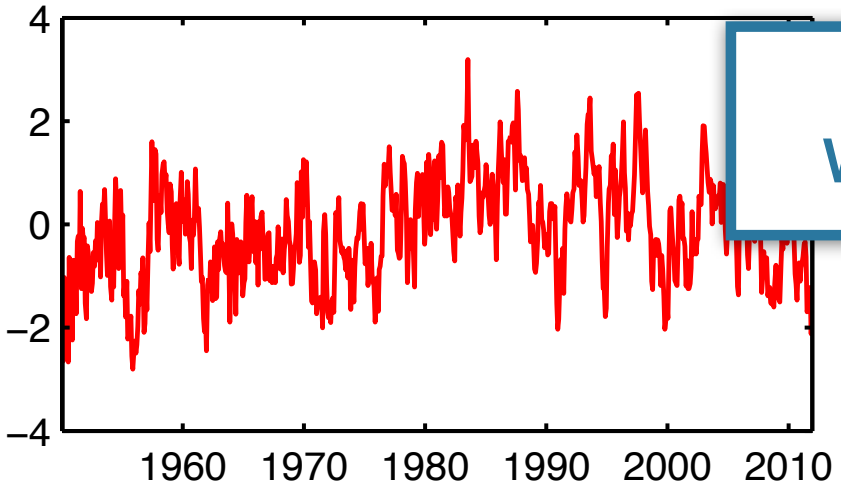

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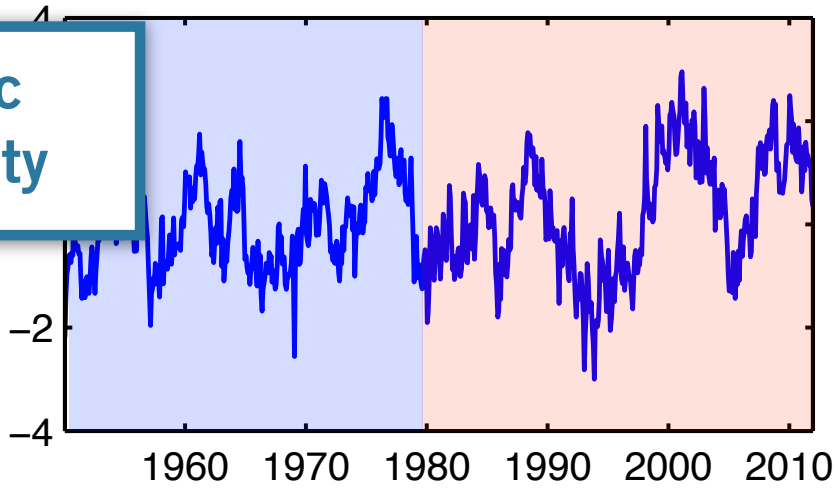

LOWER *variance*

HIGHER *variance*

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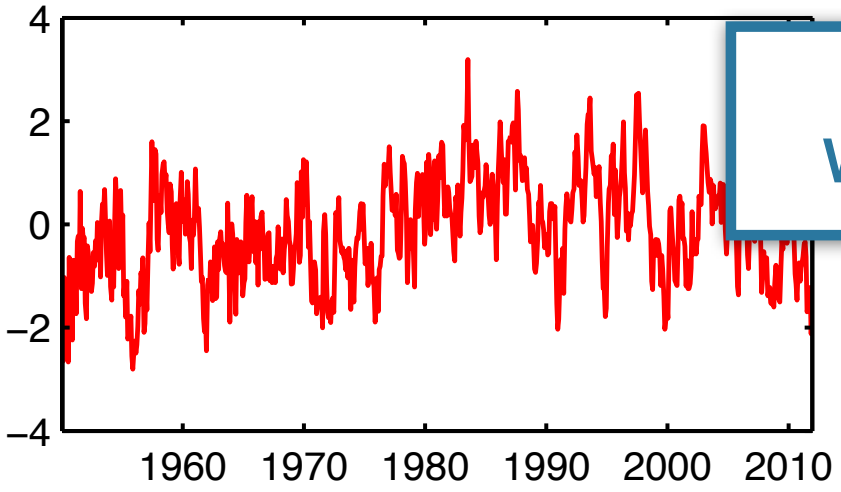

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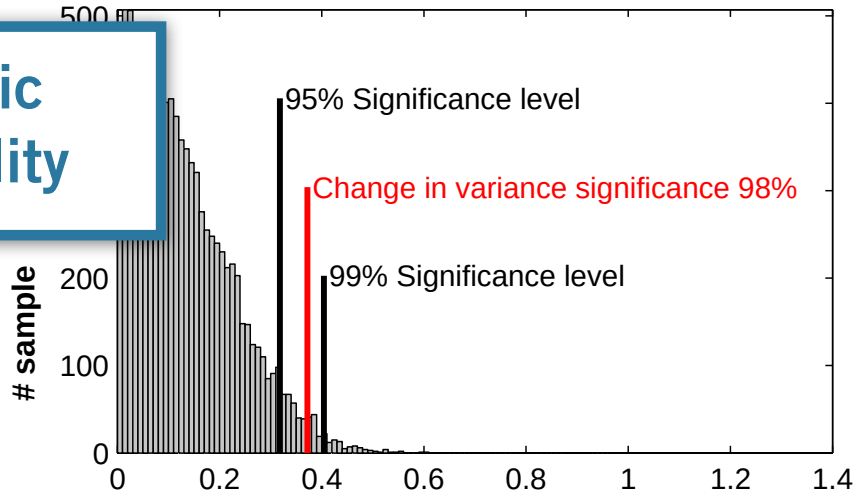

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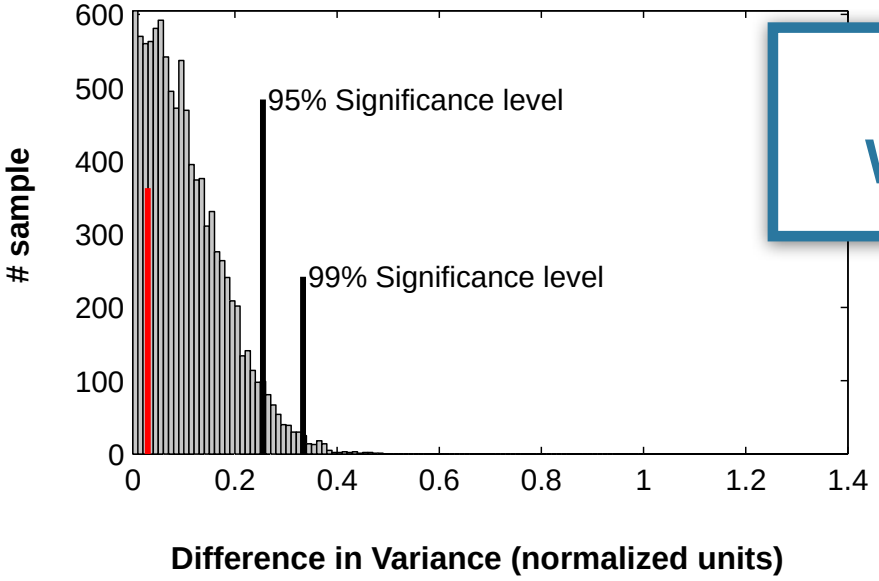

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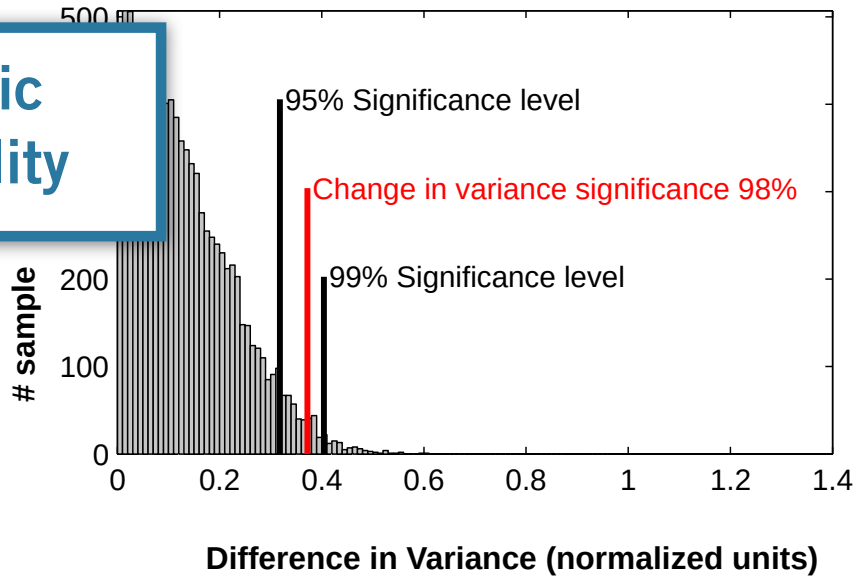

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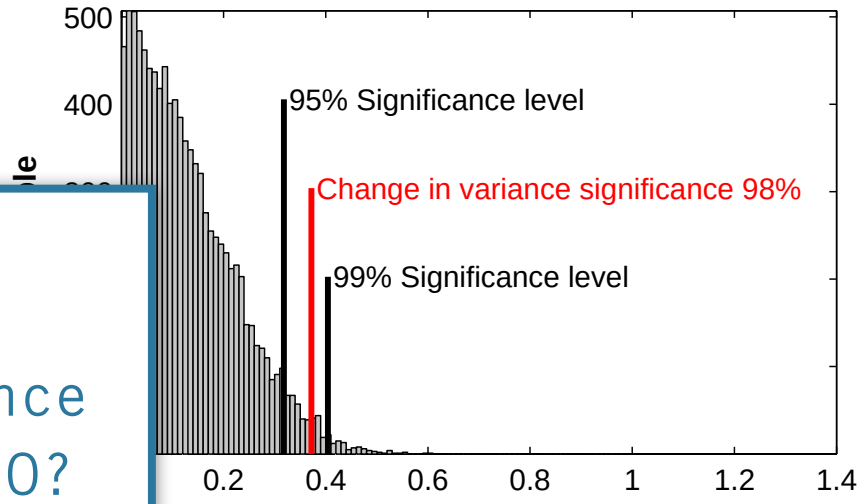

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Why has the North Pacific variance (e.g. NPGO) increased after 1980?

Understand the dynamics of Pacific Ocean variability and the coupling with the tropics

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Extra-tropics [Ocean forced by Atmosphere]

Understand the dynamics of Pacific Ocean variability and the coupling with the tropics

Tropics [Ocean-Atmosphere Coupled System]

Model for explaining Pacific decadal dynamics

Extra-tropics [Ocean forced by Atmosphere]

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Model for explaining Pacific decadal dynamics

Extra-tropics [Ocean forced by Atmosphere]

CPW

Central Pacific Warming

non-Canonical ENSO

(mature)

ENSO

Eastern Pacific

Canonical ENSO

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Tropics [Ocean-Atmosphere Coupled System]

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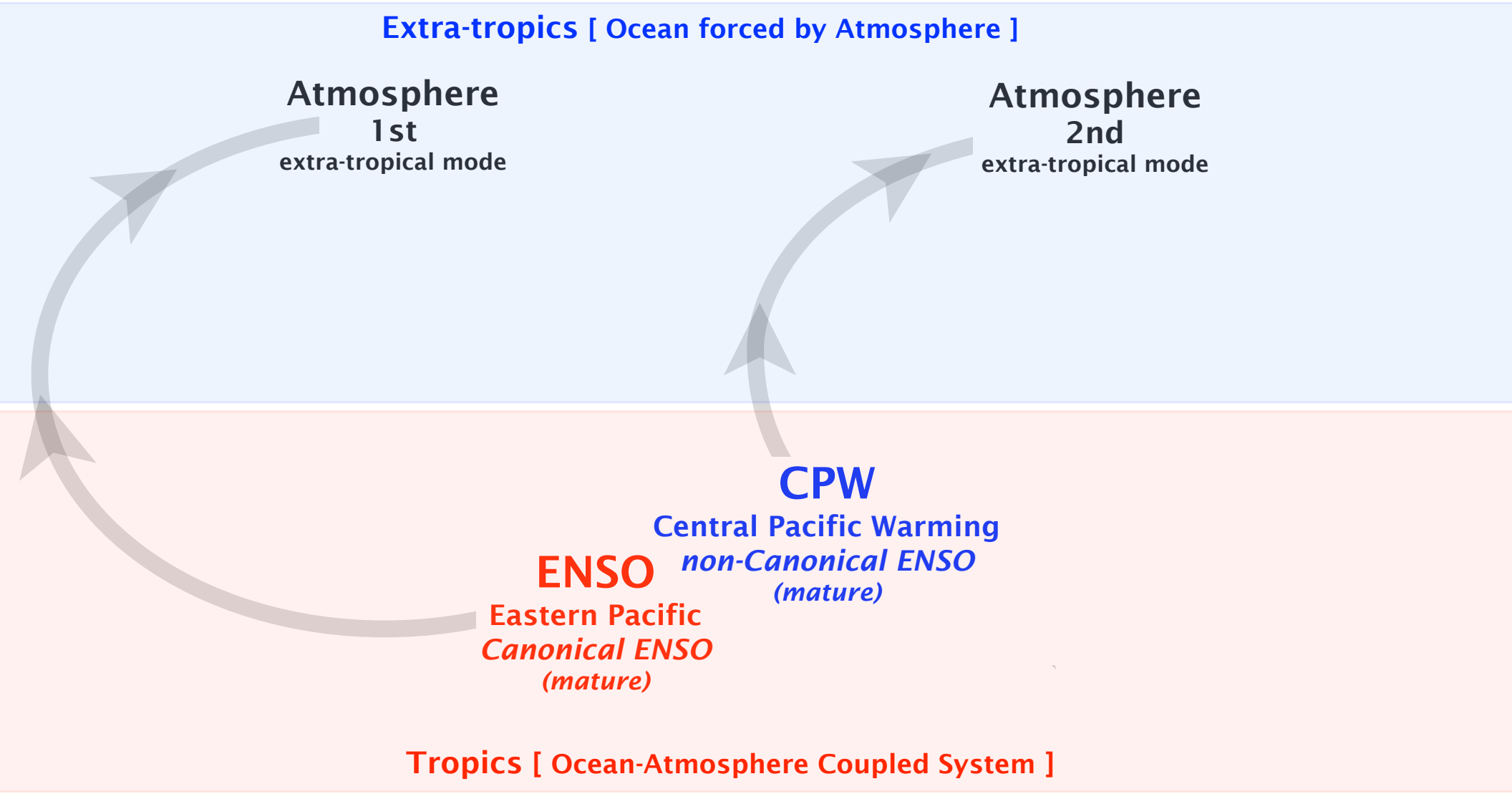

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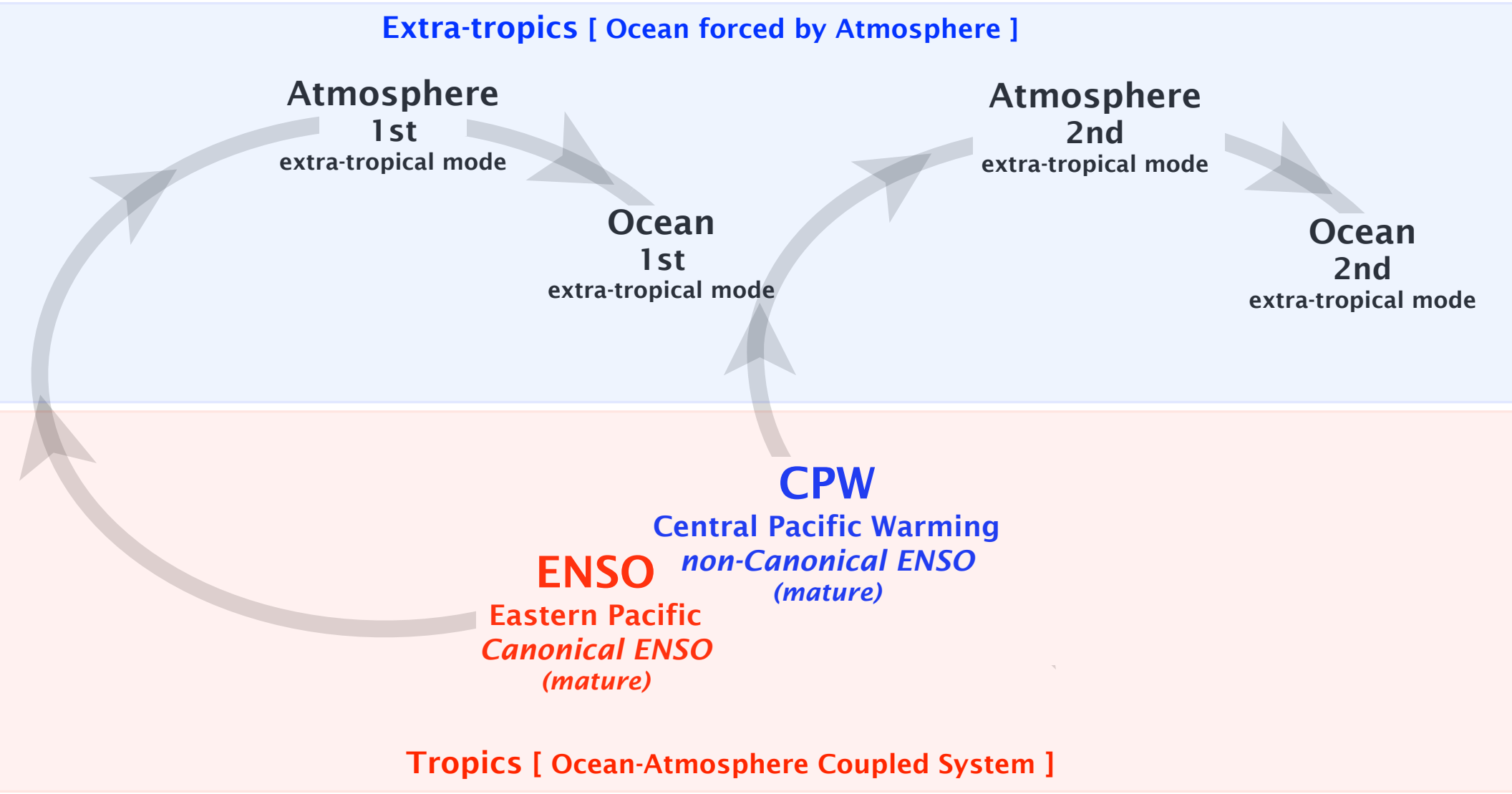

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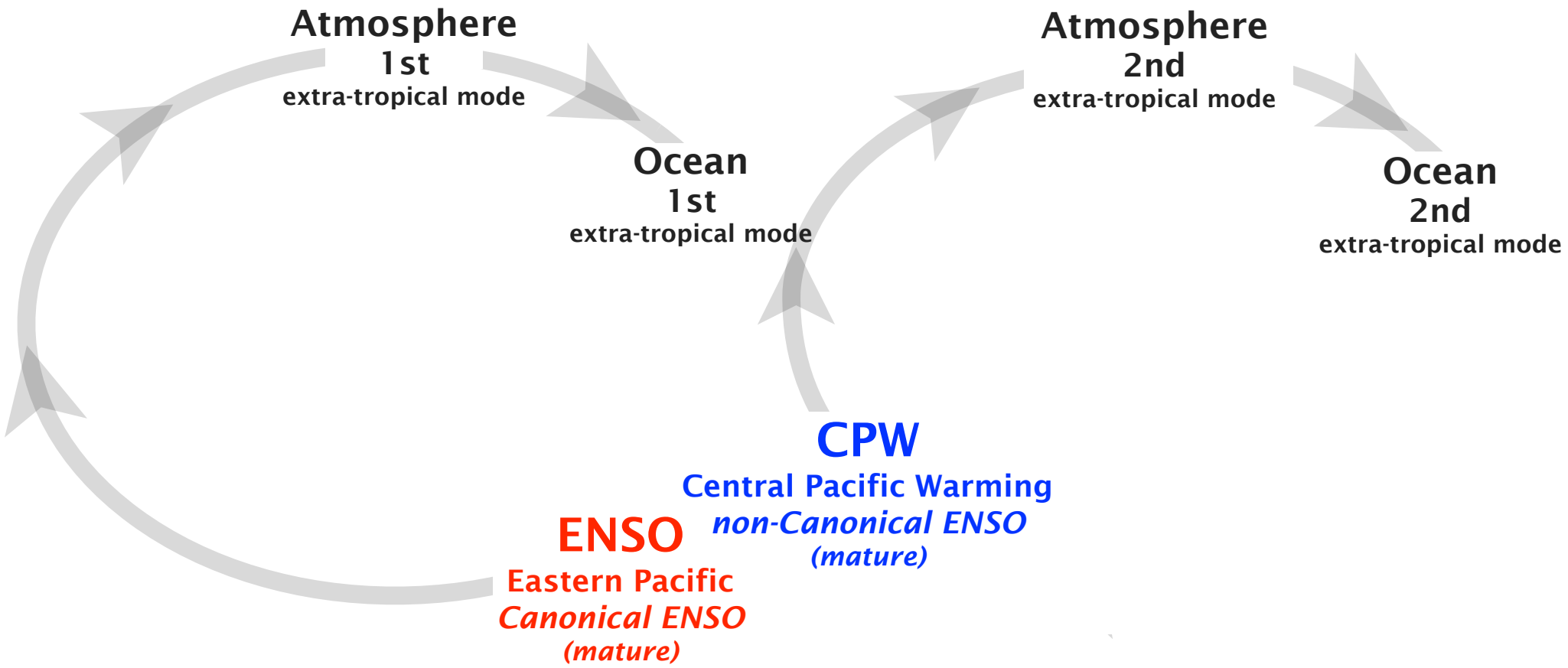

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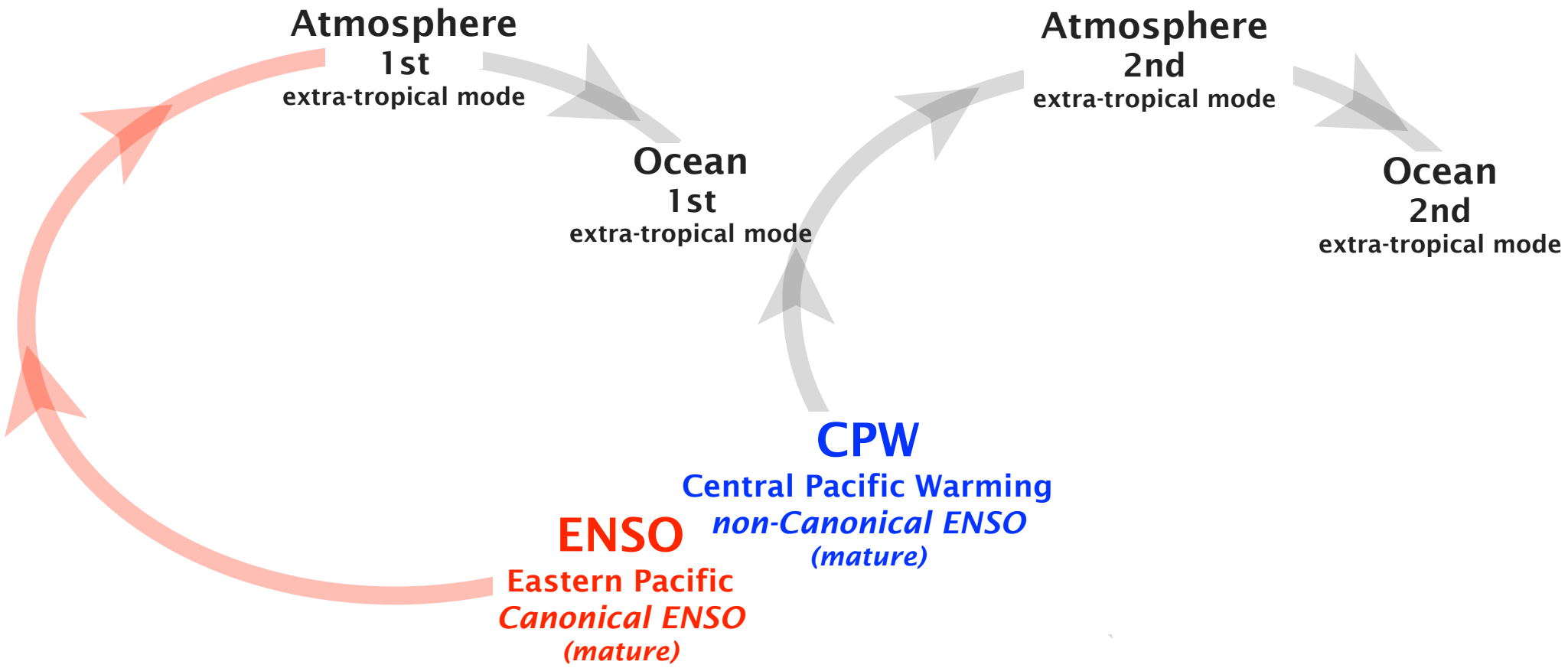

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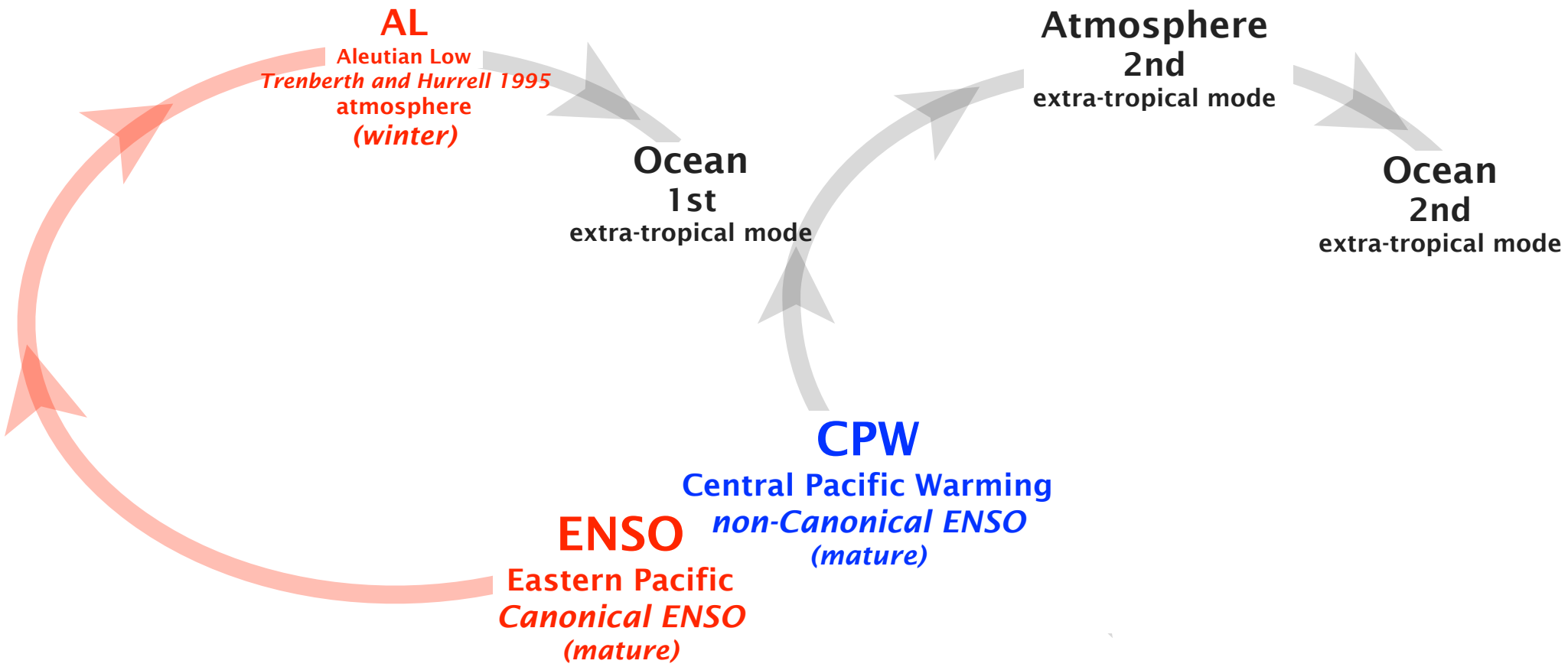

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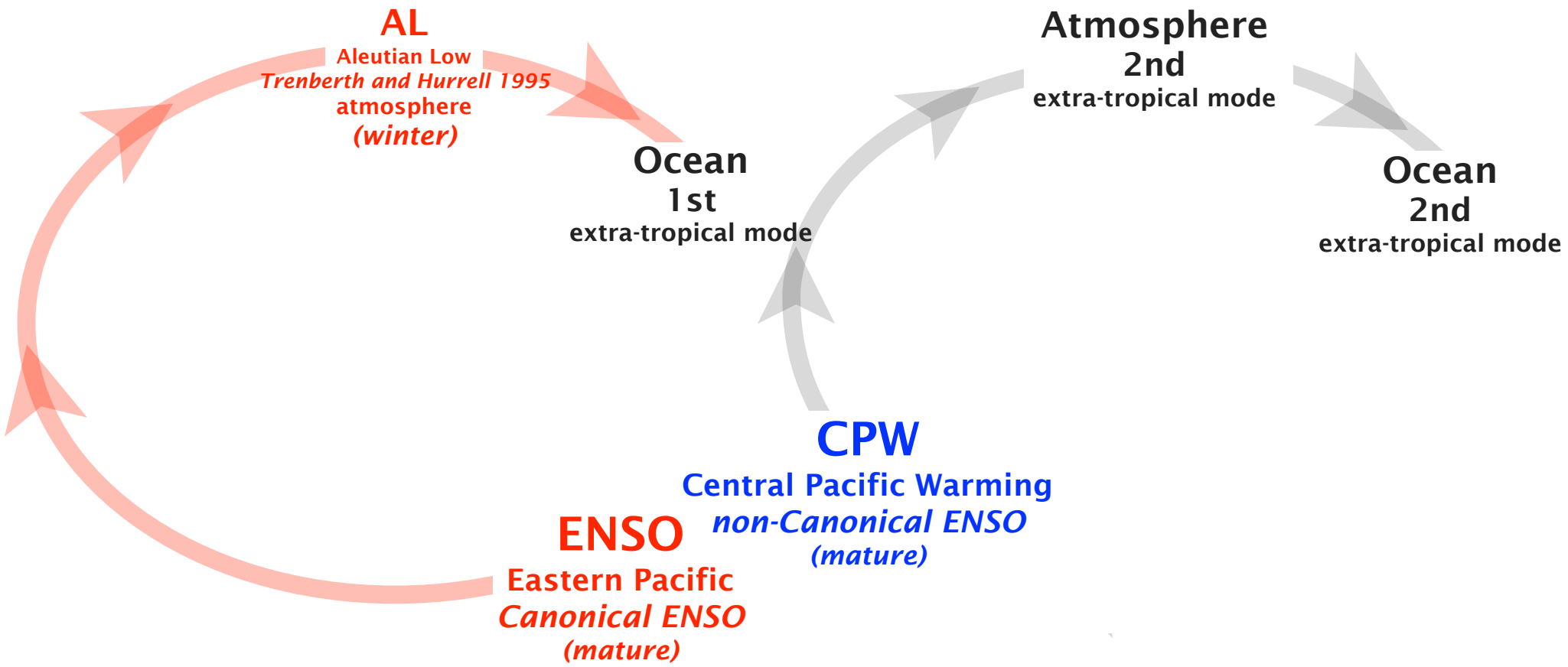

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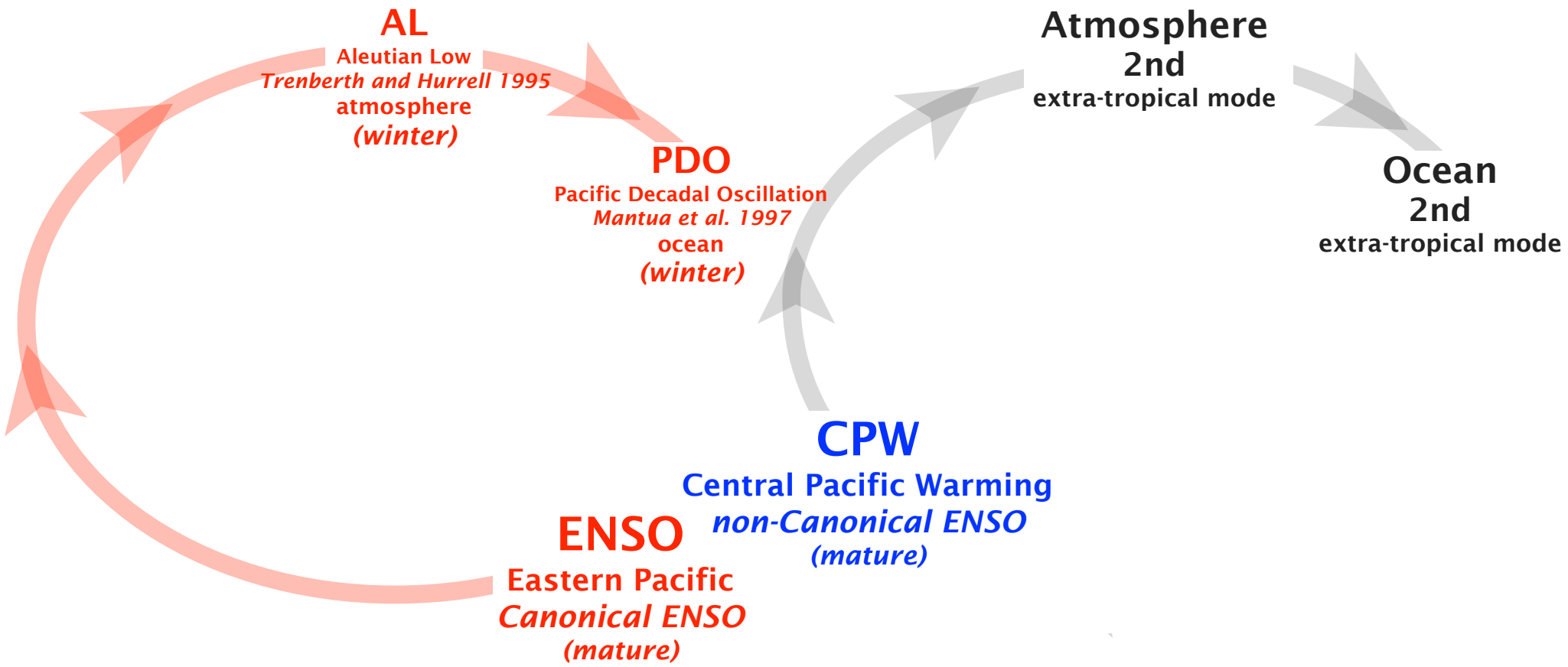

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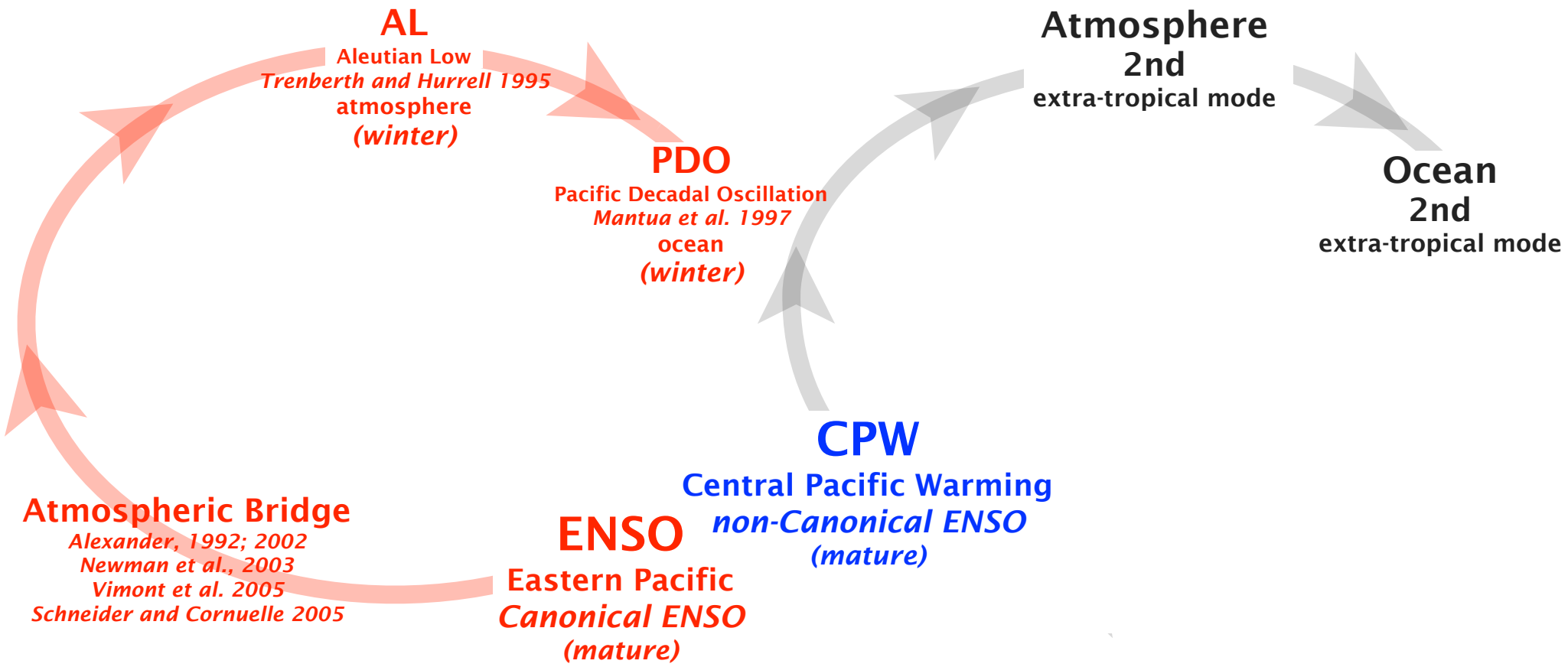

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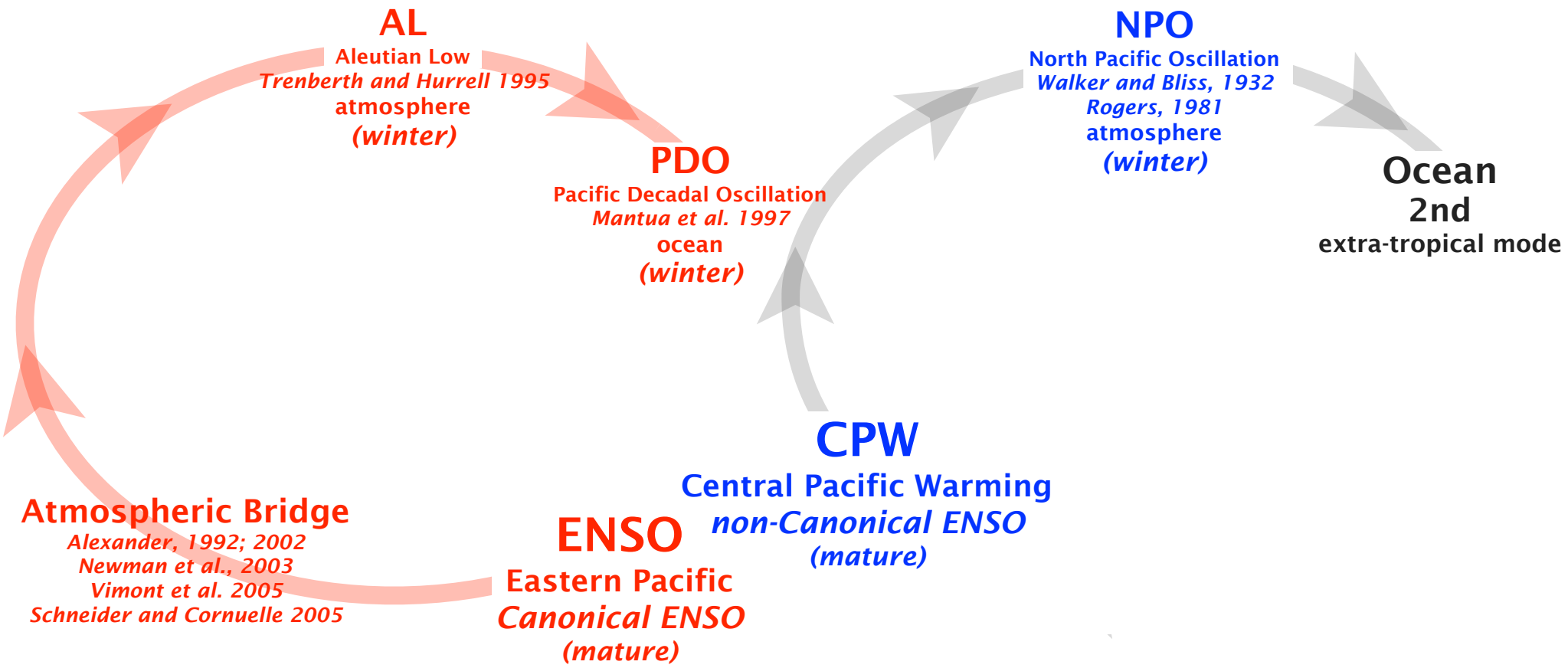

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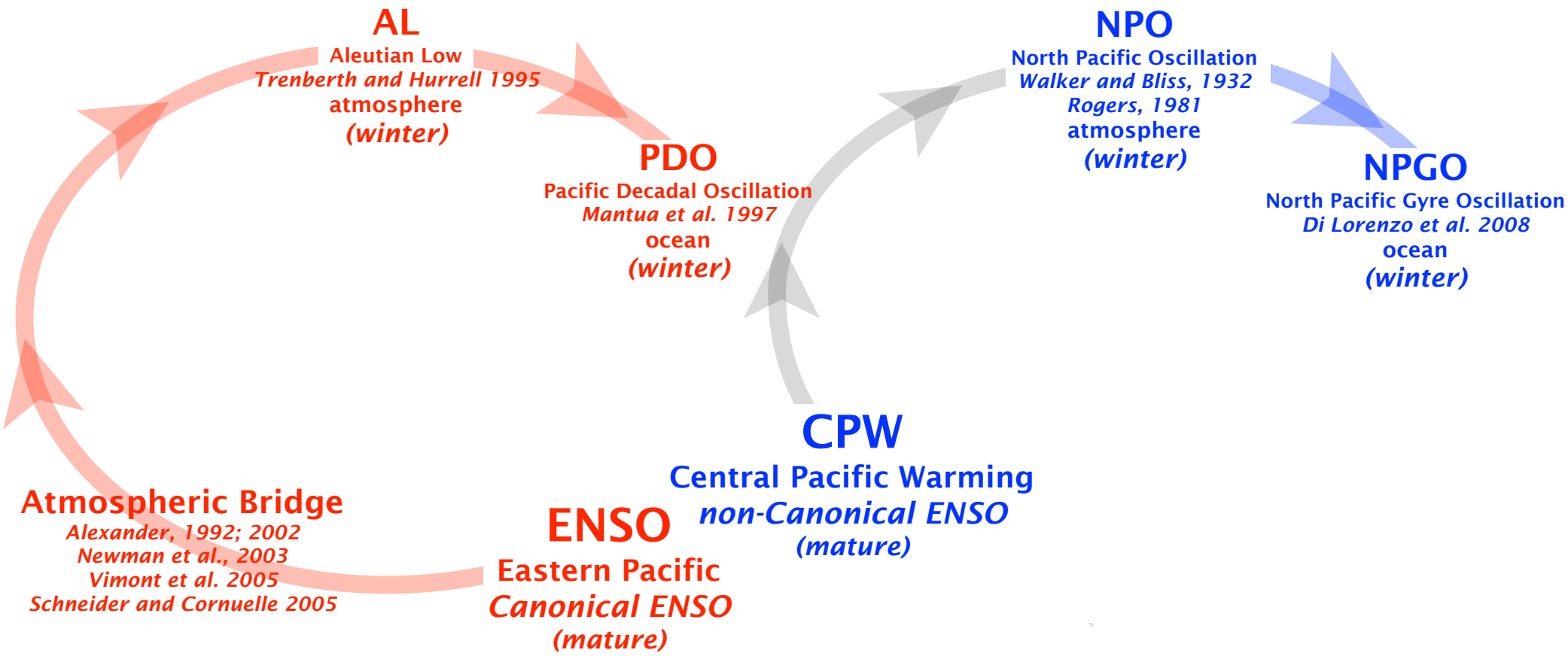

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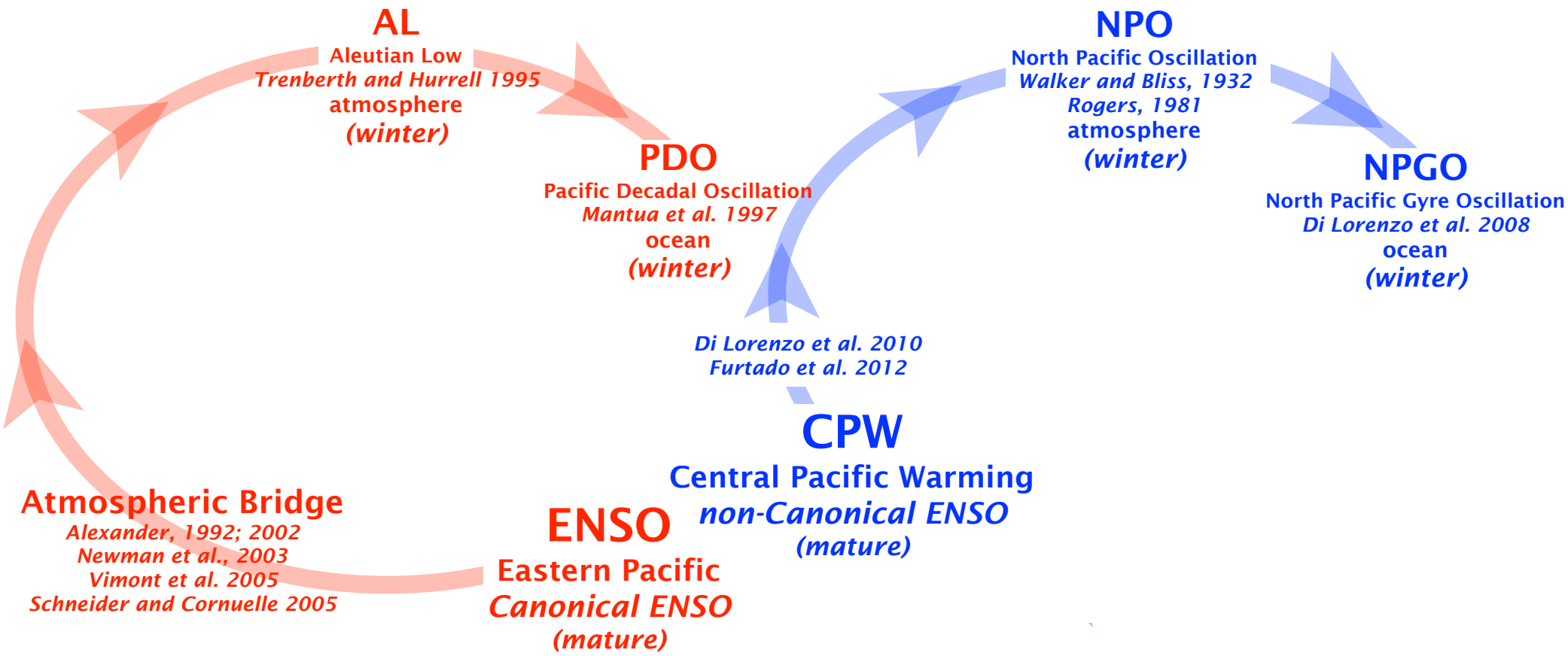

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(winter)

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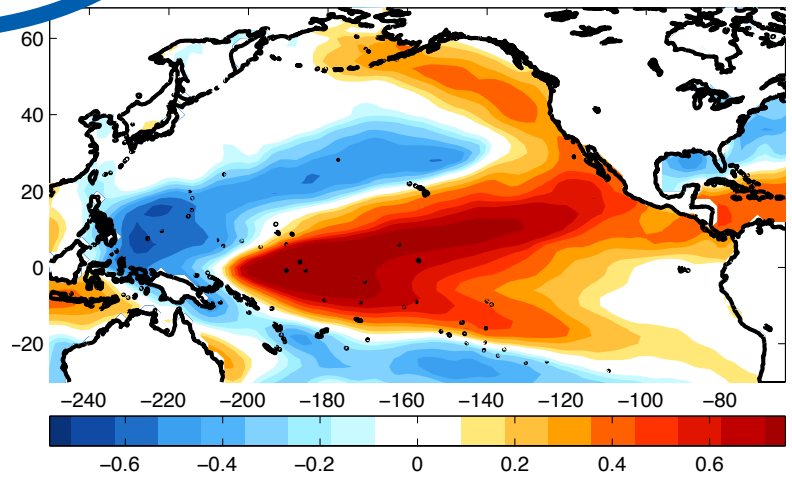
CPW (*Non*-Canonical ENSO)



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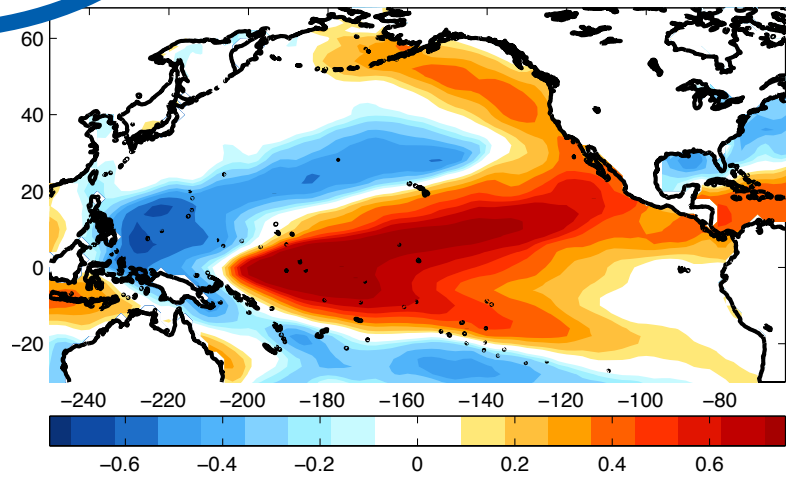

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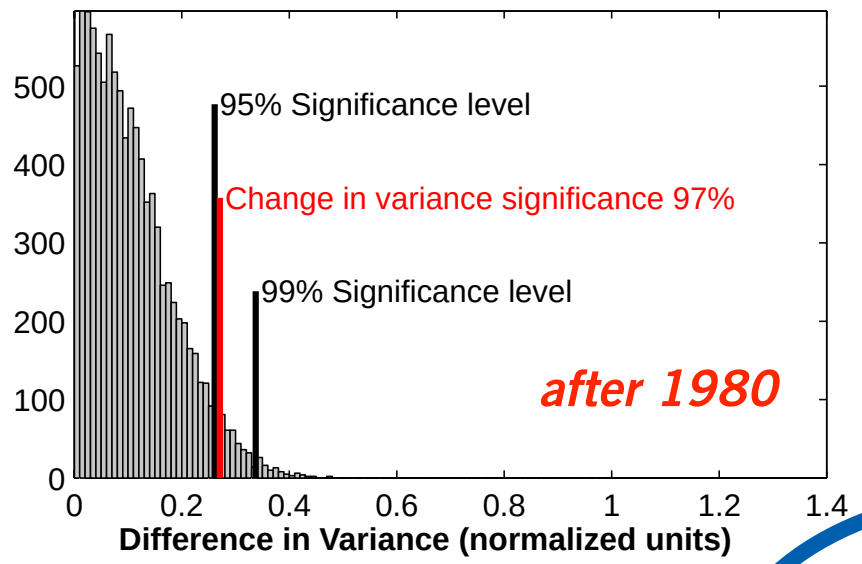

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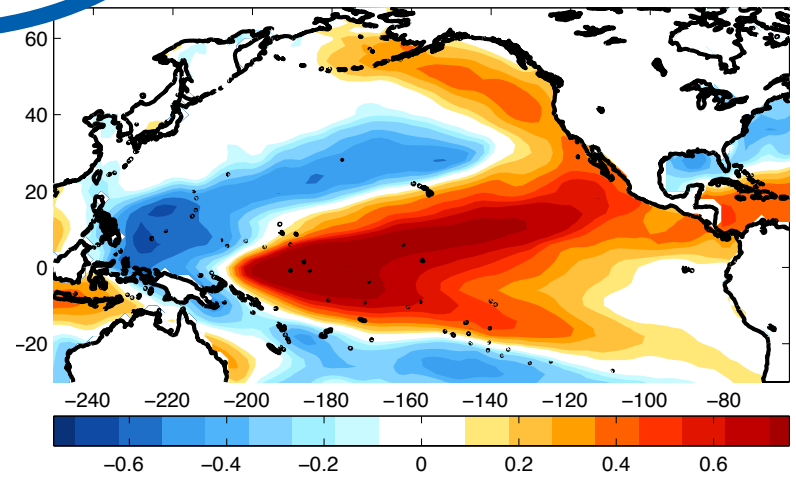

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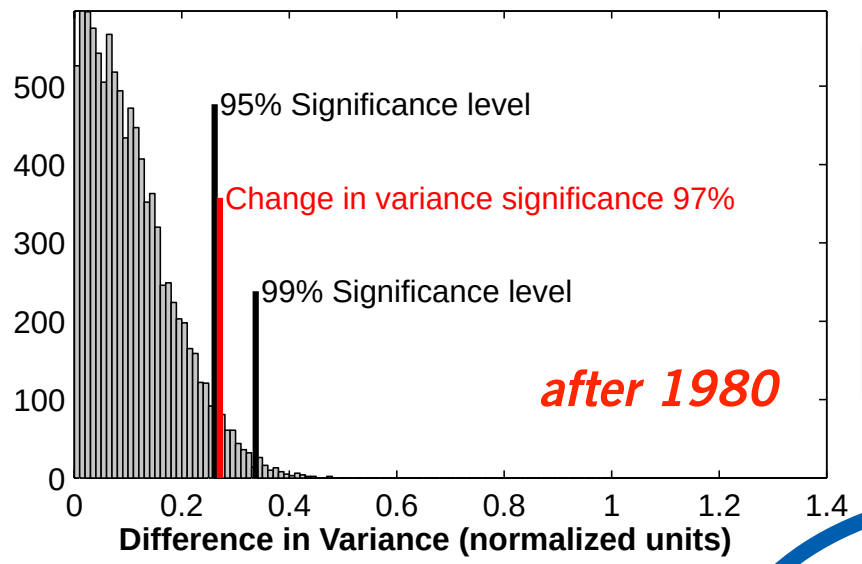

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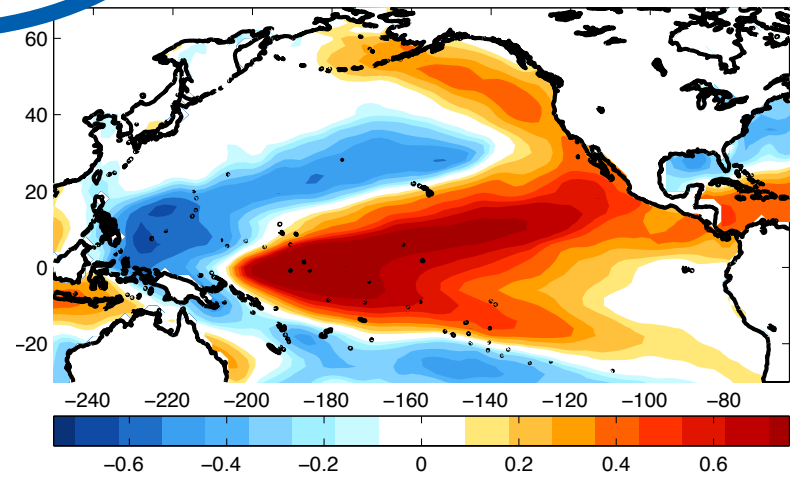

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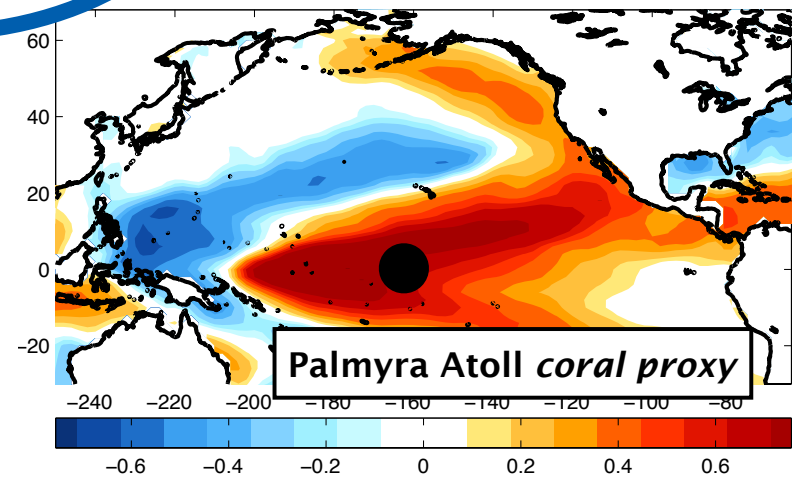

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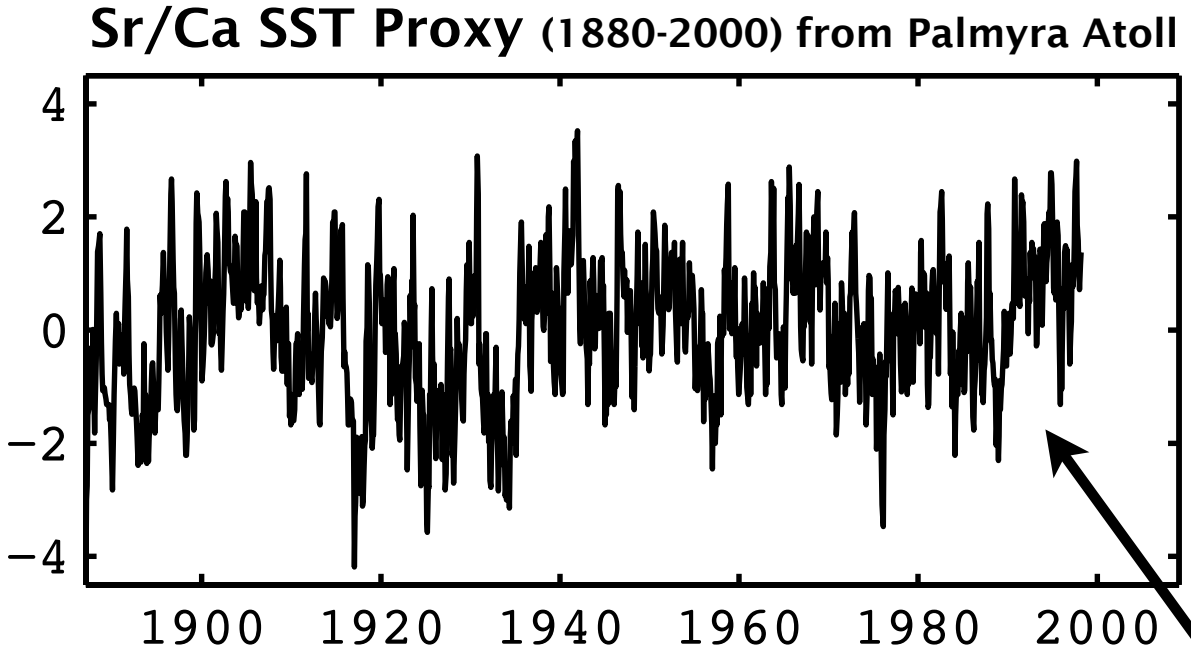

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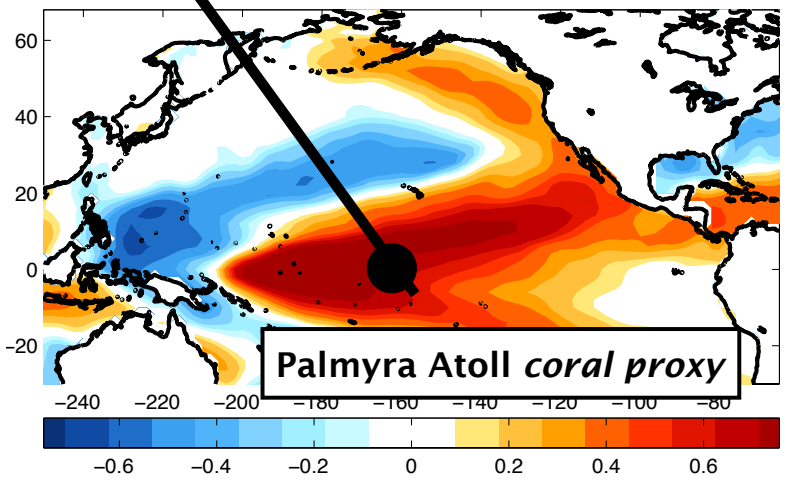

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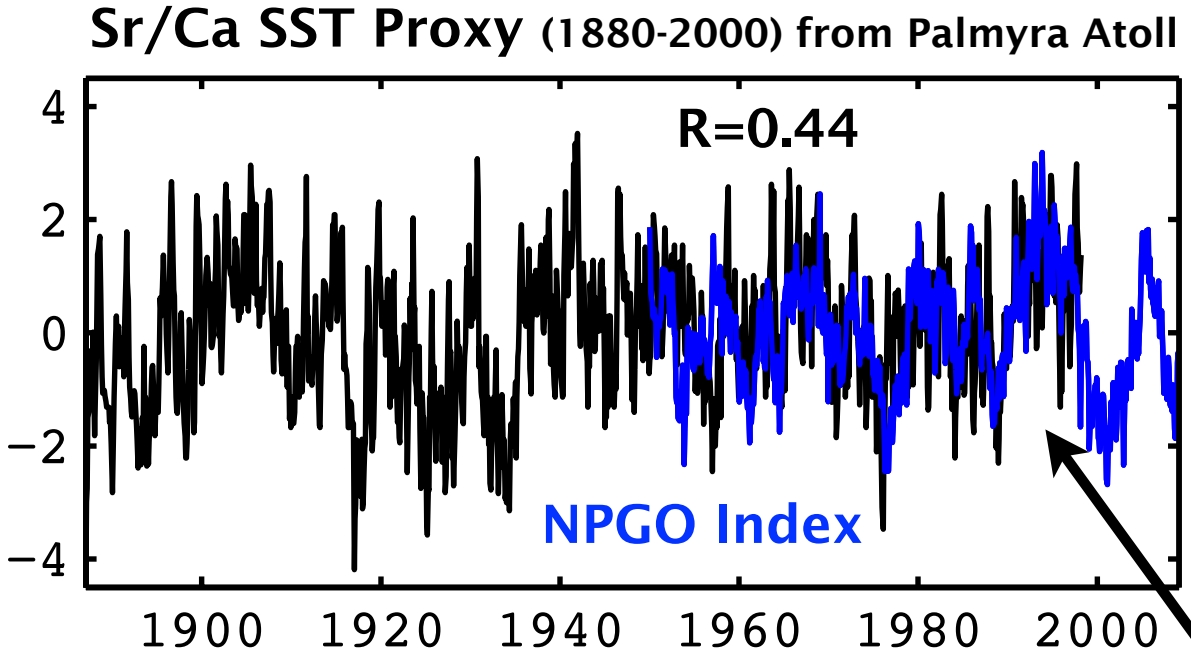

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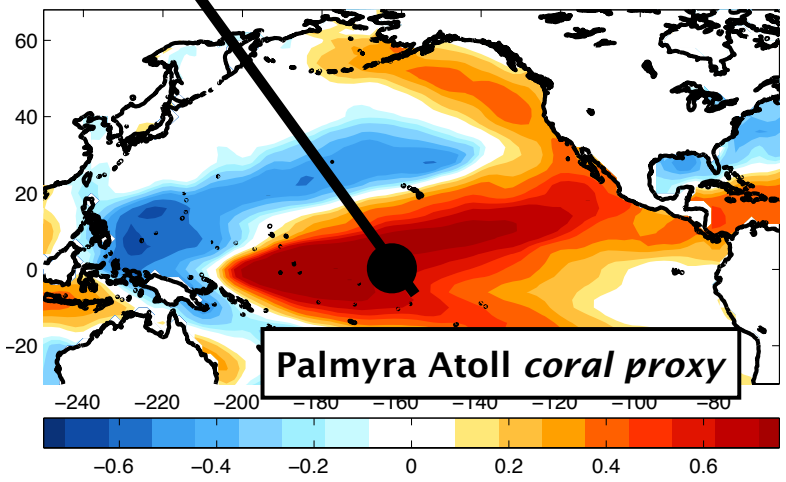
(winter)

NPGO
North Pacific Gyre Oscillation
Di Lorenzo et al. 2008
ocean
(winter)

Vimont et al. 2005
Schneider and Cornuelle 2005

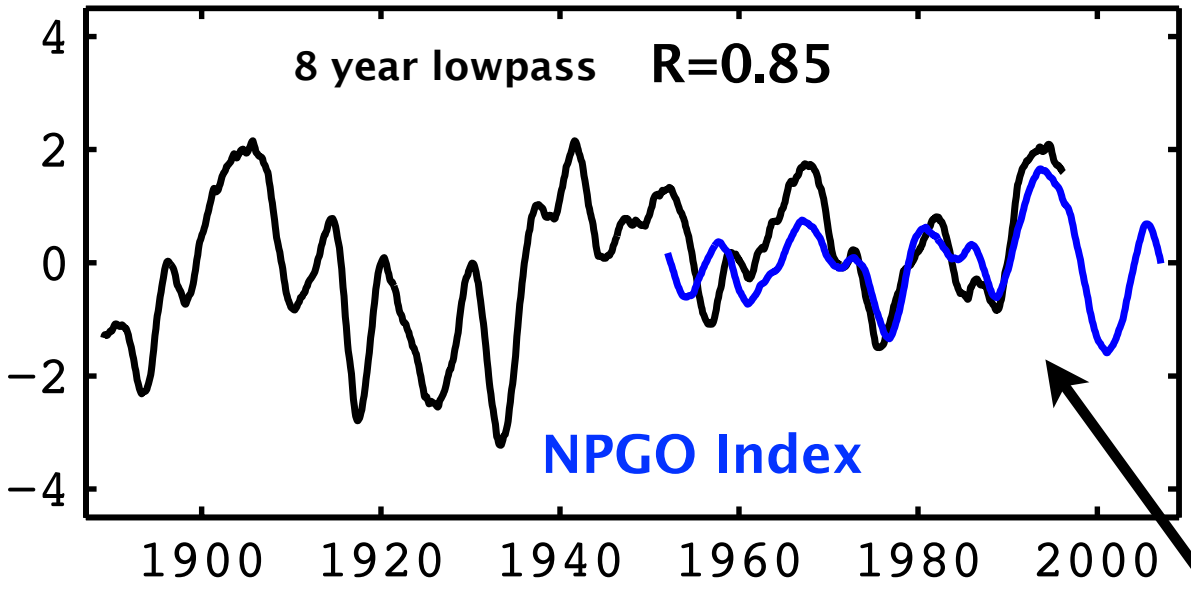
Canonical ENSO
(mature)

CPW (*Non*-Canonical ENSO)



Nurhati, I.S., Cobb, K.M., Di Lorenzo, E., 2011. Journal of Climate, 24, 3294-3308.

Model for explaining Pacific decadal dynamics



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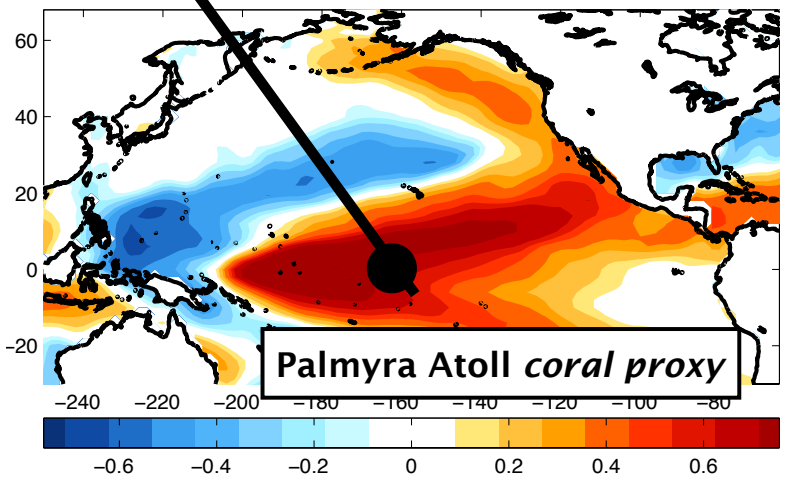

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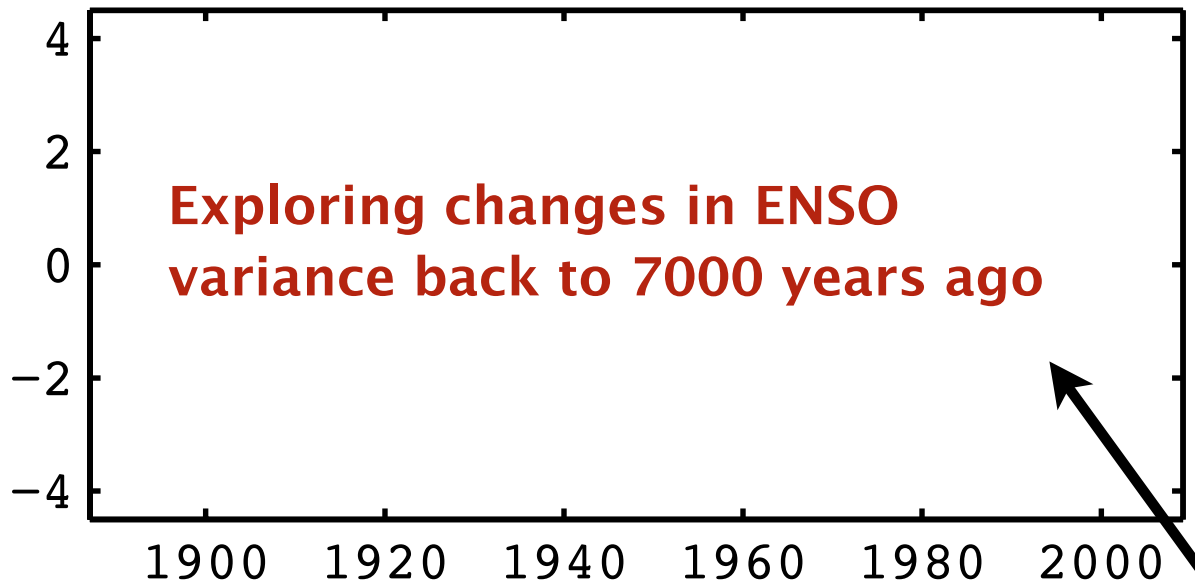

Exploring changes in ENSO variance back to 7000 years ago

NPO
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Rogers, 1981
atmosphere
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NPGO
North Pacific Gyre Oscillation
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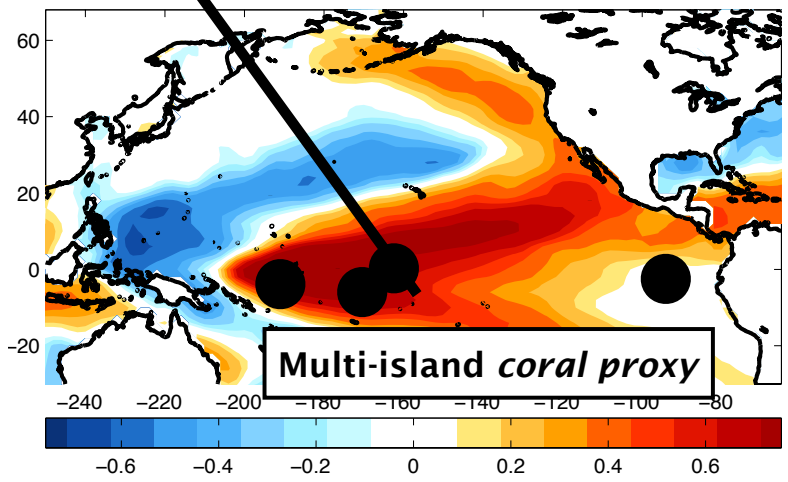
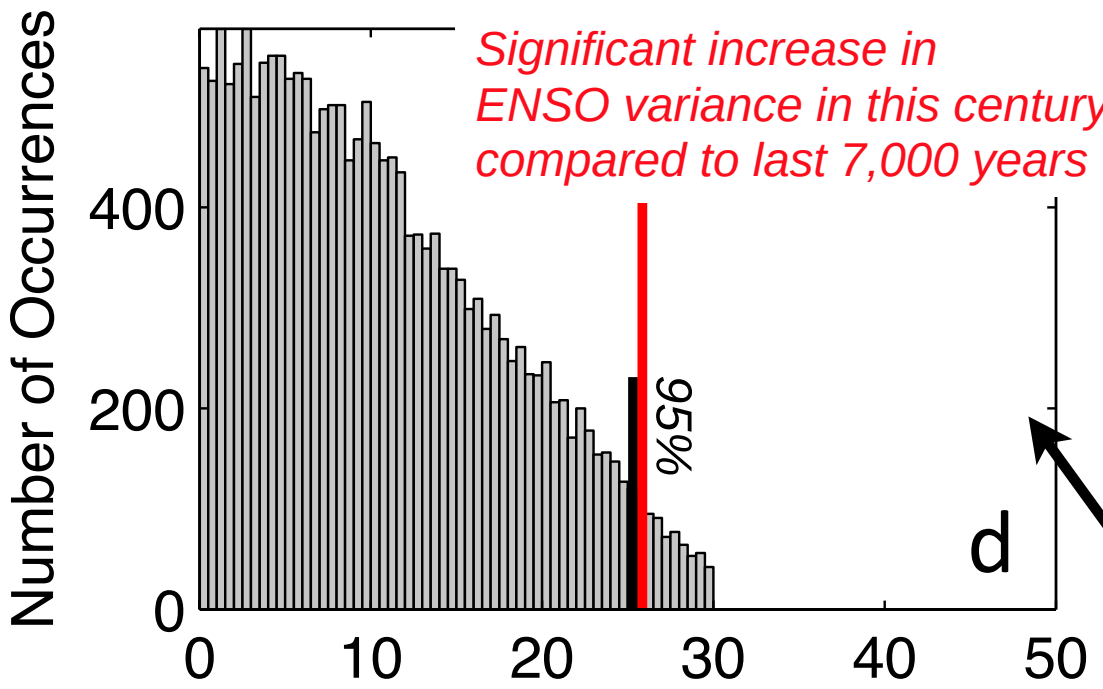


Cobb, K.M., Westphal, N., Sayani, H.R., Watson, J.T., Di Lorenzo, E., et al, 2013. ***Science****, 339, 67-70.*

Model for explaining Pacific decadal dynamics



Significant increase in ENSO variance in this century compared to last 7,000 years

NPO
h Pacific Oscillation
ker and Bliss, 1932
Rogers, 1981
atmosphere
(winter)

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North Pacific Gyre Oscillation
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Eastern Pacific
Canonical ENSO
(mature)

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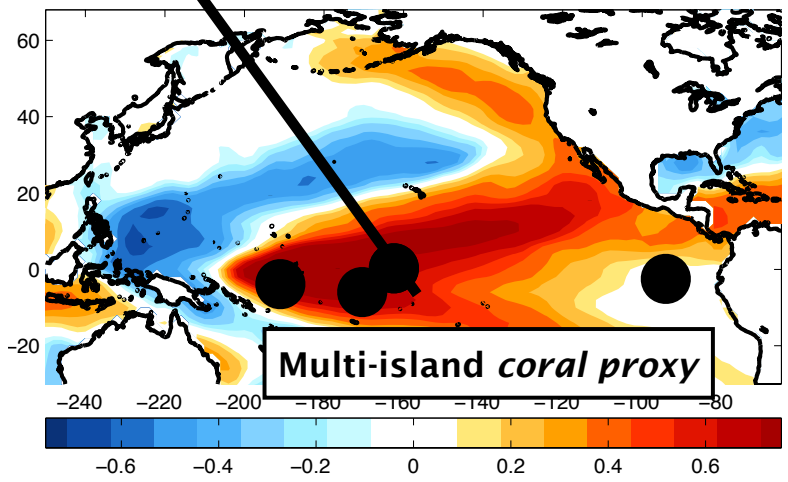


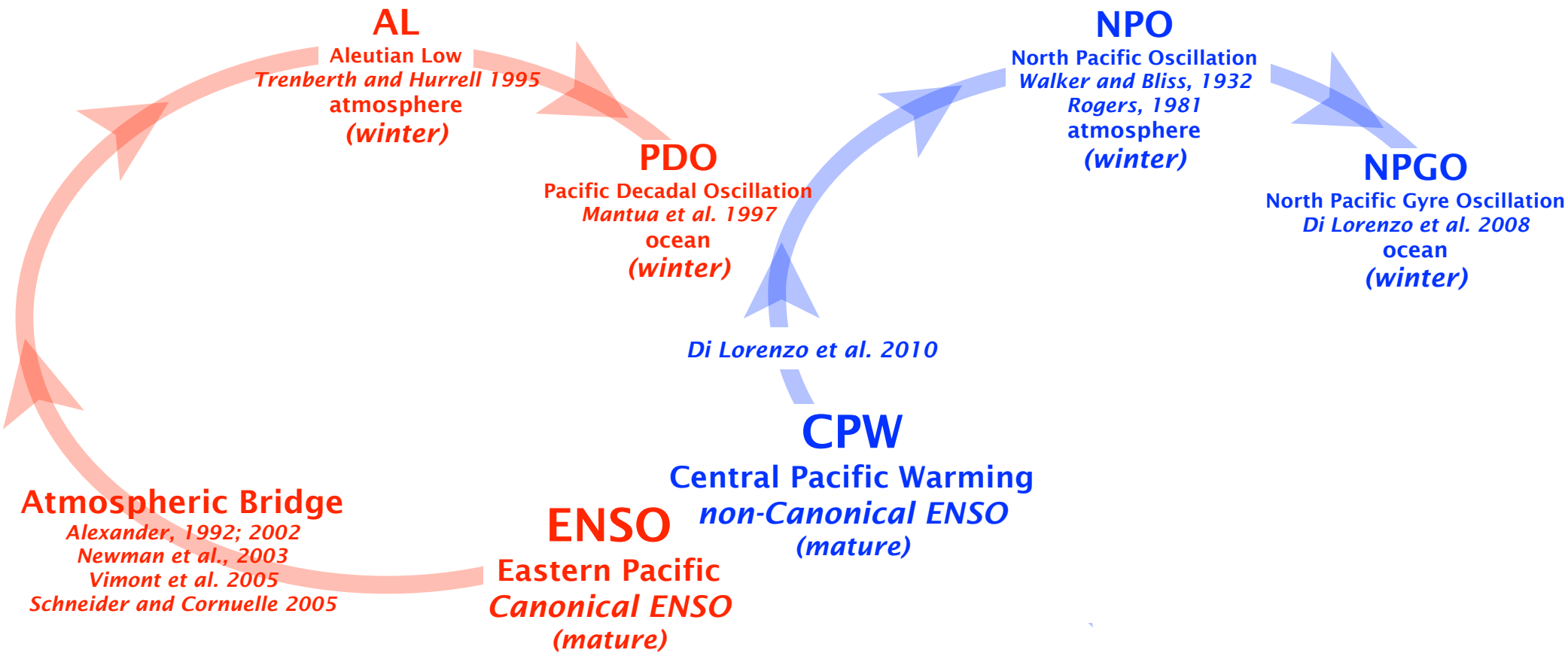
Cobb, K.M., Westphal, N., Sayani, H.R., Watson, J.T., Di Lorenzo, E., et al, 2013. ***Science****, 339, 67-70.*

Model for explaining Pacific decadal dynamics

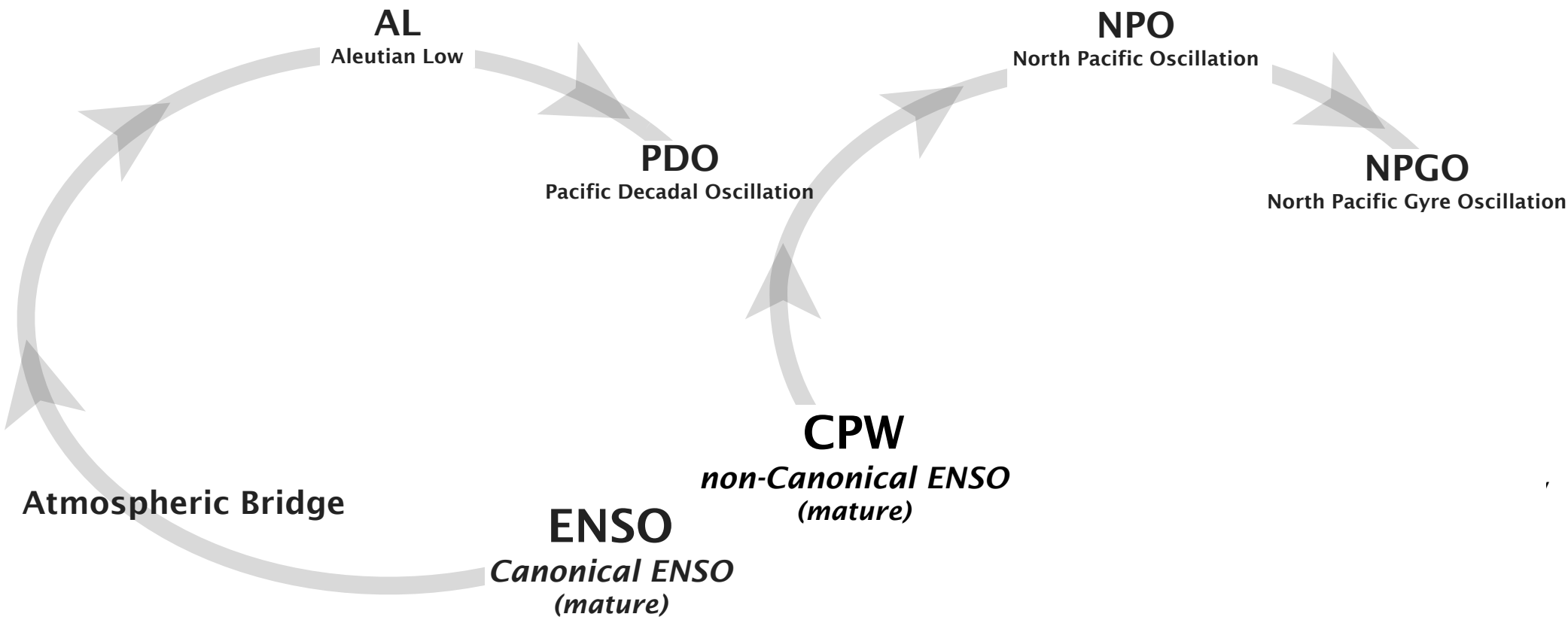
QUESTION:

Can we use IPCC climate model to forecast the changes in North Pacific variance?

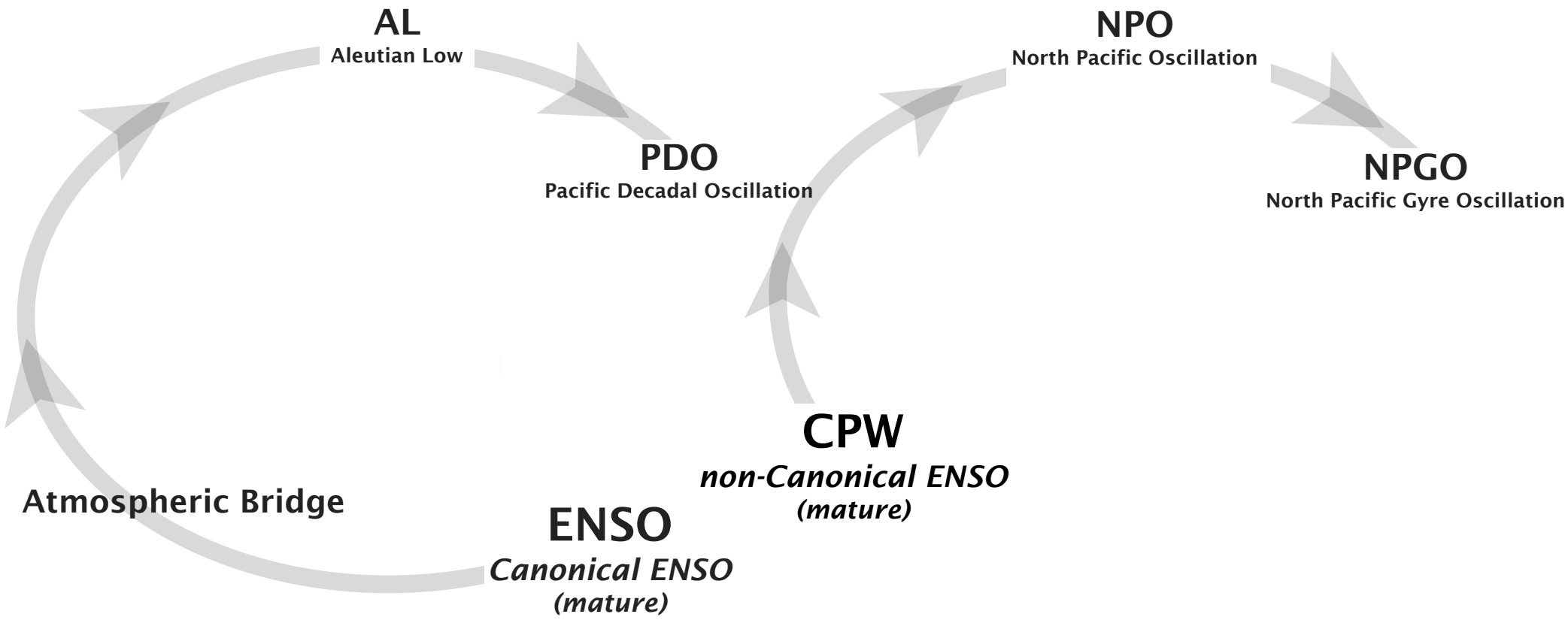
Model for explaining Pacific decadal dynamics



Model for explaining Pacific decadal dynamics



Test the AR4 models Pacific decadal dynamics 1800-2000



Furtado, J.C., Di Lorenzo, et al., 2011.
North Pacific Decadal Variability and Climate Change in the IPCC AR4 Models.
Journal of Climate, 24, 3049-3067.

Furtado et al., 2011

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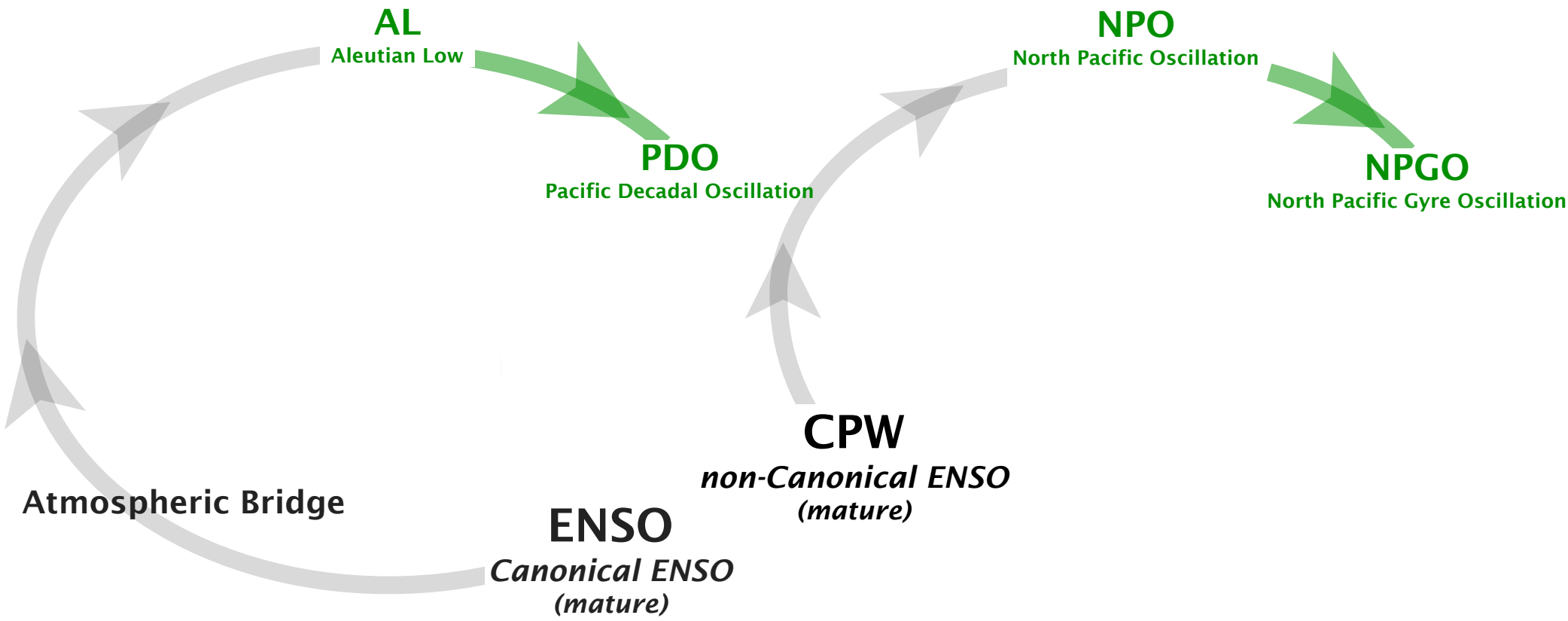
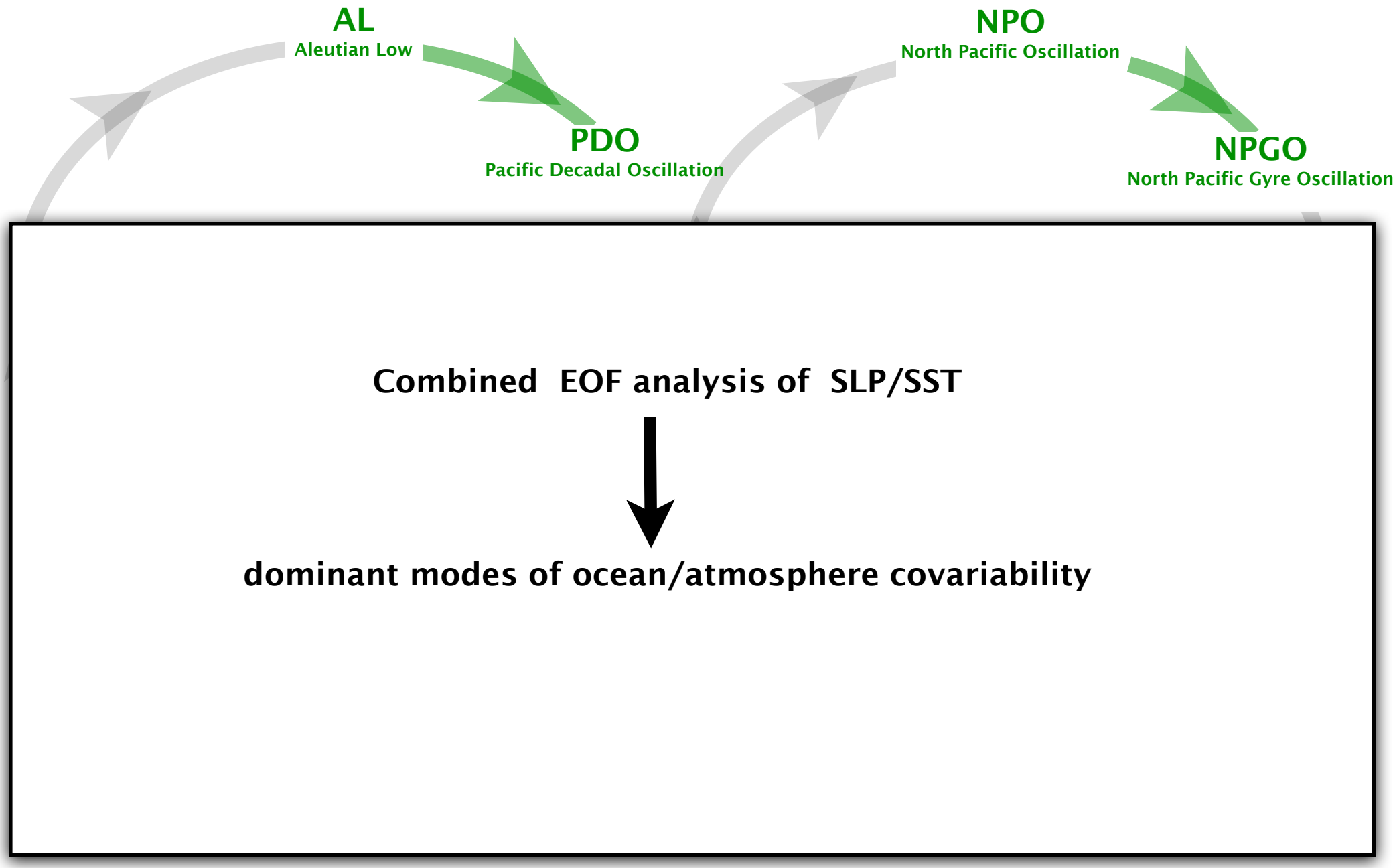


Furtado et al., 2011

Test the AR4 models Pacific decadal dynamics 1800-2000



Furtado et al., 2011

Test the AR4 models Pacific decadal dynamics 1800-2000

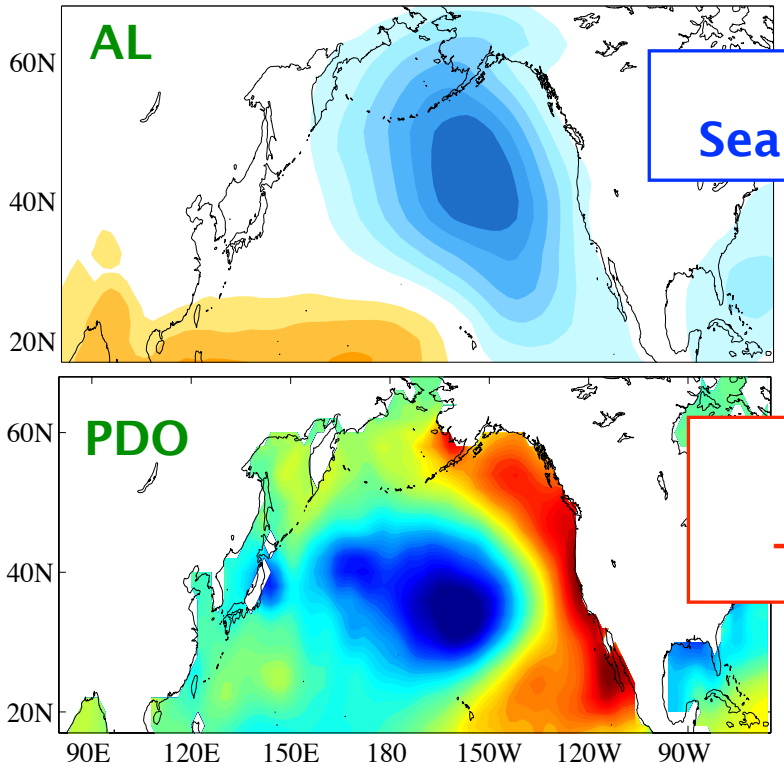
AL
Aleutian Low

NPO
North Pacific Oscillation

PDO
Pacific Decadal Oscillation

NPGO
North Pacific Gyre Oscillation

Observations



Atmosphere
Sea Level Pressure

Ocean
Sea Surface Temperature

Ocean/Atmosphere Combined EOF Mode 1

Furtado et al., 2011

Test the AR4 models Pacific decadal dynamics 1800-2000

AL
Aleutian Low

PDO
Pacific Decadal Oscillation

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North Pacific Oscillation

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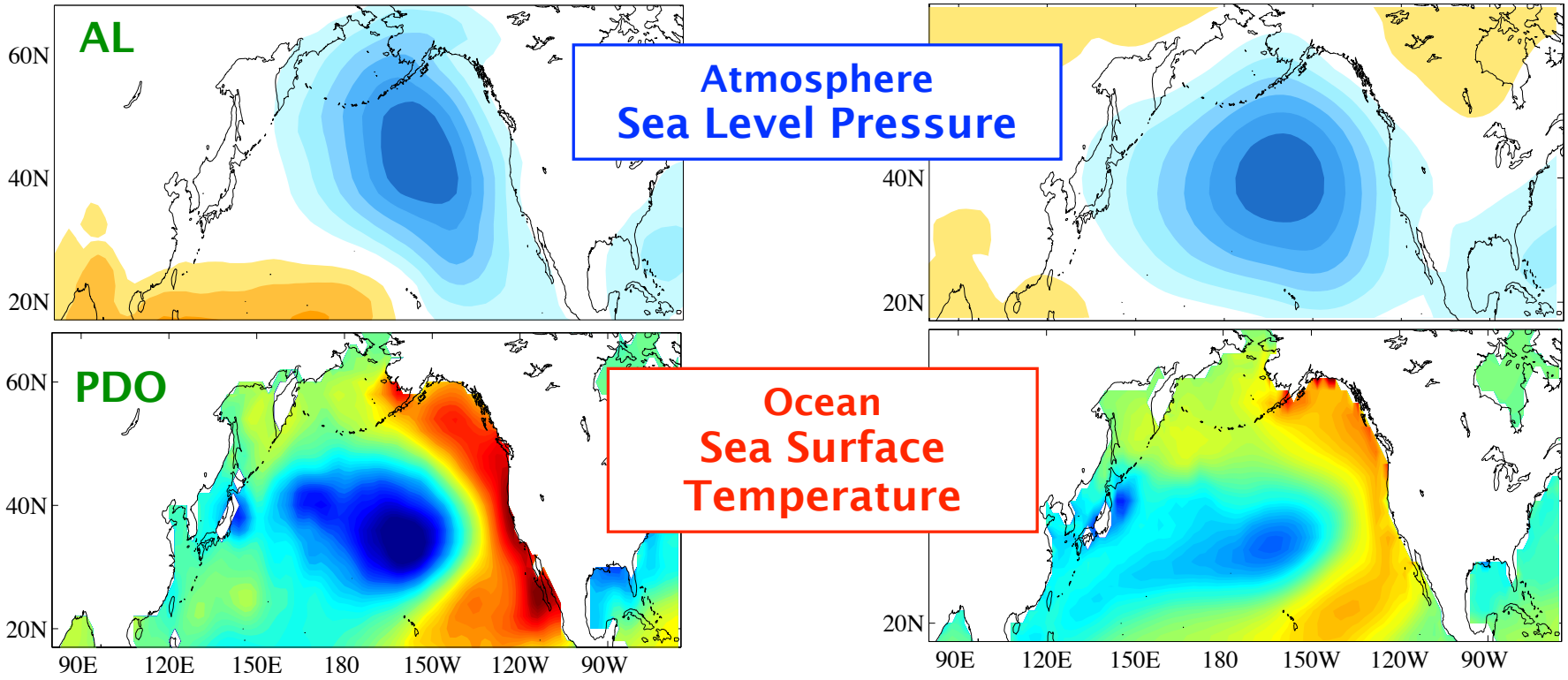
North Pacific Gyre Oscillation

Observations

AR4 Models (Ensemble Mean)



Atmosphere
Sea Level Pressure

Ocean
Sea Surface
Temperature

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Furtado et al., 2011

Test the AR4 models Pacific decadal dynamics 1800-2000

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Aleutian Low

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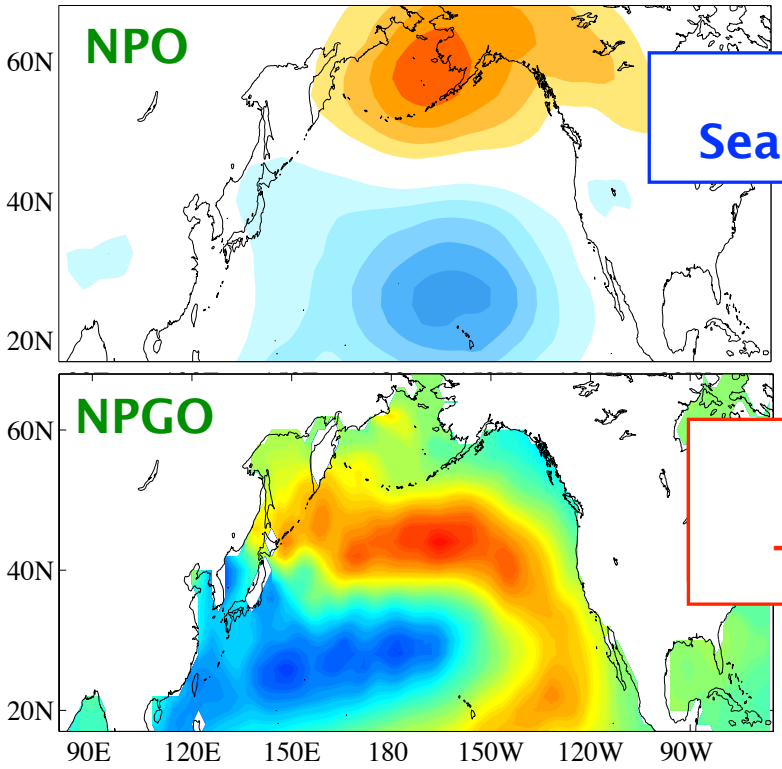

Atmosphere
Sea Level Pressure

Ocean
Sea Surface Temperature

Ocean/Atmosphere Combined EOF Mode 2

Furtado et al., 2011

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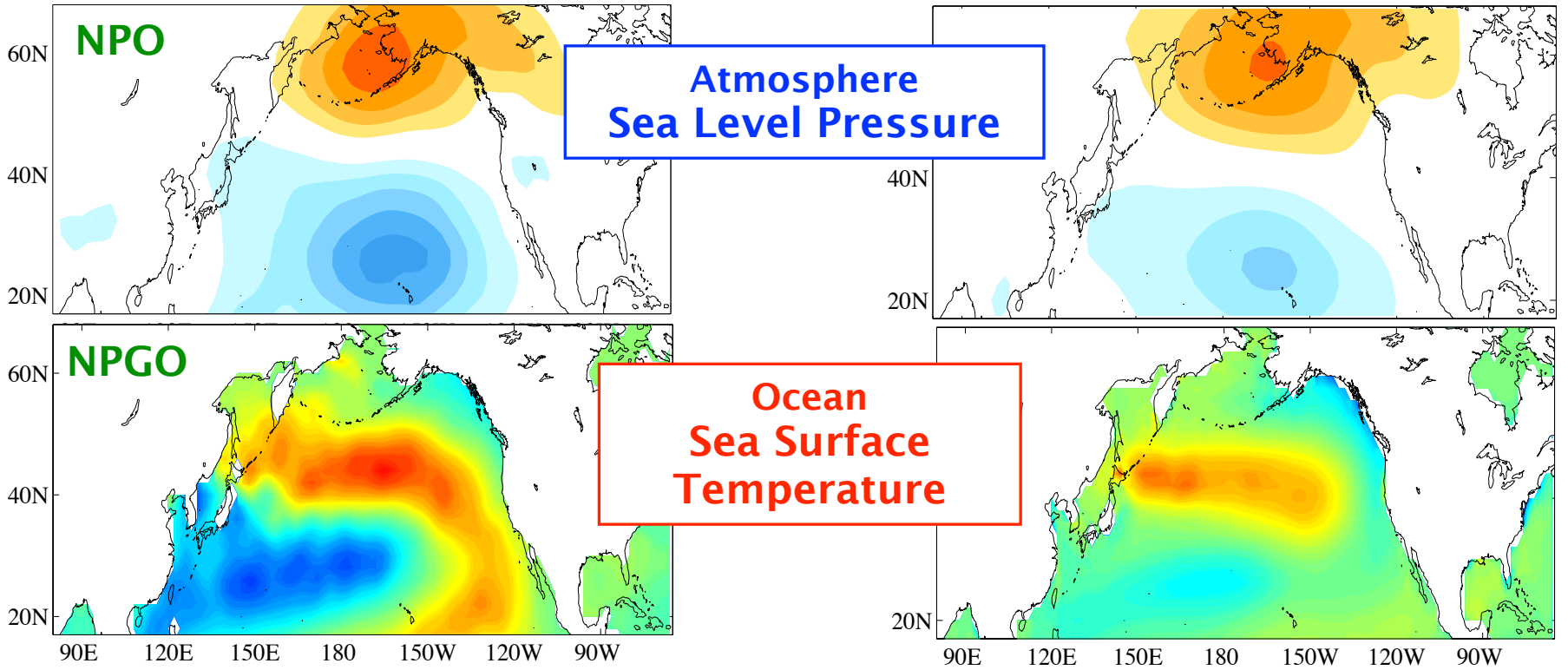

Atmosphere
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Furtado et al., 2011

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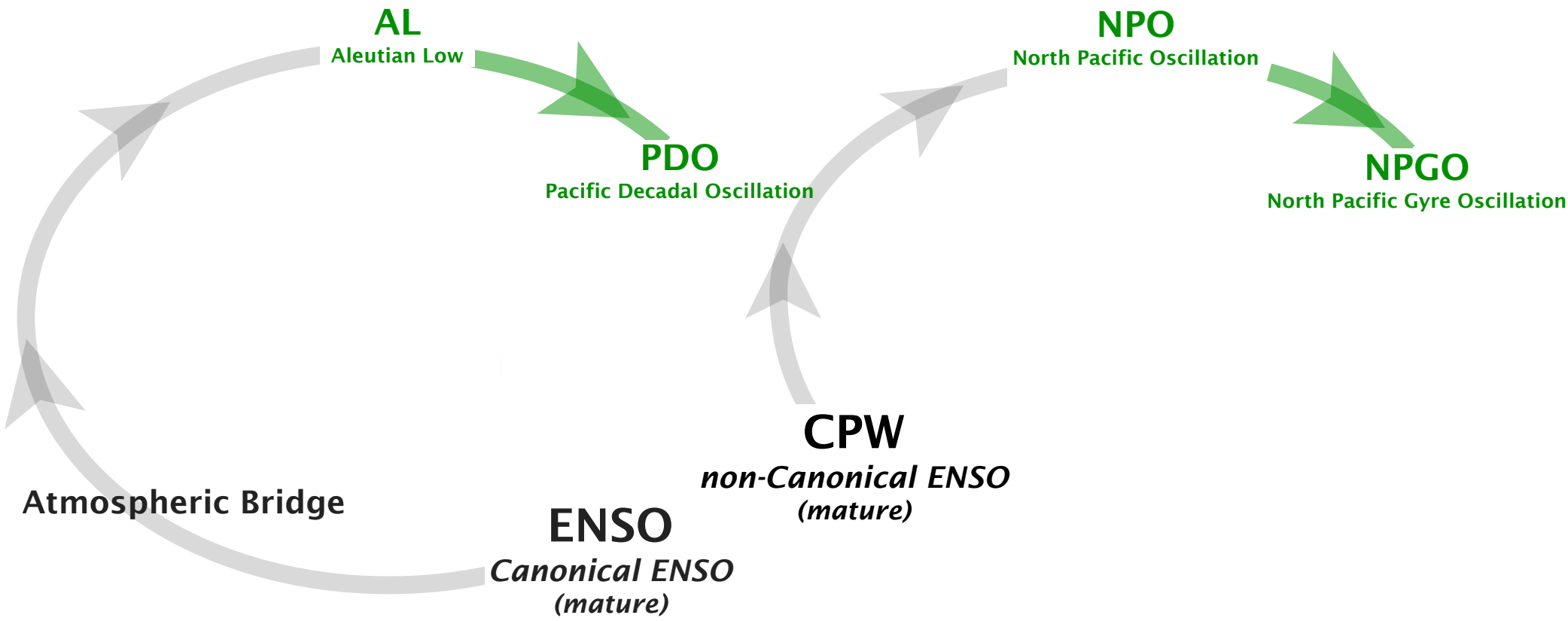

Furtado et al., 2011

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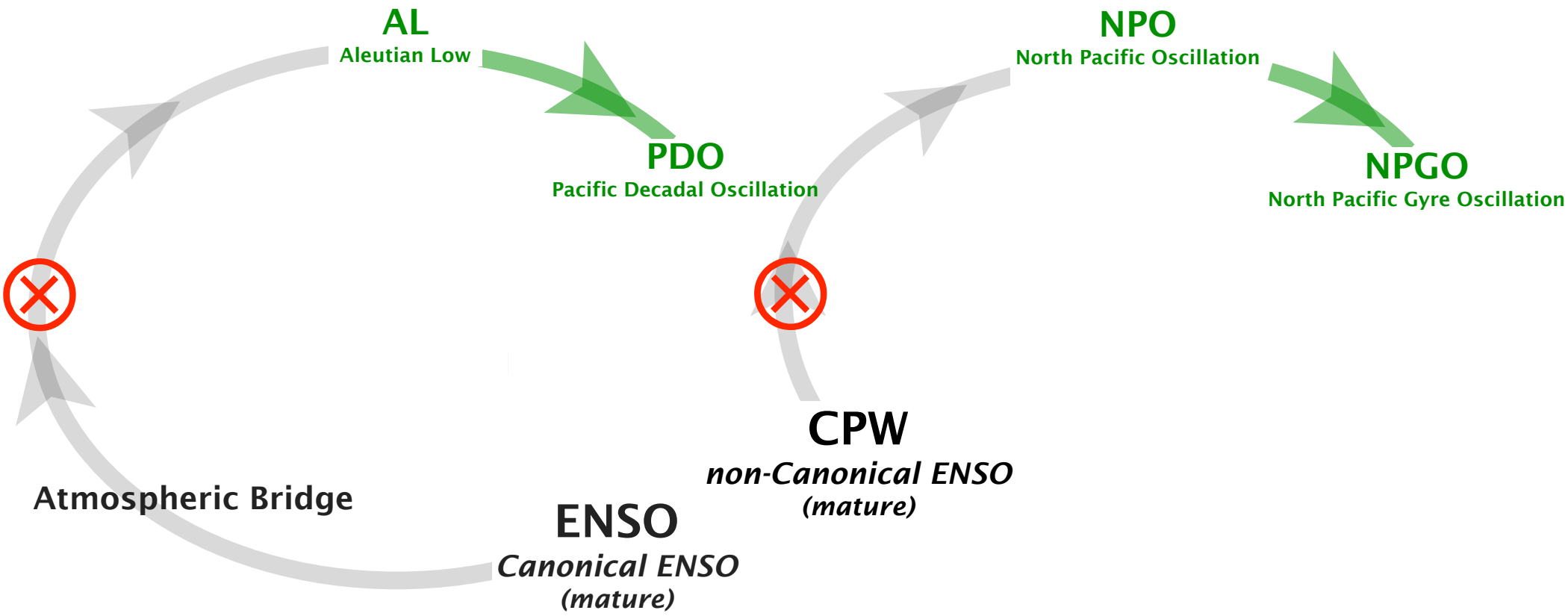

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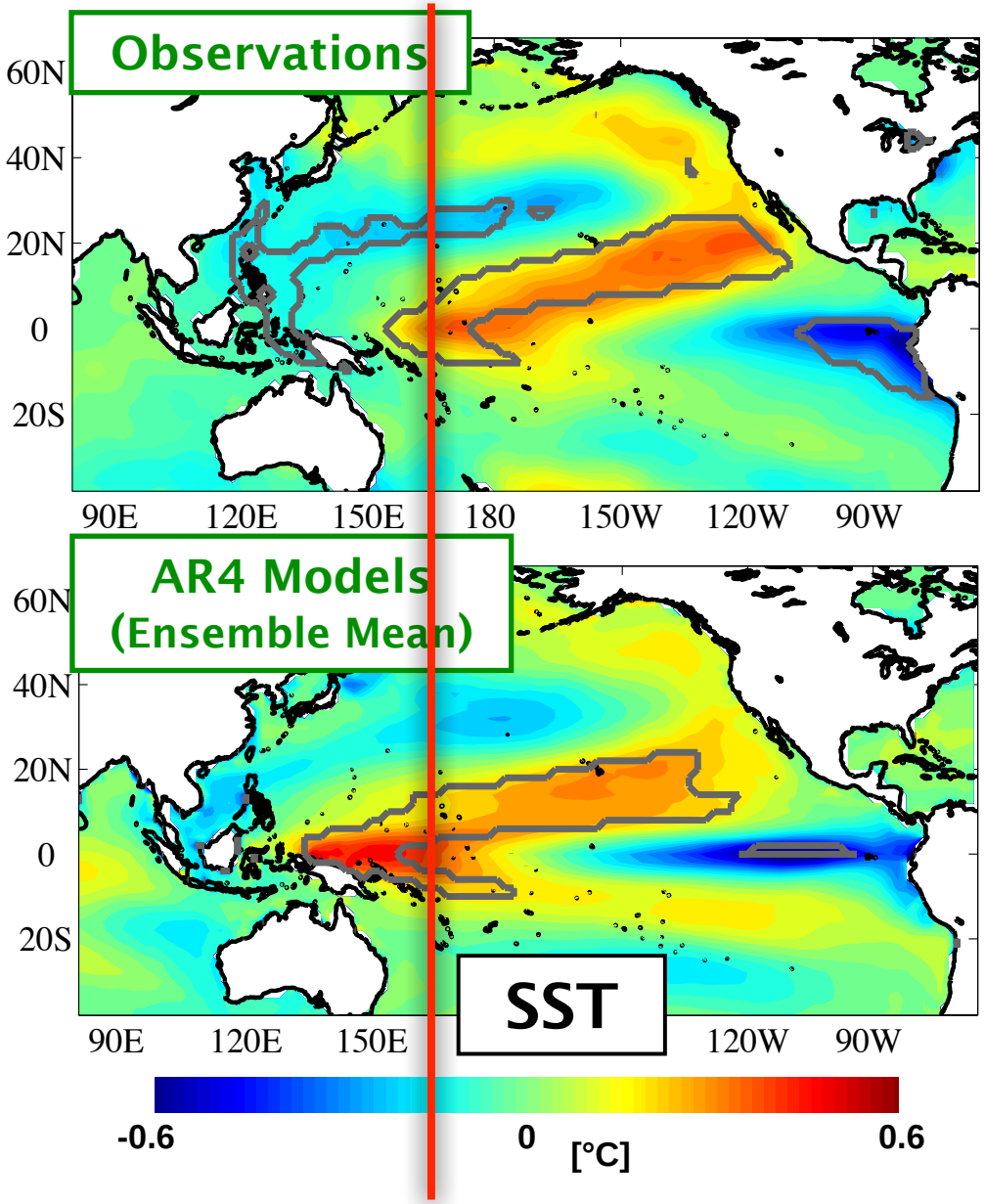


CP El Niño pattern

emerges as

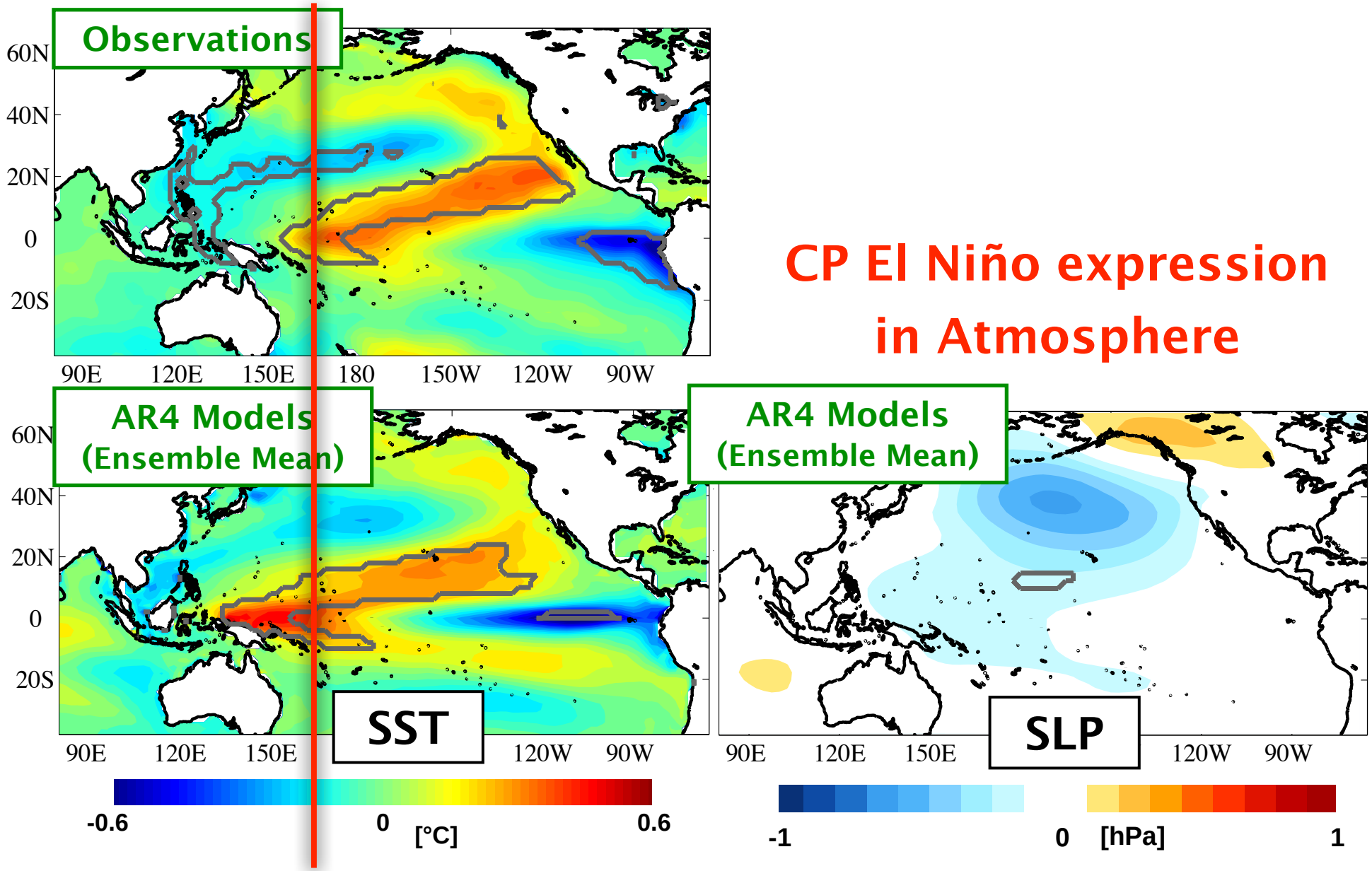
2nd mode

Tropics [12S 12N]

Ocean/Atmosphere Combined EOF Mode 2

Furtado et al., 2011

Test the AR4 models Pacific decadal dynamics 1800-2000



Ocean/Atmosphere Combined EOF Mode 2

Furtado et al., 2011

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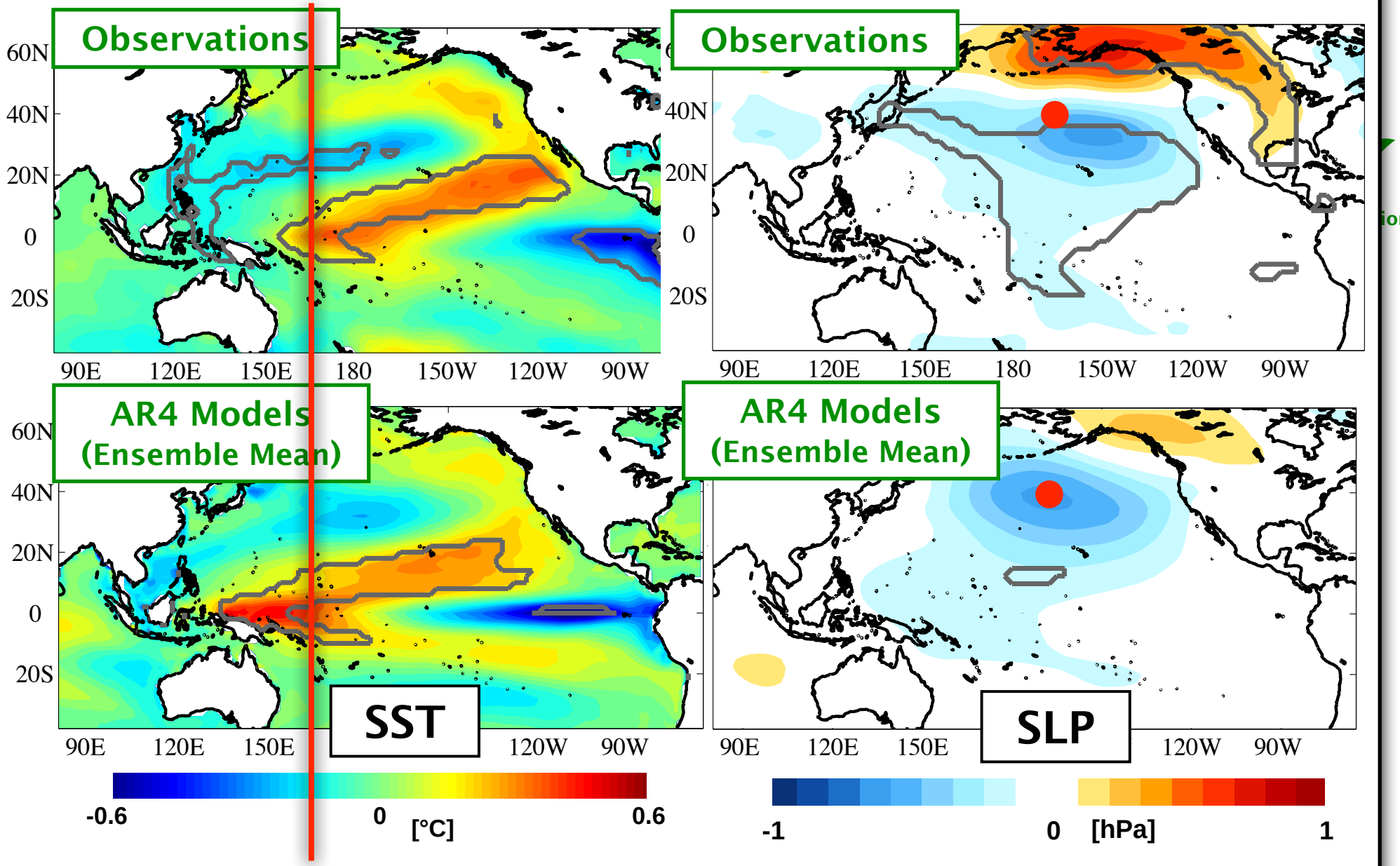
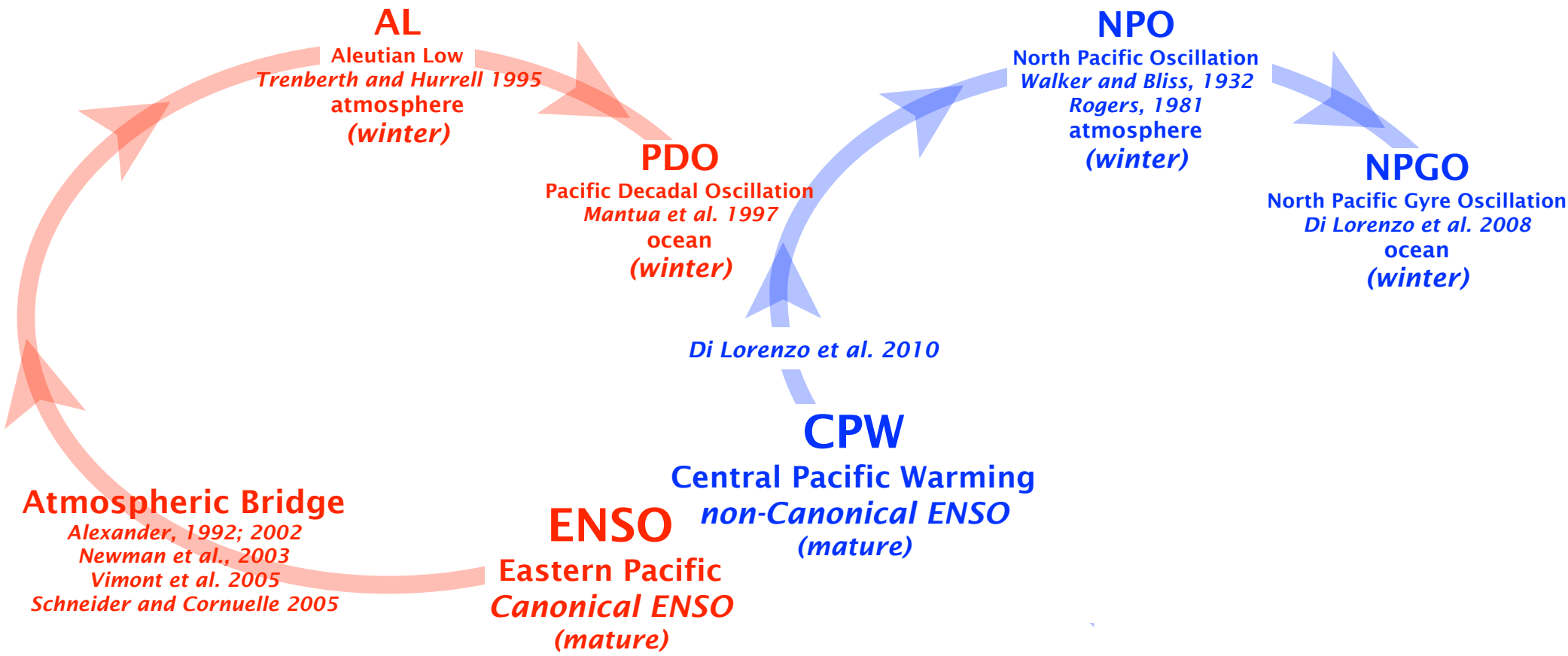


Ocean/Atmosphere Combined EOF Mode 2

Furtado et al., 2011

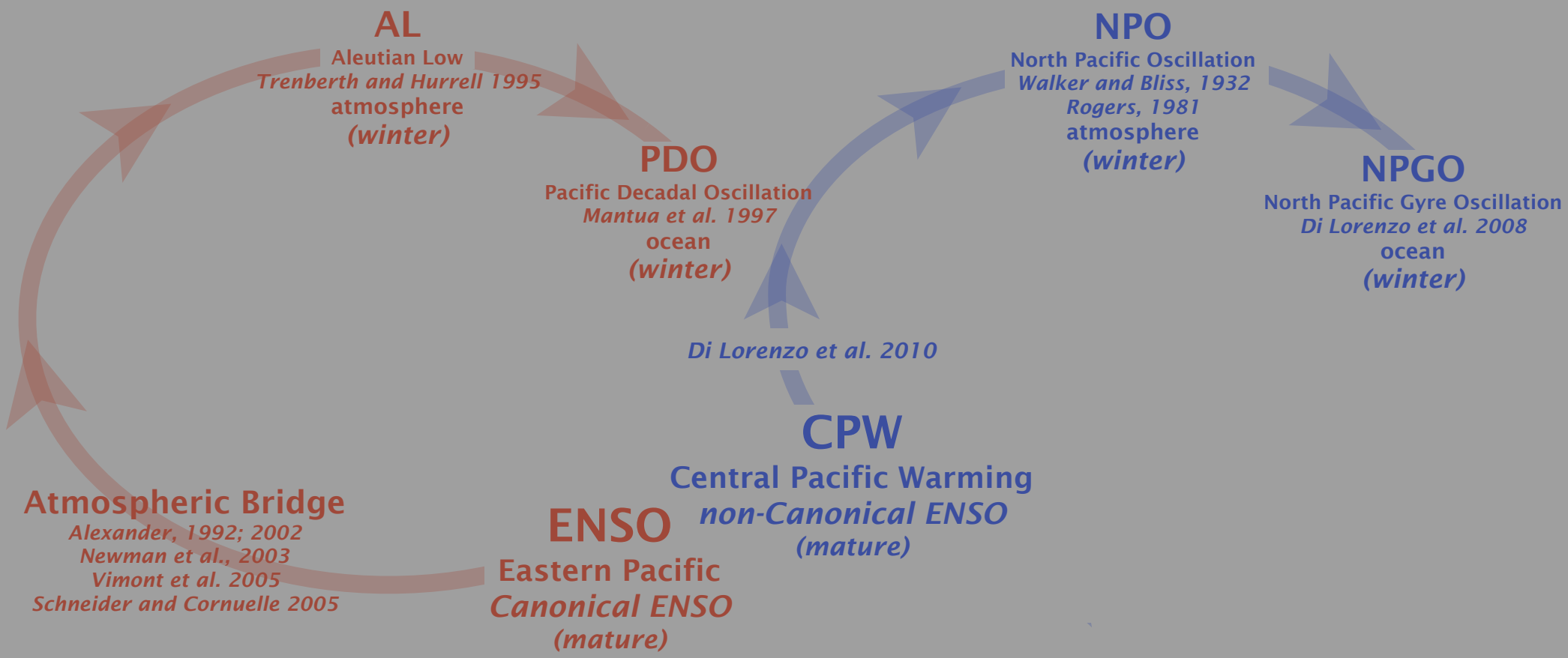
Model for explaining Pacific decadal dynamics



IPCC climate model AR-4 do not consistently reproduce the decadal dynamics of the Pacific, the structure and variability of ENSO and its teleconnections.

Furtado et al., 2011

Model for explaining Pacific decadal dynamics

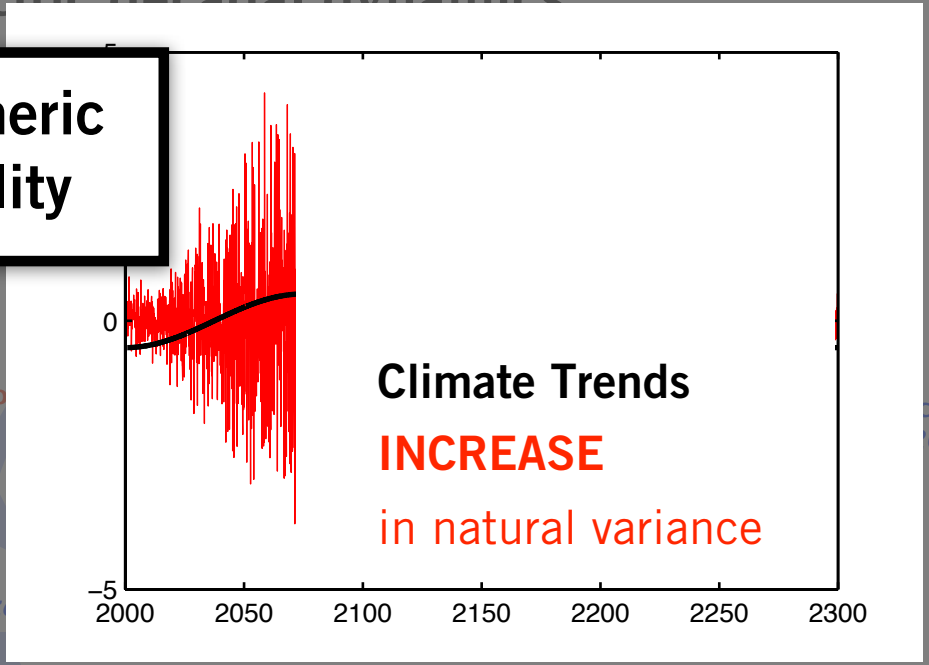


ASSUME:

The North Pacific variance is increasing in response to greenhouse forcing

Model for explaining Pacific decadal dynamics

Atmospheric Variability



AL
Aleutian Low
Trenberth and Hurrell 1995
atmosphere
(winter)

PDO
Pacific Decadal Oscillatio
Mantua et al. 1997
ocean
(winter)

Di Lorenz

CPW
Central Pacific Warming
non-Canonical ENSO
(mature)

Atmospheric Bridge
Alexander, 1992; 2002
Newman et al., 2003
Vimont et al. 2005
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Eastern Pacific
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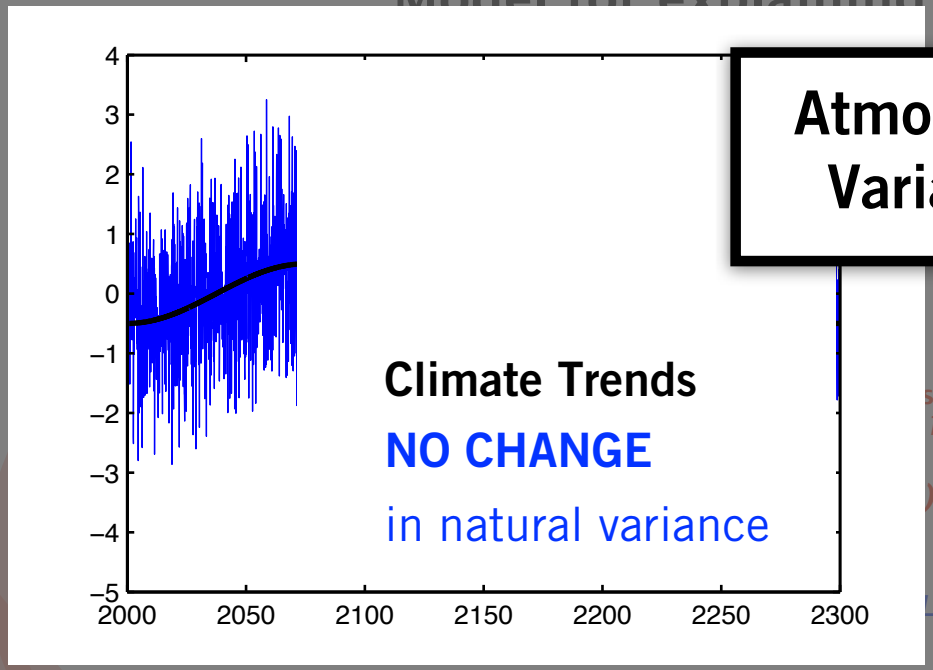
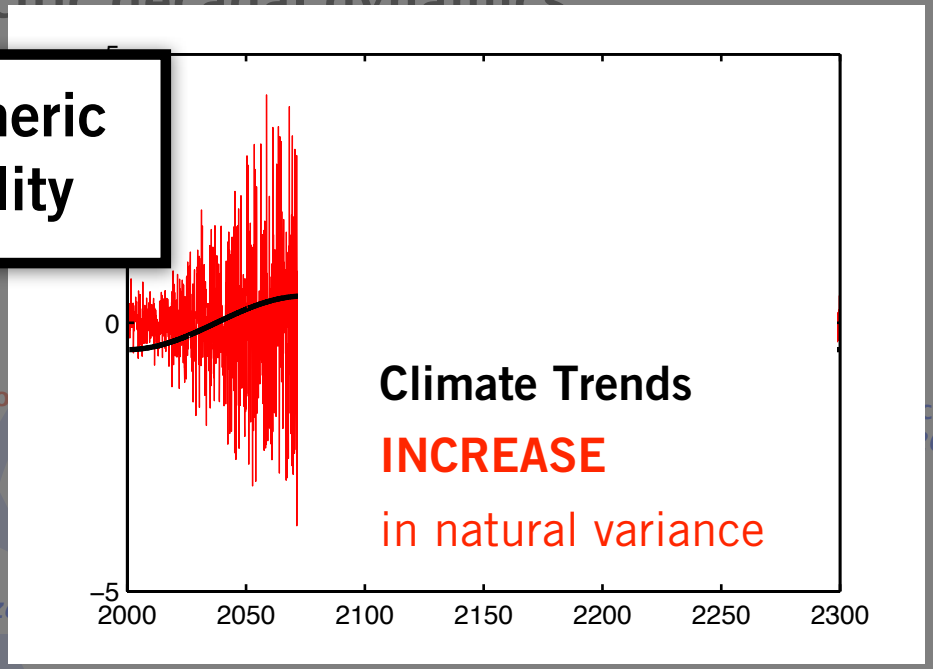
Model for explaining Pacific decadal dynamics



Atmospheric Variability



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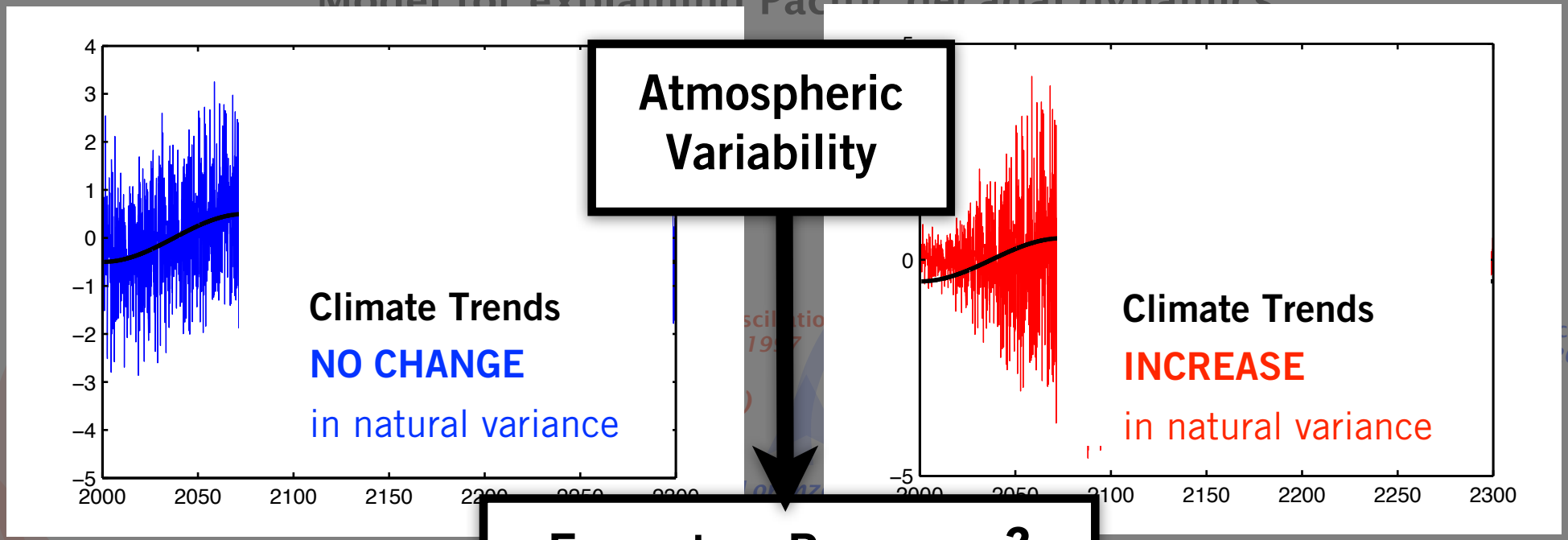

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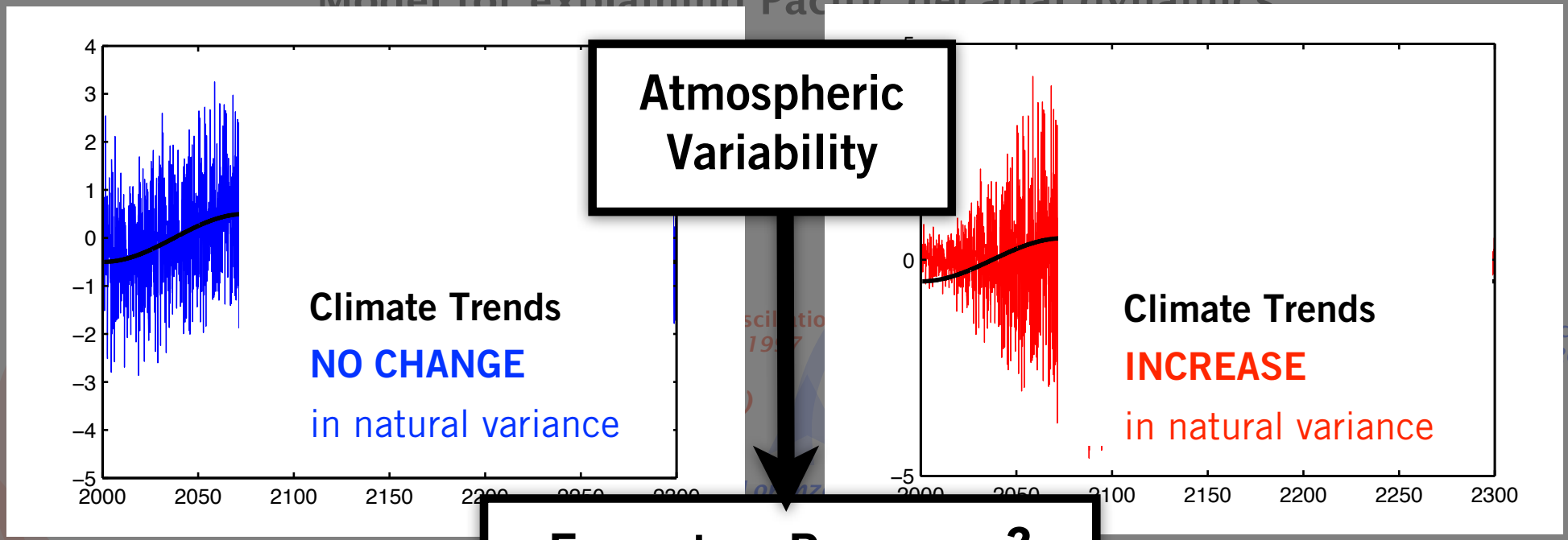

Di Lorenzo, E., Ohman, M.D., 2013.

A double-integration hypothesis to explain ocean ecosystem response to climate forcing.

PNAS, 110, 2496-2499.

ASSUME:

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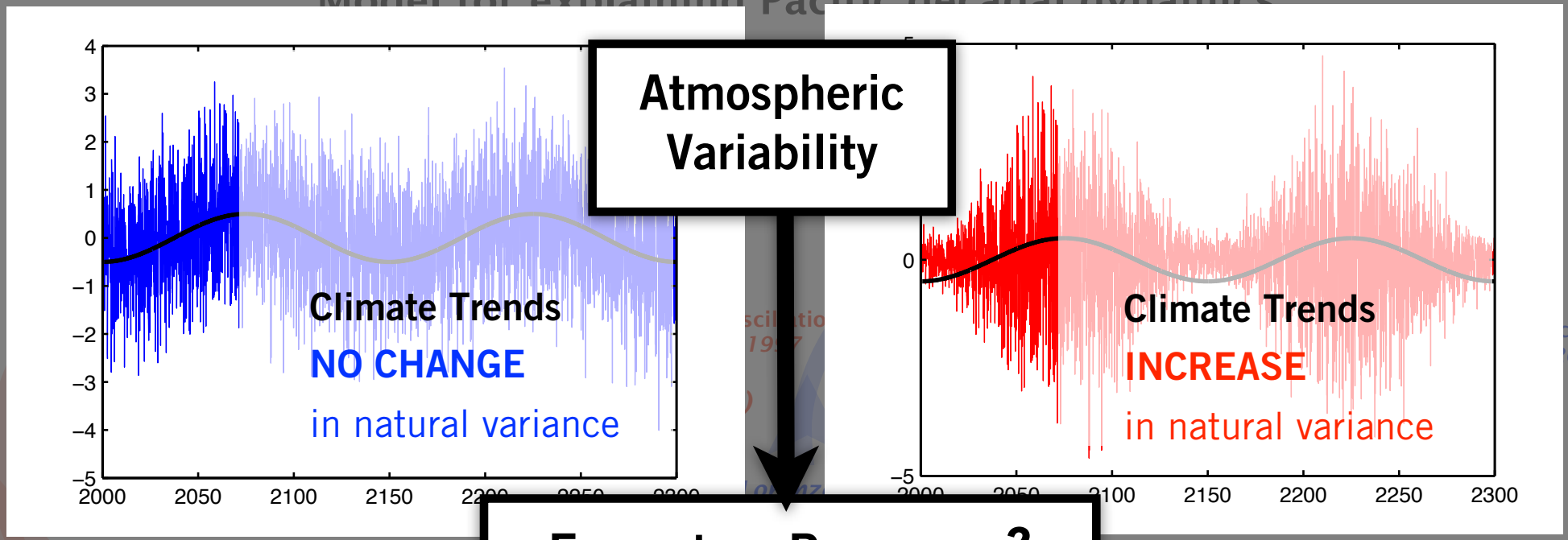

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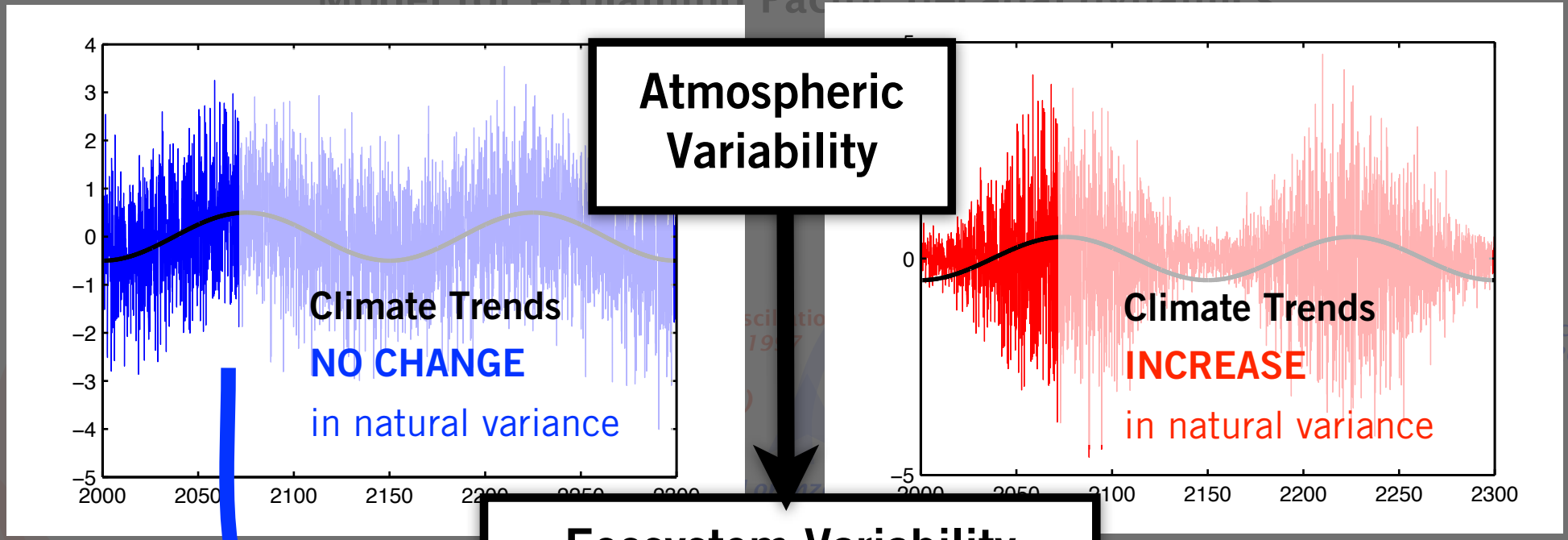

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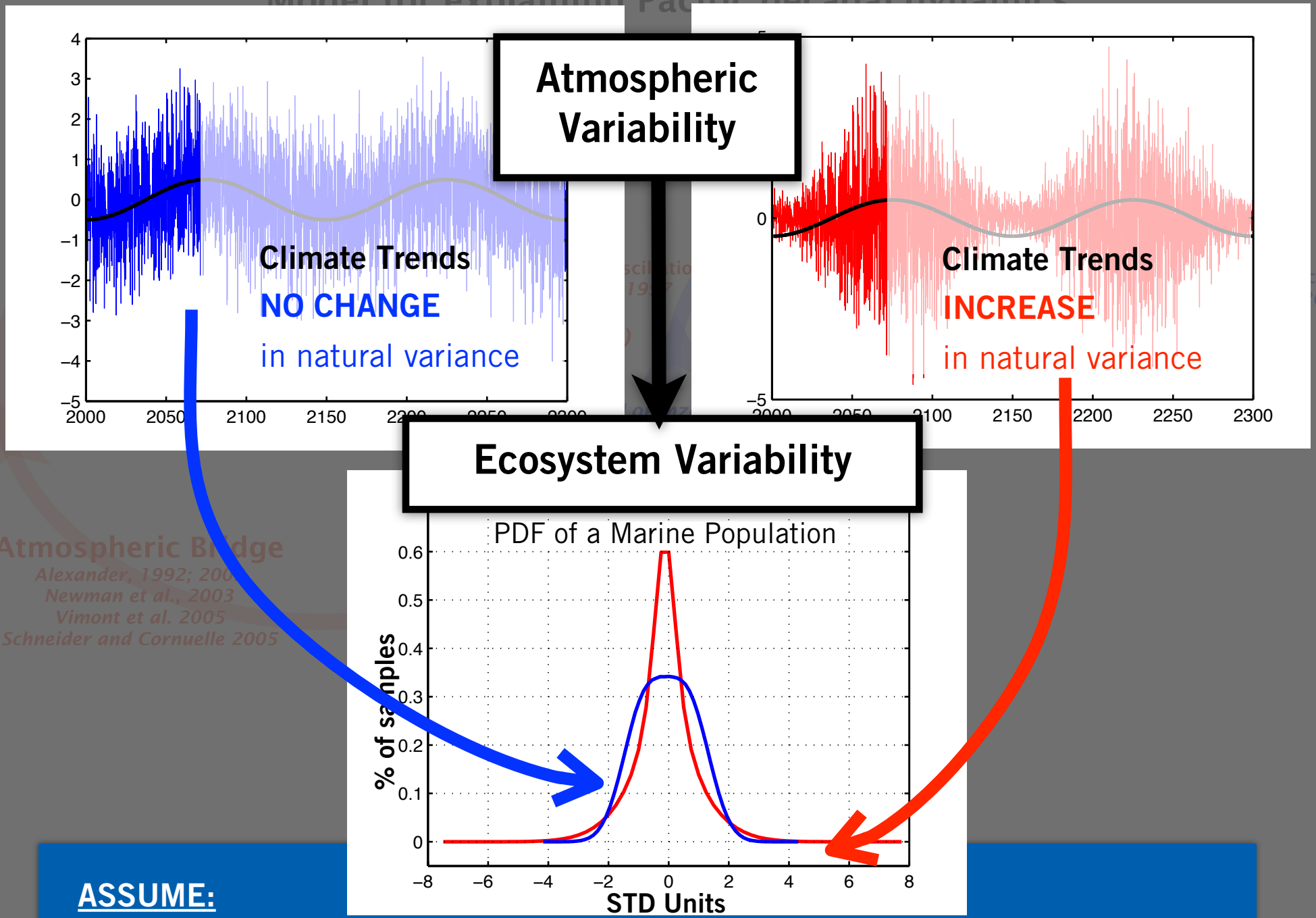
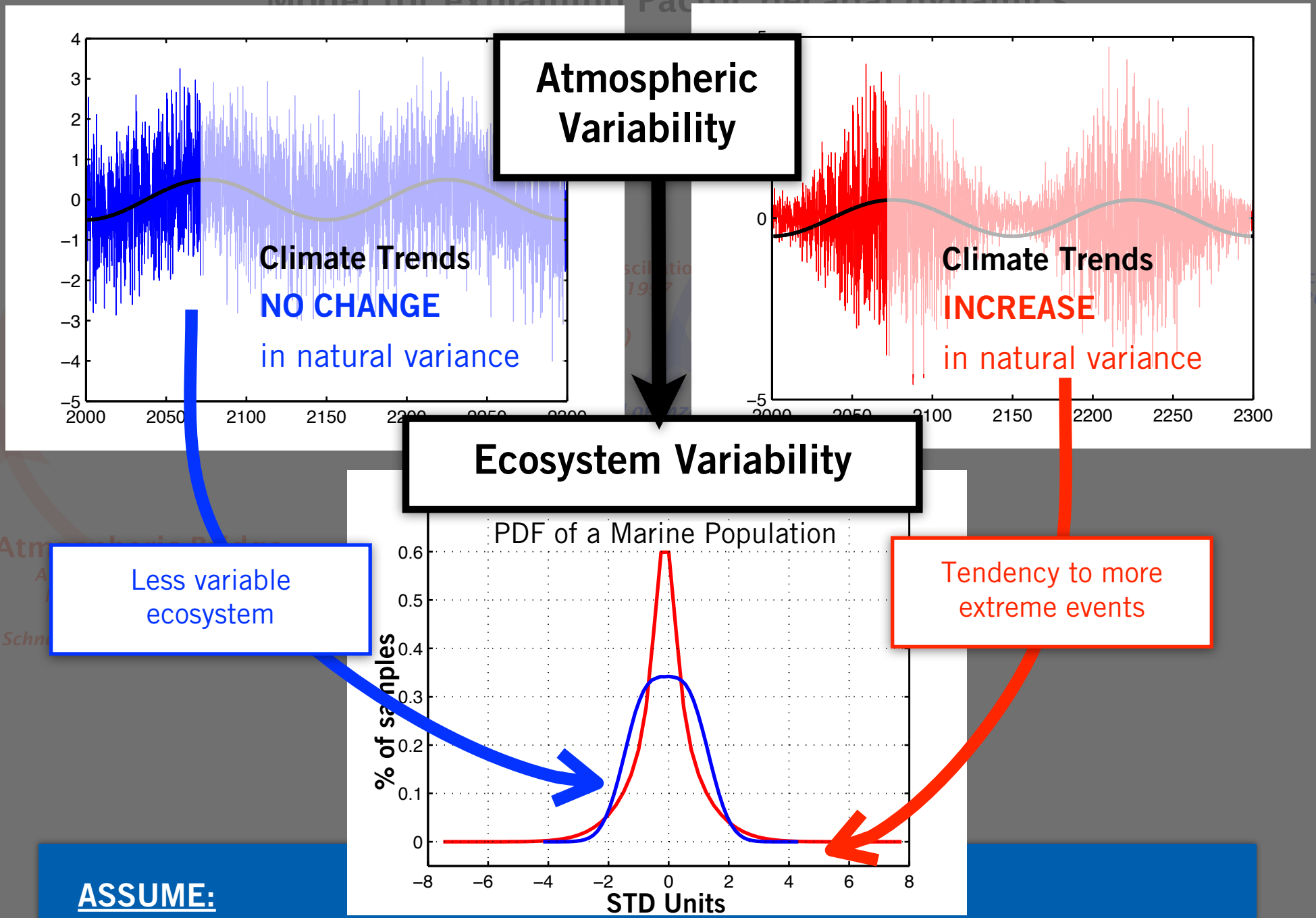

Atmospheric Variability
Climate Trends
NO CHANGE
in natural variance
Climate Trends
INCREASE
in natural variance
Ecosystem Variability
PDF of a Marine Population
% of samples
STD Units
ASSUME:
The North Pacific variance is increasing in response to greenhouse forcing



ASSUME:

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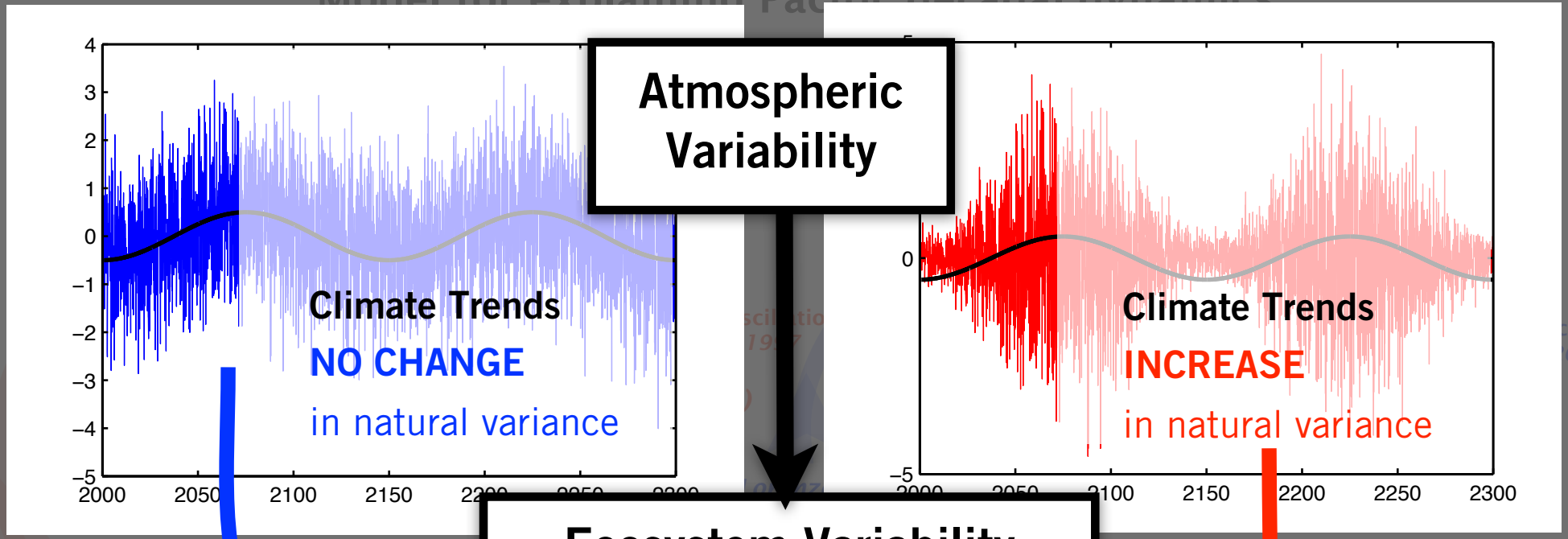
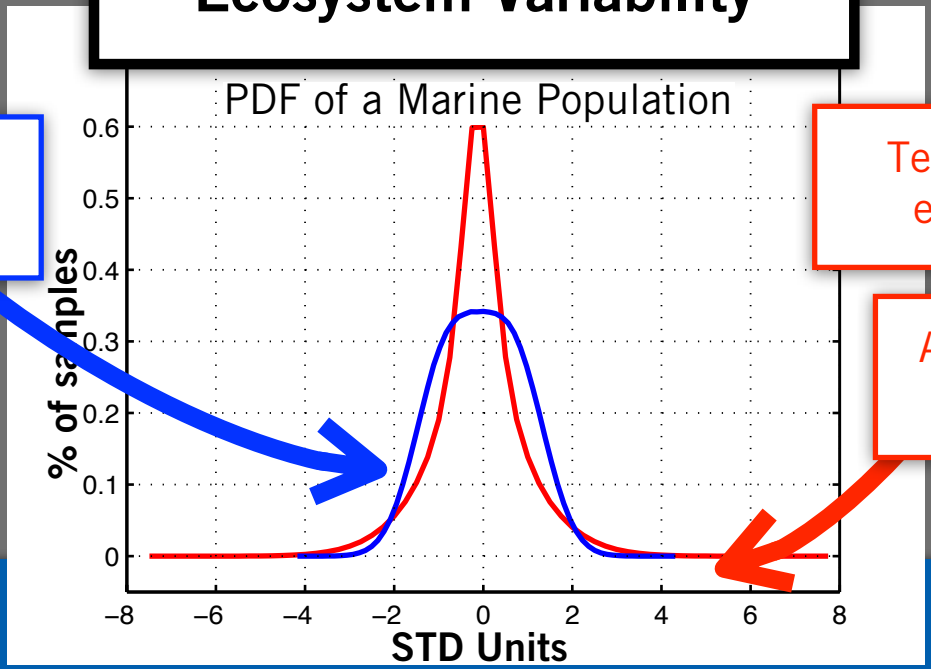


Ecosystem Variability



Less variable ecosystem

Tendency to more extreme events

Adaptation and Resilience of ecosystem may increase

ASSUME:

The North Pacific variance is increasing in response to greenhouse forcing