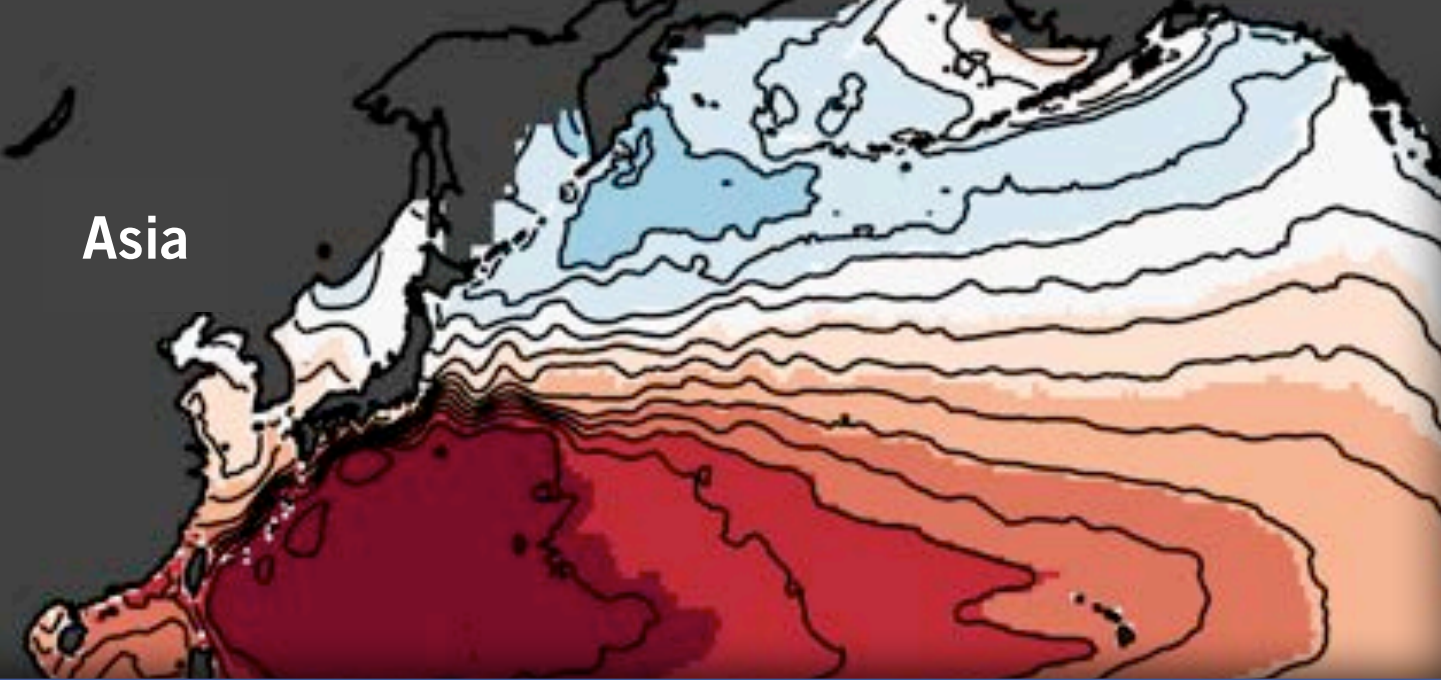


Asia



MULTI-SCALE CLIMATE IMPACTS ON PACIFIC TRANSITION AREAS

Georgia Tech  **Ocean Science
& Engineering**

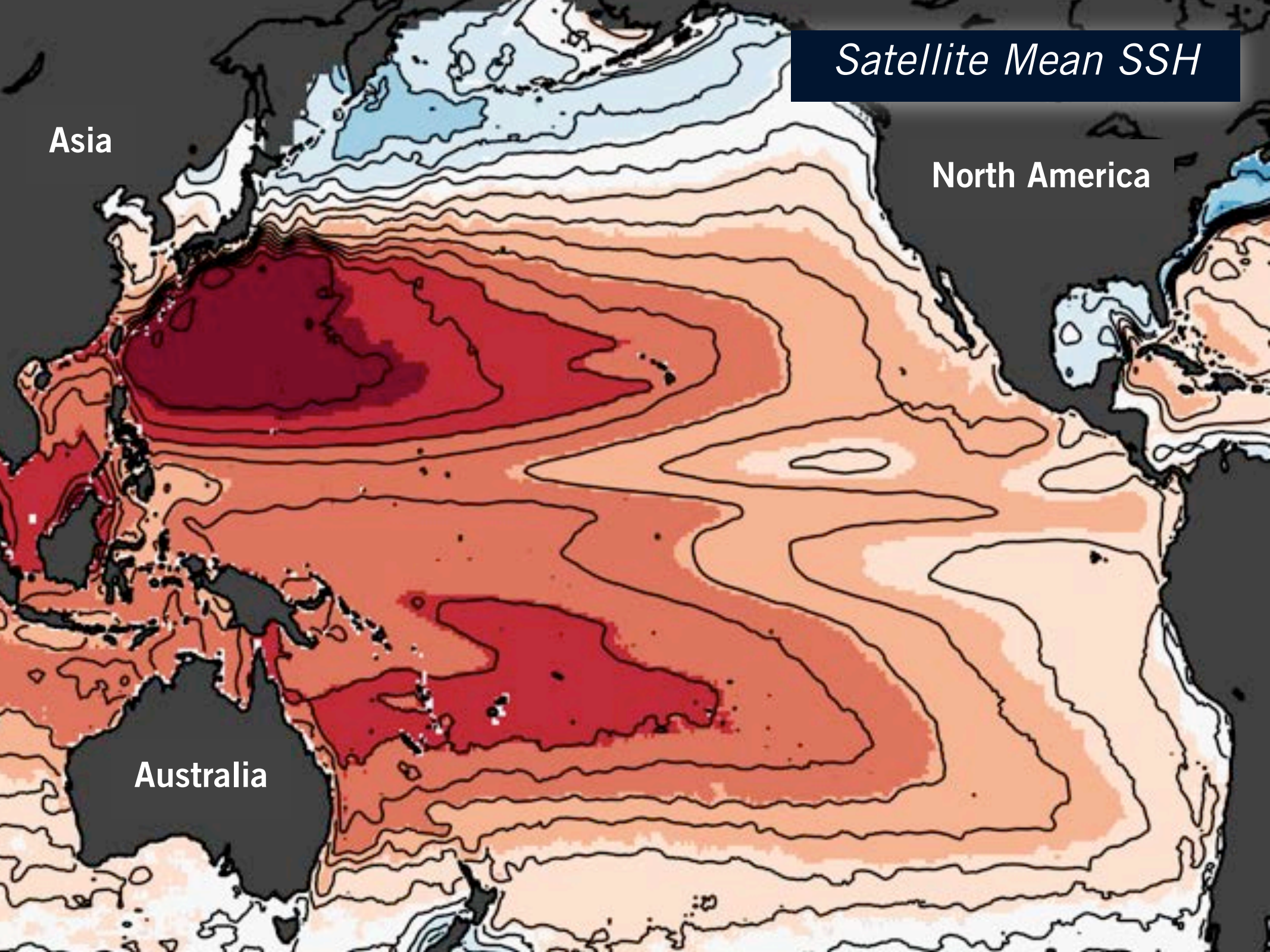
Emanuele Di Lorenzo
La Paz, April 26, 2018

Satellite Mean SSH

Asia

North America

Australia



Satellite Mean SSH

Asia

North America

QUESTION:

How is climate change impacting PTAs?

Australia

LARGE-SCALE (> 300KM)

EDDY-SCALE (< 300KM)

A satellite map of the Pacific Ocean showing Mean Sea Surface Height (SSH). The map uses a color scale from dark blue (low) to dark red (high). A prominent high-pressure system is visible in the western Pacific, near Asia, with values reaching into the red. The eastern Pacific, near North America, shows lower values in the blue and light blue. The southern Pacific, near Australia, shows intermediate values in orange and light red. Contour lines are overlaid on the color map, indicating specific height values.

Satellite Mean SSH

Asia

North America

GOAL:

Identify ocean circulation indicators of
“ecologically relevant” PTAs

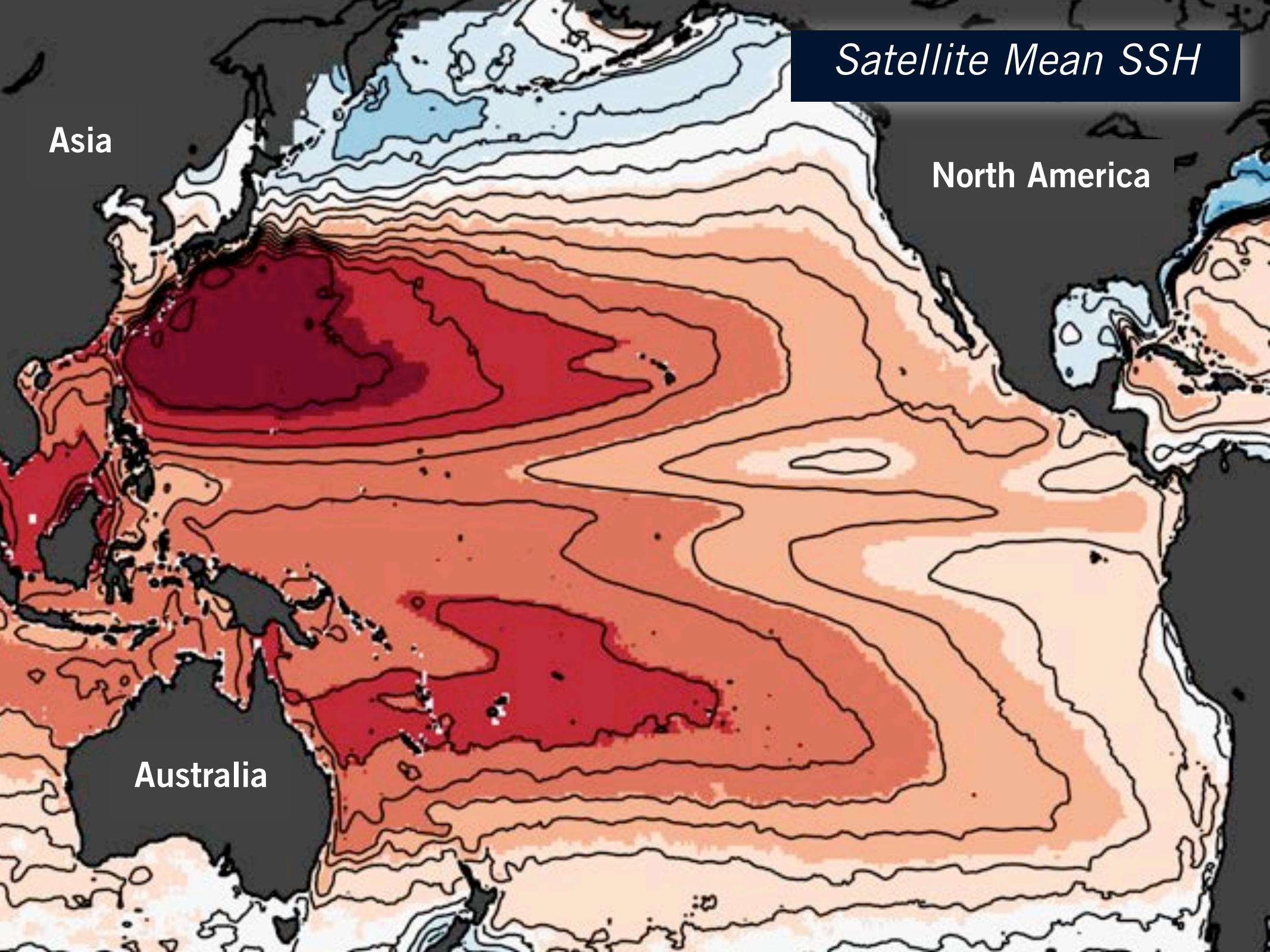
Australia

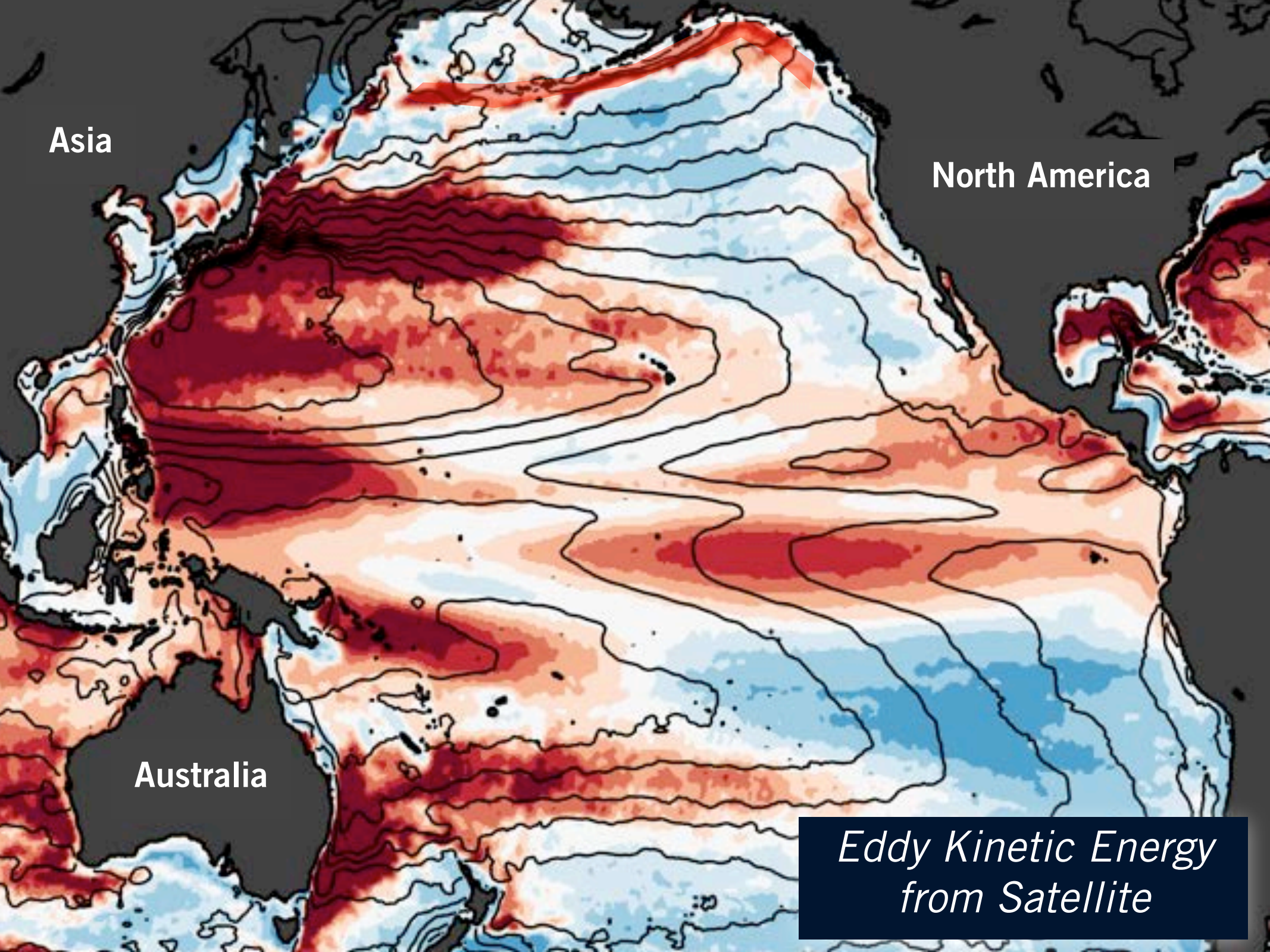
Satellite Mean SSH

Asia

North America

Australia





Asia

North America

Australia

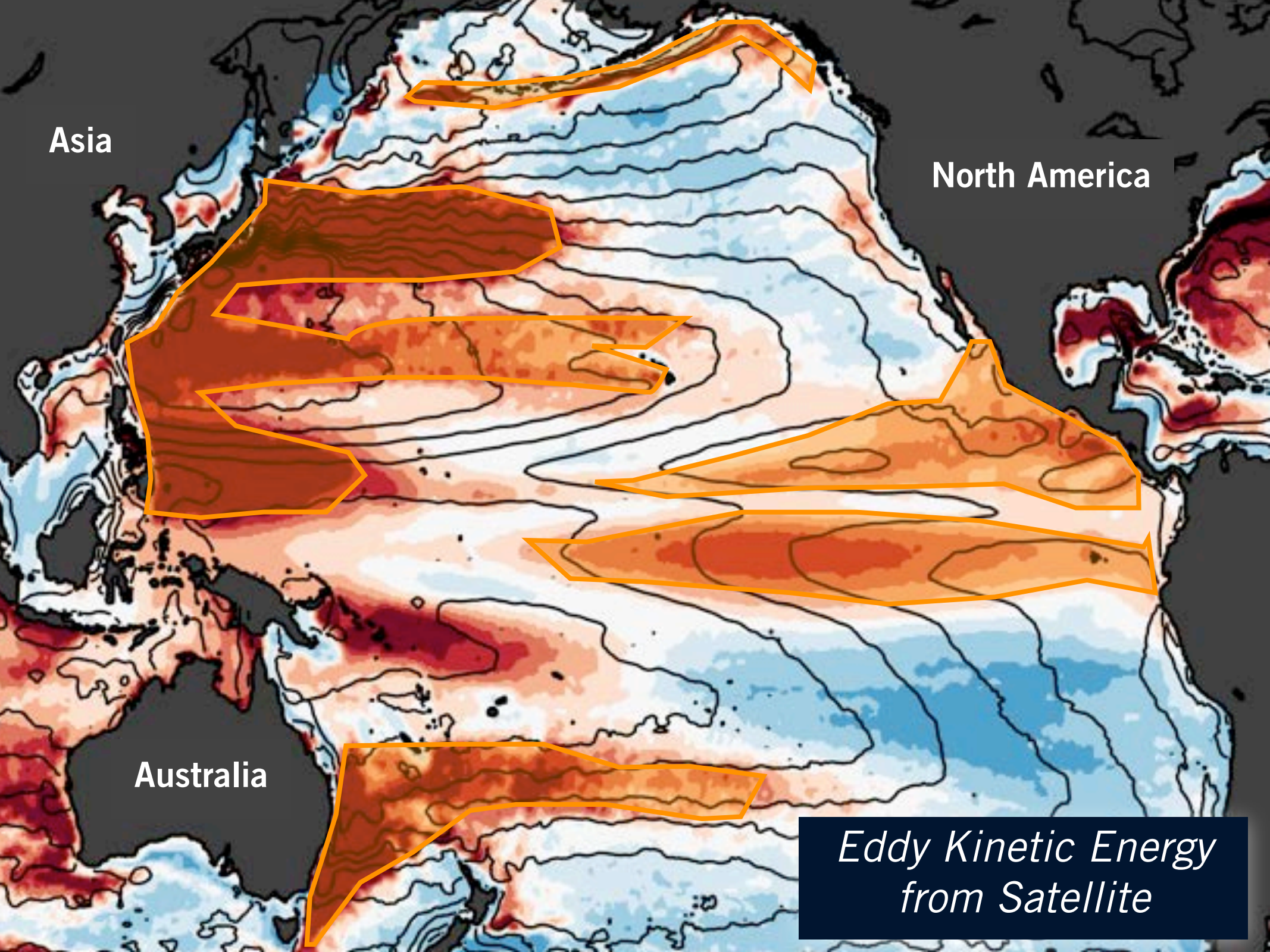
*Eddy Kinetic Energy
from Satellite*

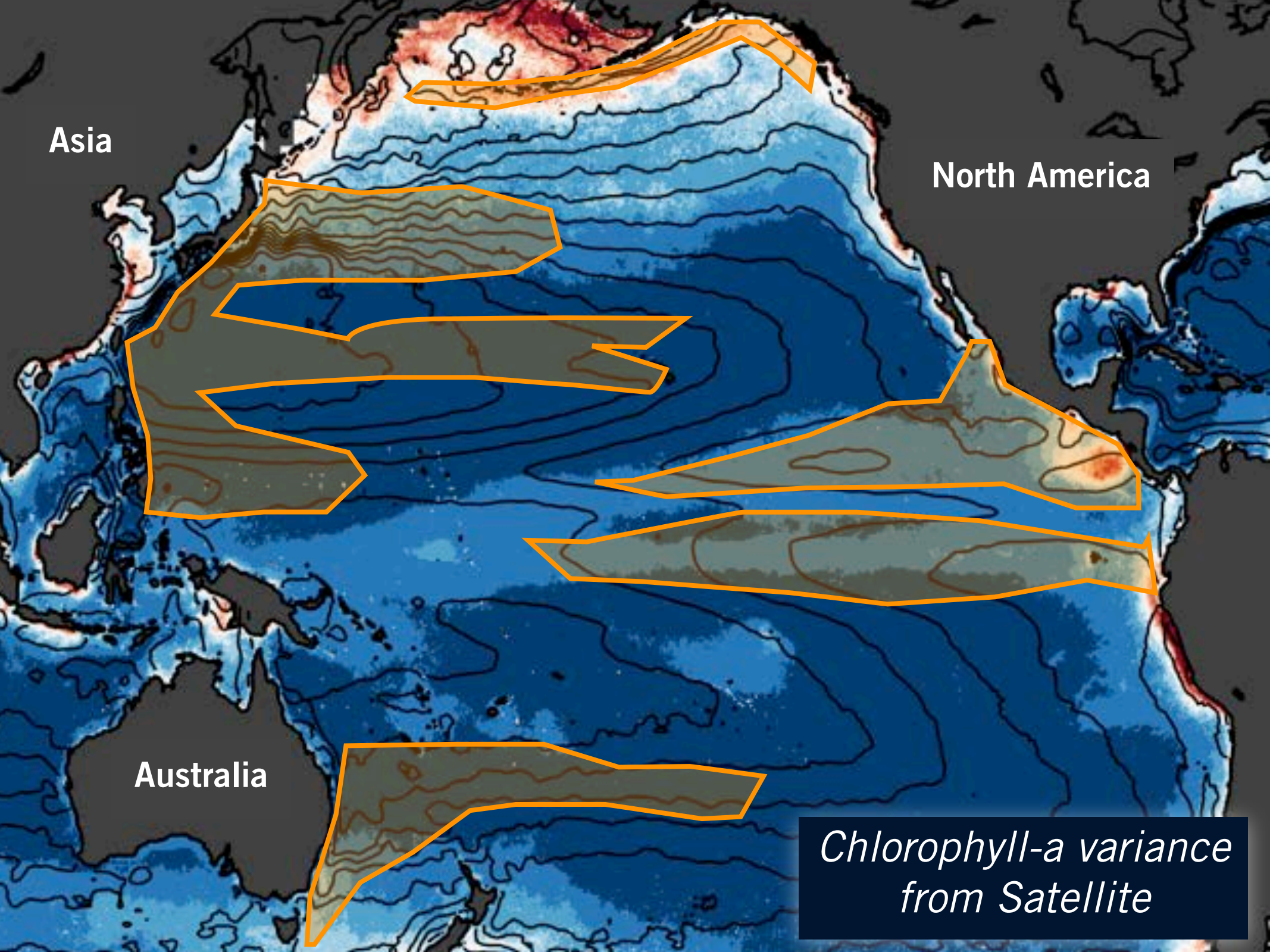
Asia

North America

Australia

*Eddy Kinetic Energy
from Satellite*





Asia

North America

Australia

*Chlorophyll-a variance
from Satellite*



Asia

North America

APPROACH

Covariability between SSH and CHLa to
identify PTAs

Australia

*Chlorophyll-a variance
from Satellite*

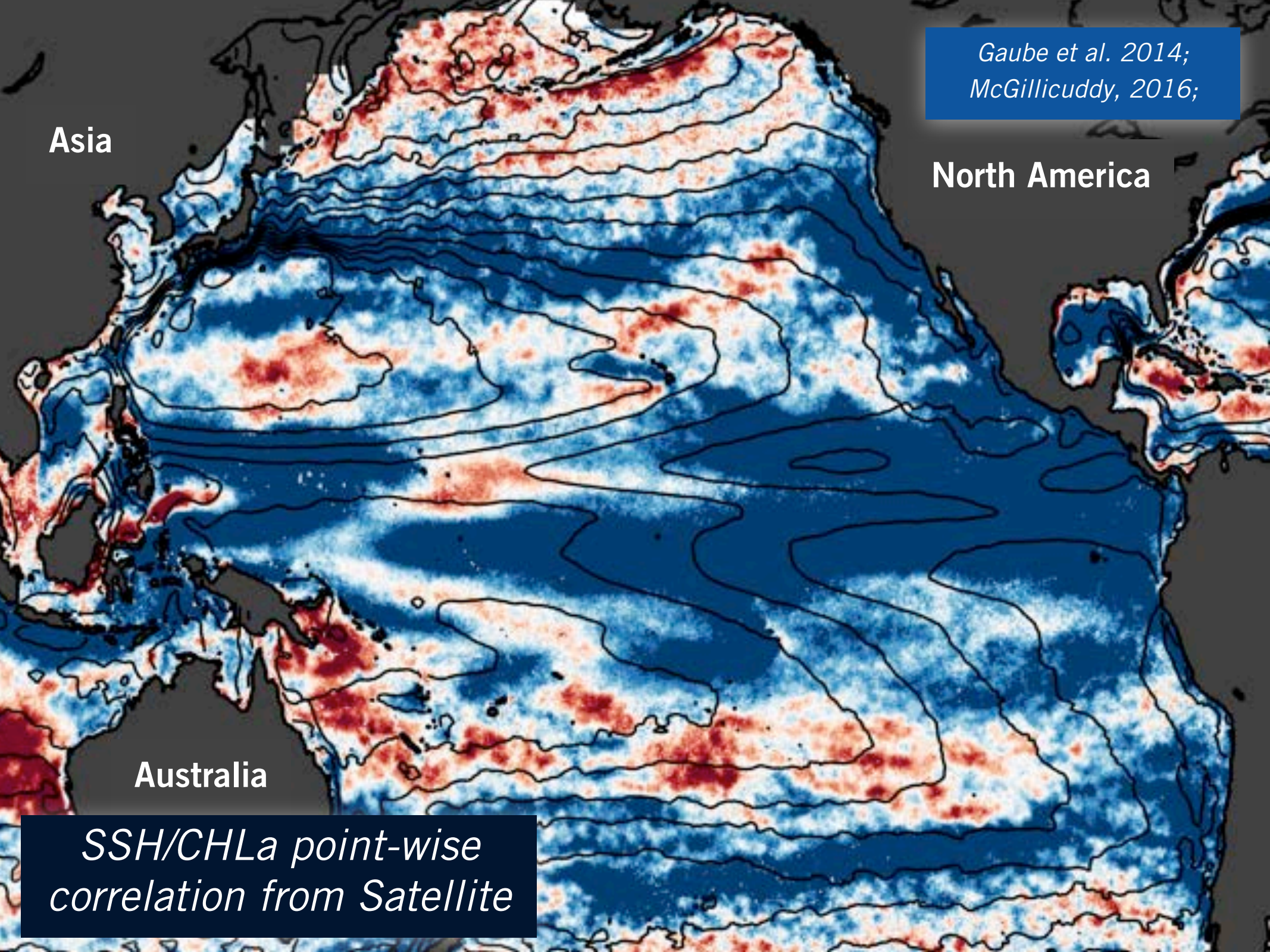
*Gaube et al. 2014;
McGillicuddy, 2016;*

Asia

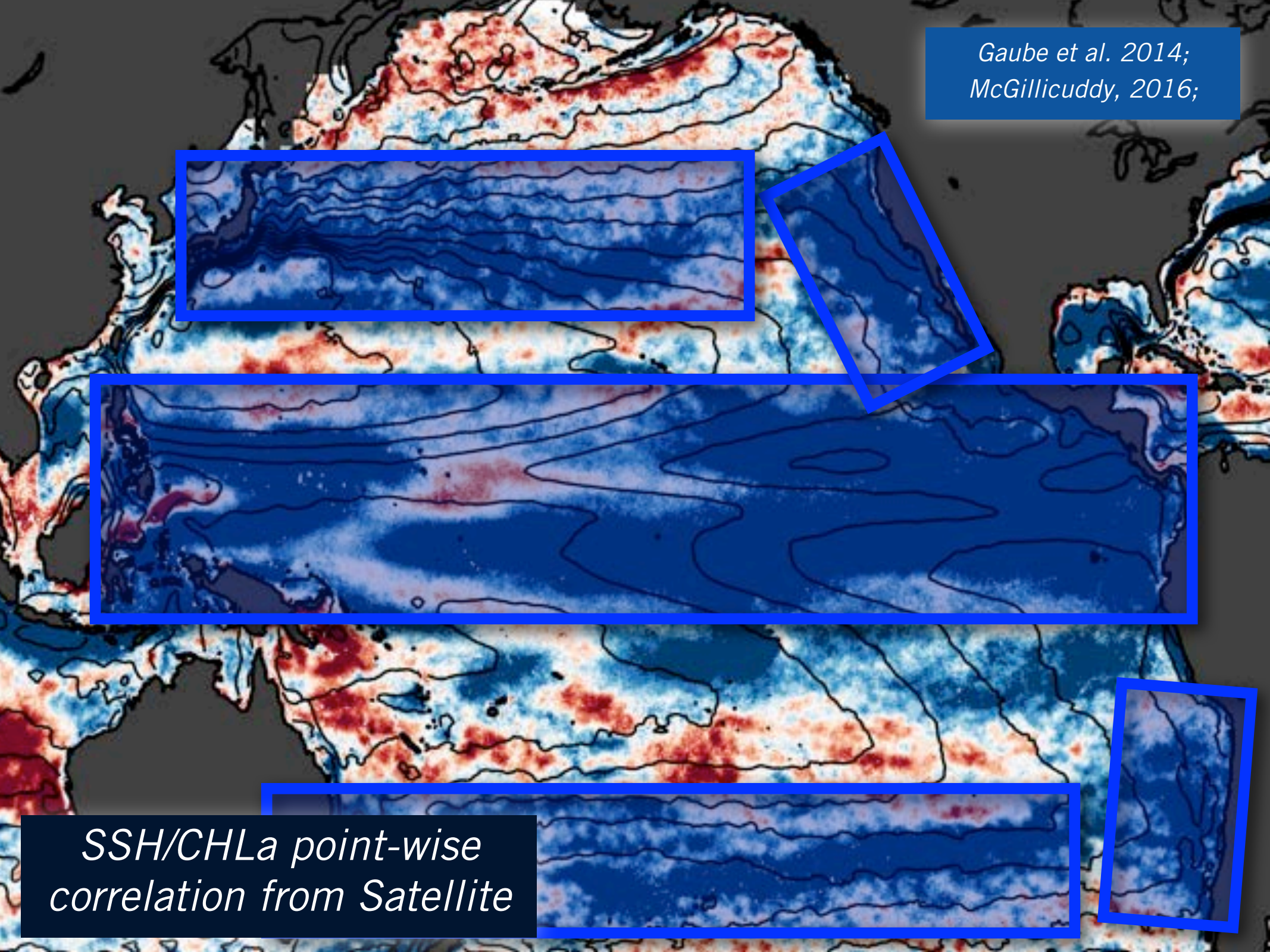
North America

Australia

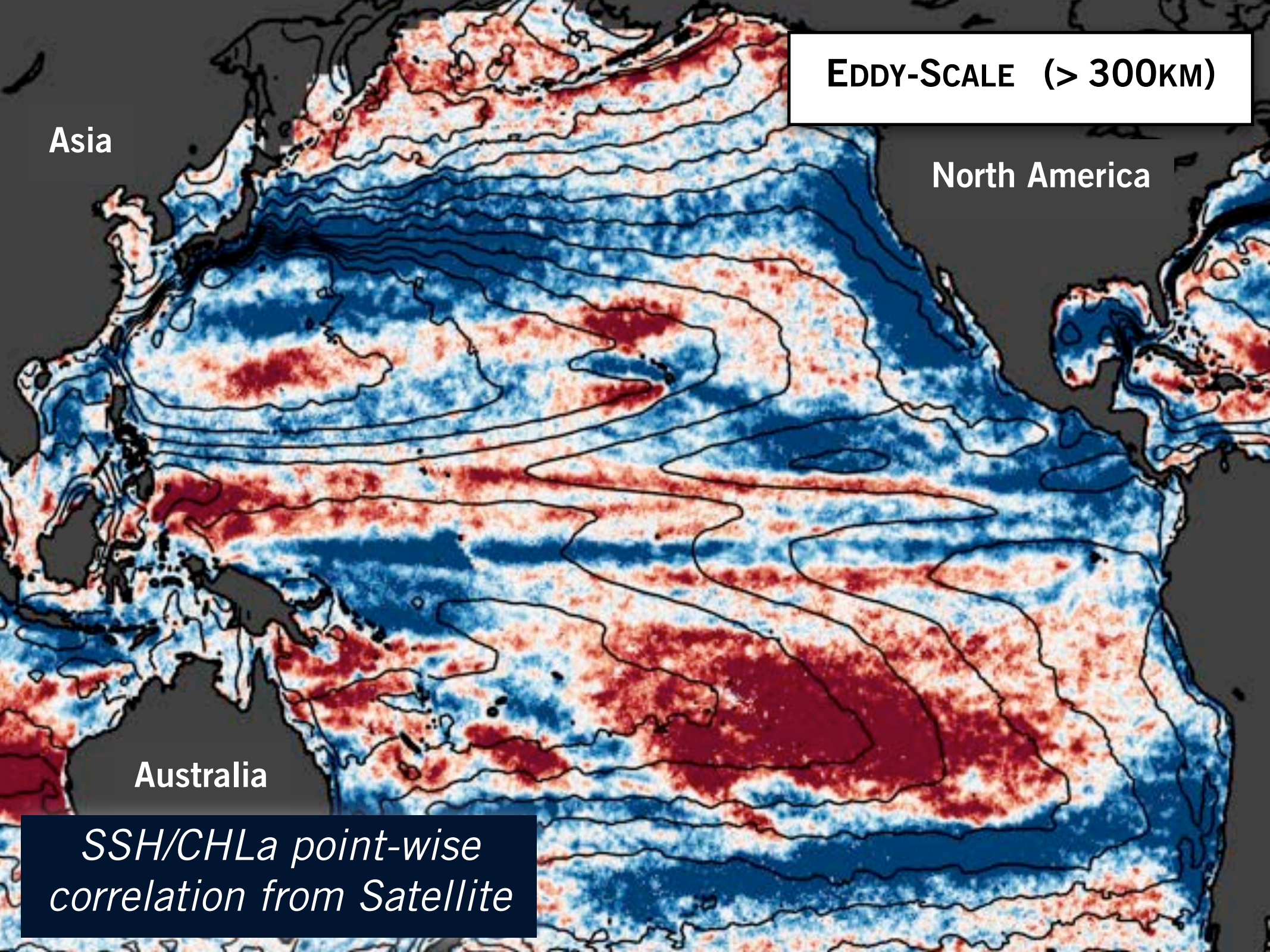
*SSH/CHLa point-wise
correlation from Satellite*



*Gaube et al. 2014;
McGillicuddy, 2016;*



*SSH/CHLa point-wise
correlation from Satellite*



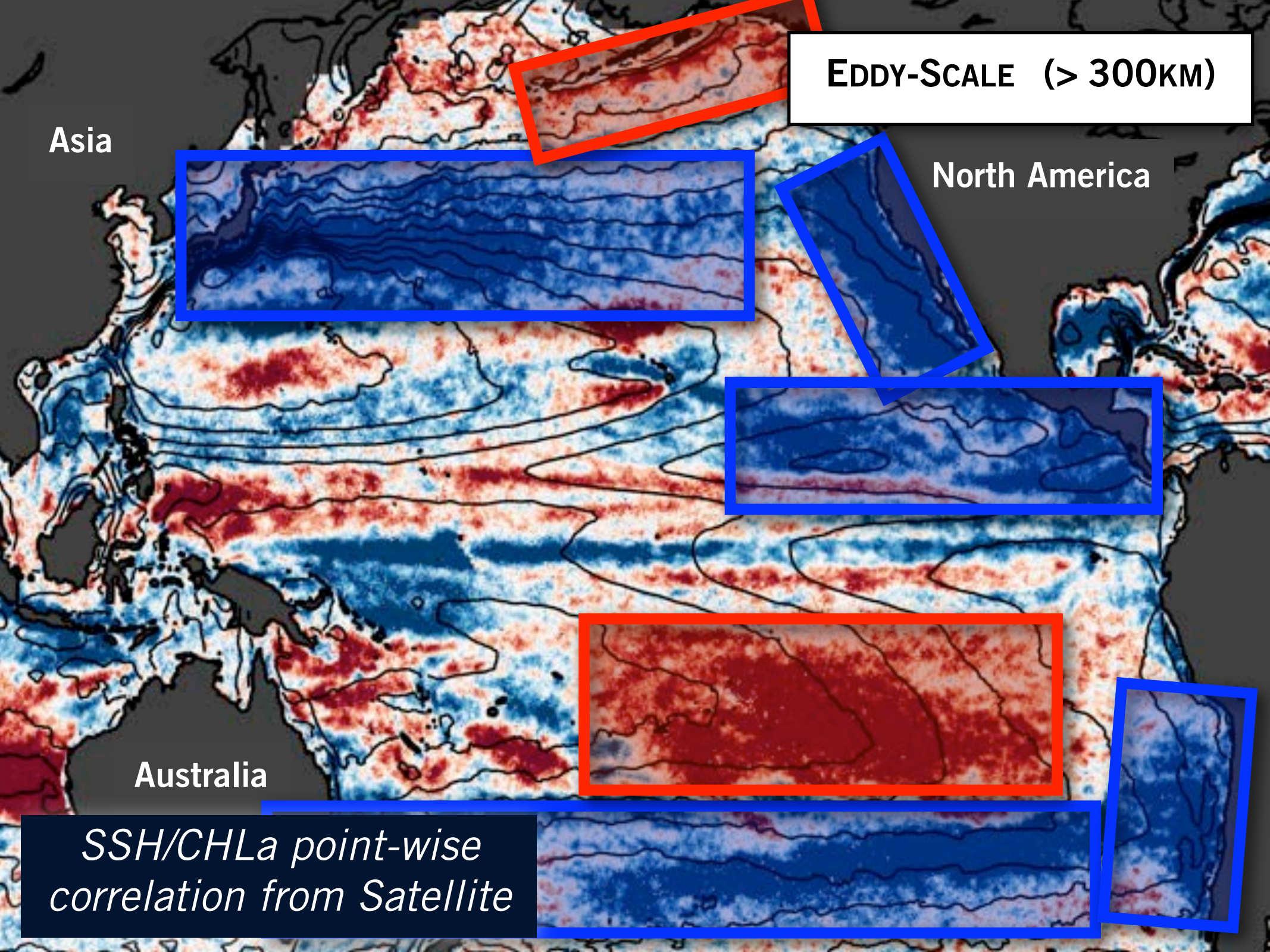
EDDY-SCALE (> 300KM)

Asia

North America

Australia

SSH/CHLa point-wise correlation from Satellite



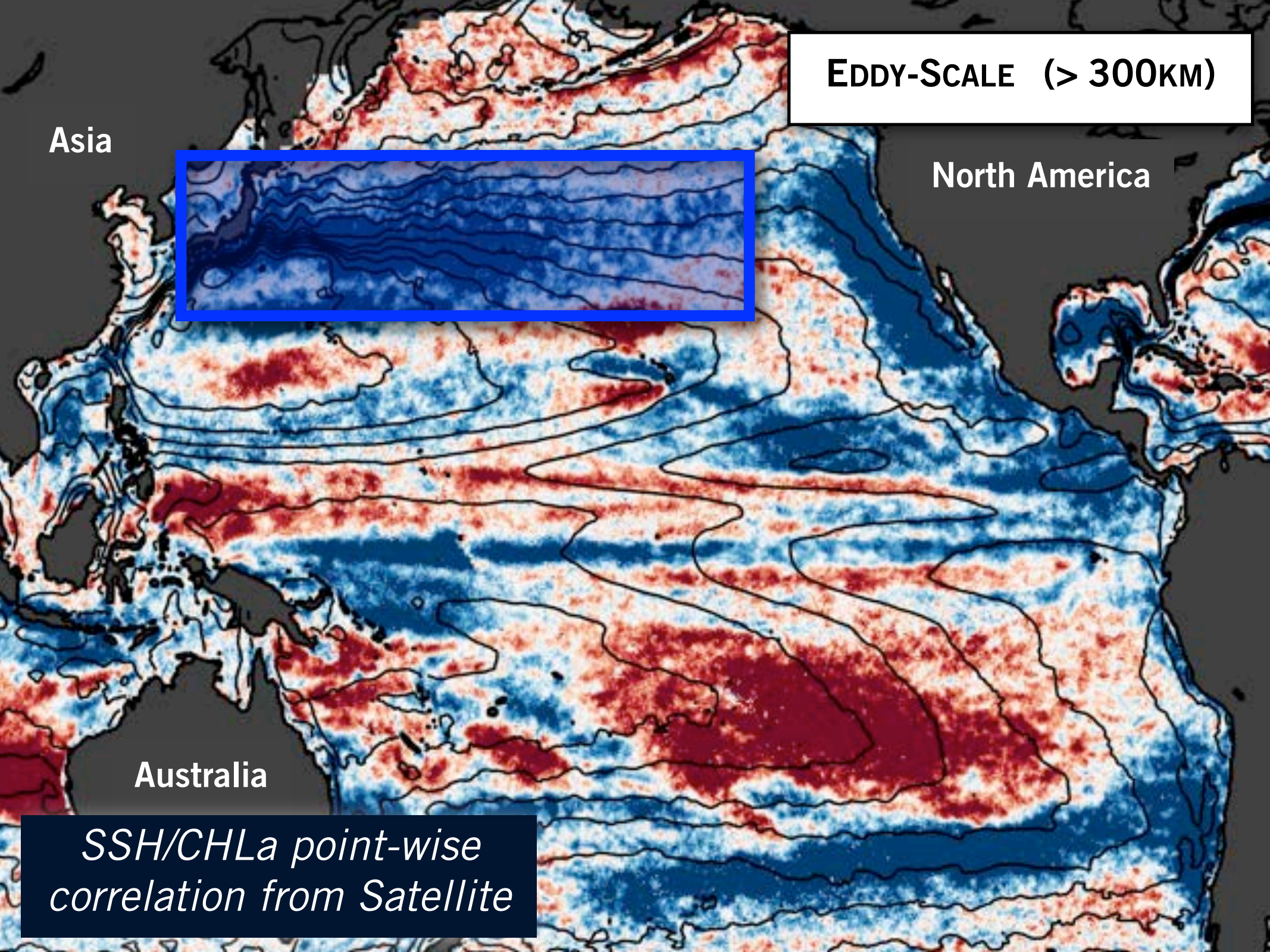
Asia

EDDY-SCALE (> 300KM)

North America

Australia

SSH/CHLa point-wise correlation from Satellite



EDDY-SCALE (> 300KM)

Asia

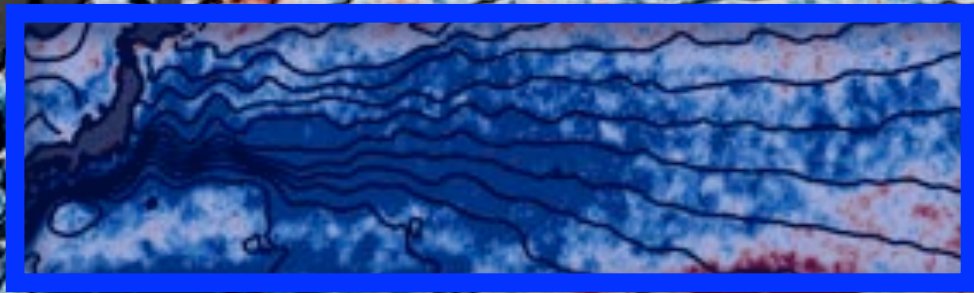
North America

Australia

SSH/CHLa point-wise correlation from Satellite

Asia

North America



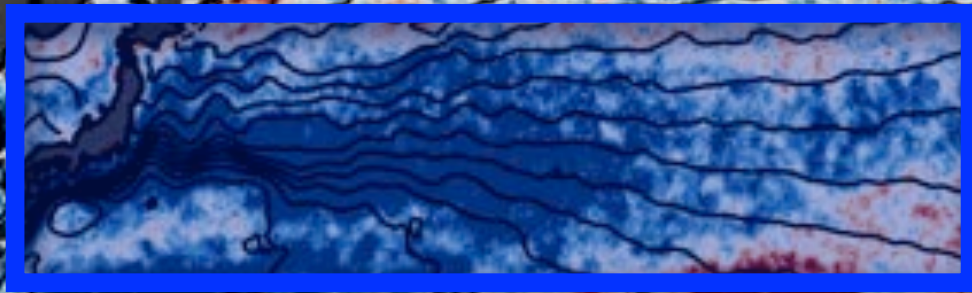
Loggerhead sea turtles foraging



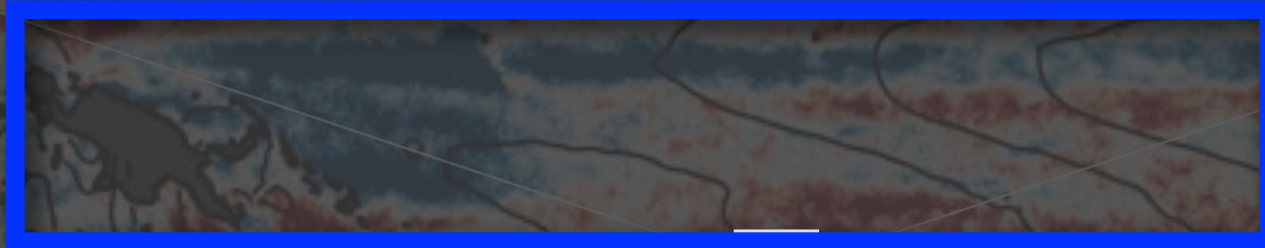
Australia

Asia

North America



Loggerhead sea turtles foraging

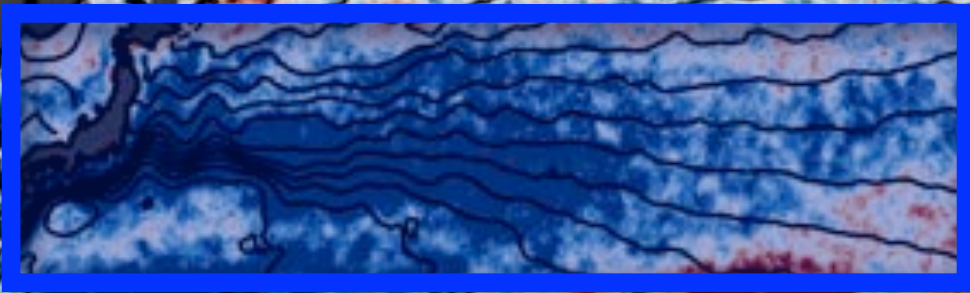


Australia

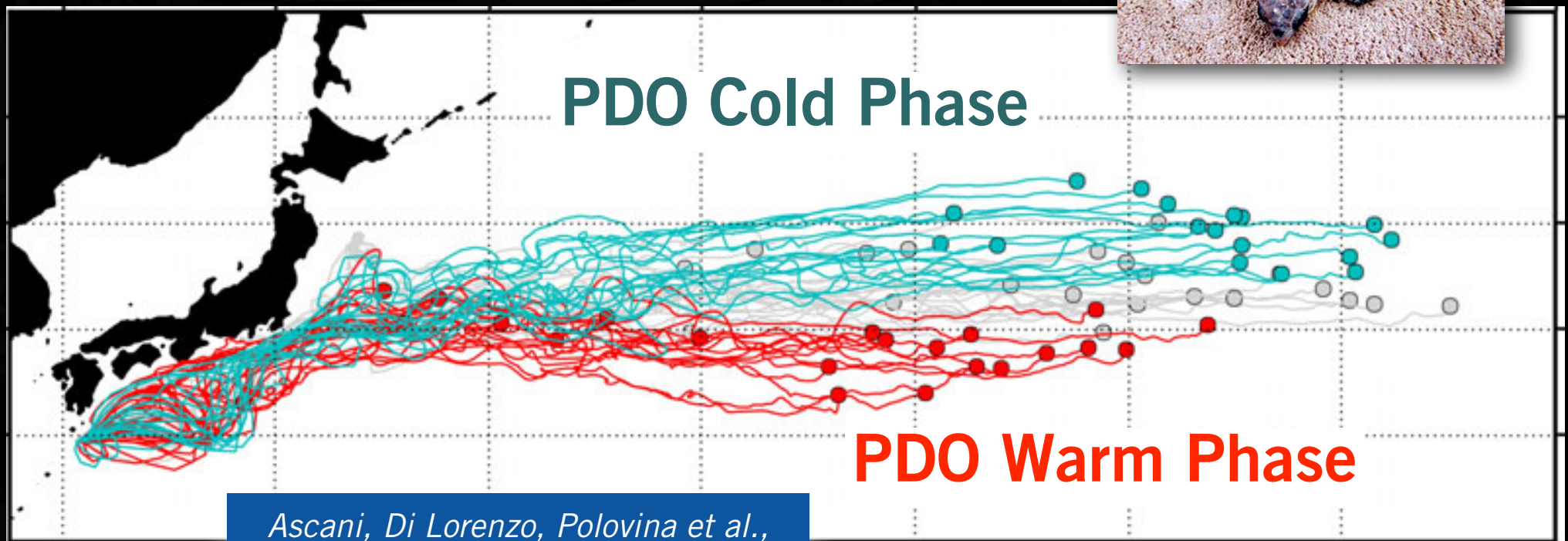
from Polovina talk

Asia

North America



Trajectories of Loggerhead from Japan

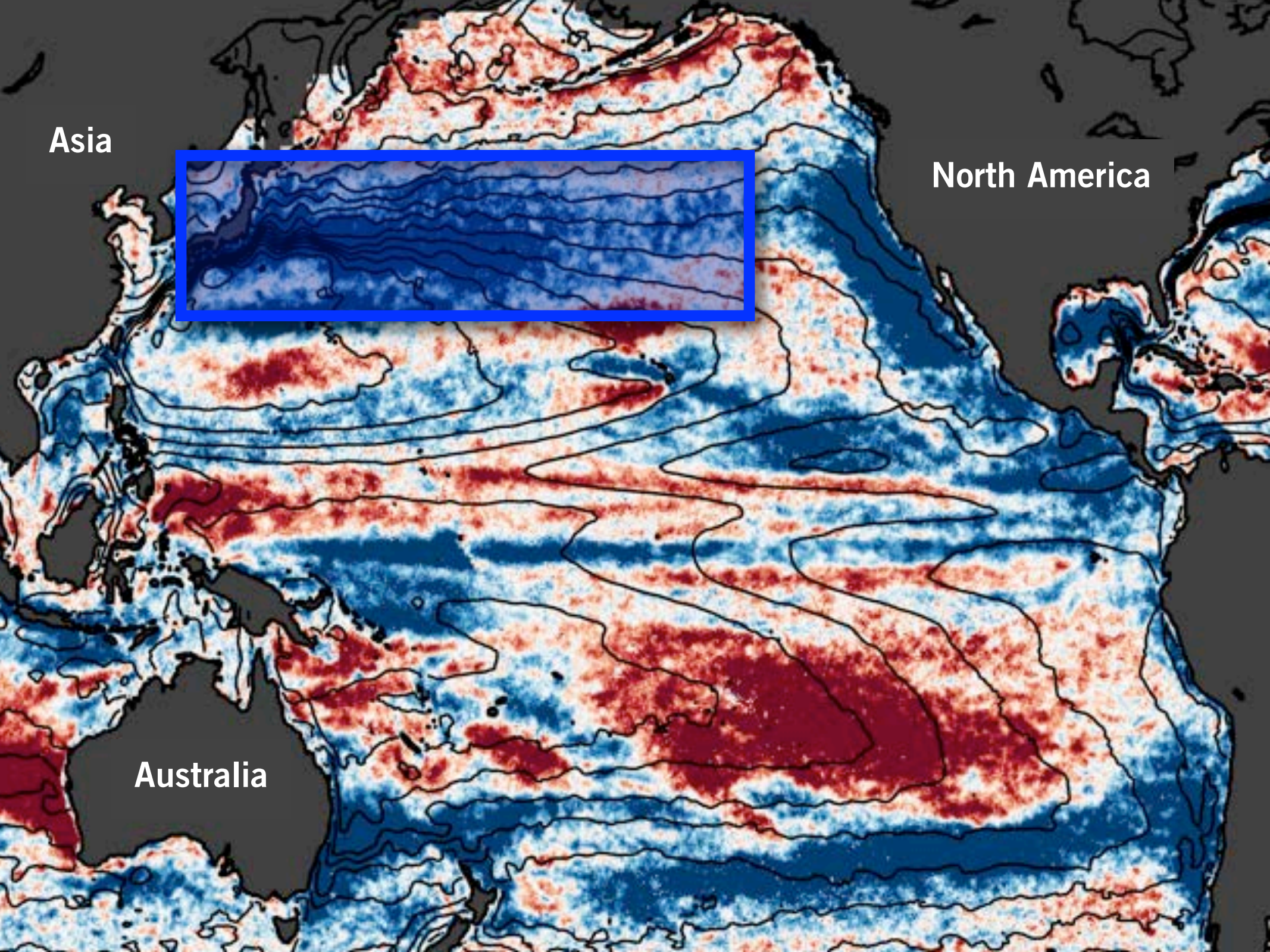


Ascani, Di Lorenzo, Polovina et al.,
Global Change Biology, 2016

Asia

North America

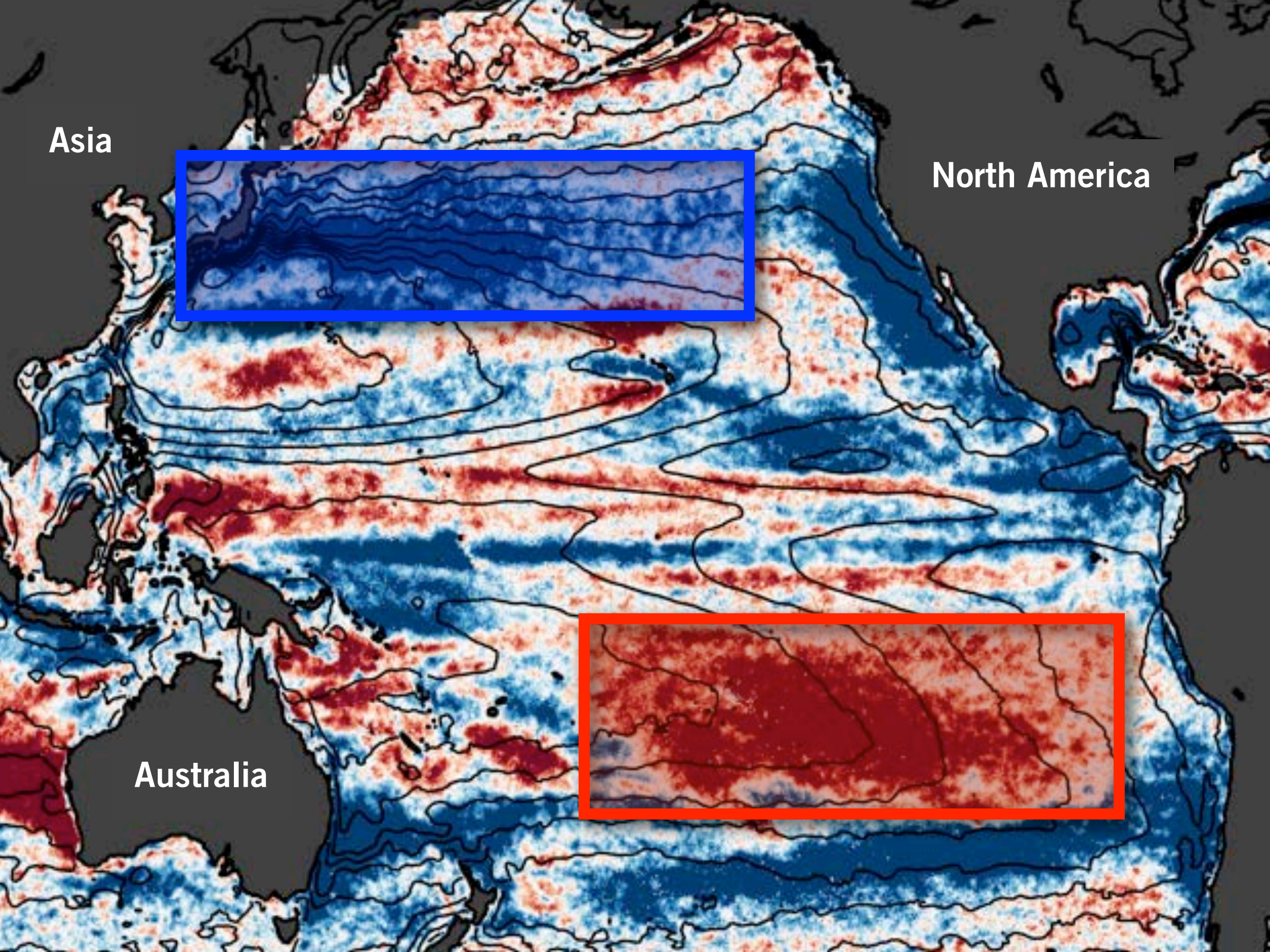
Australia



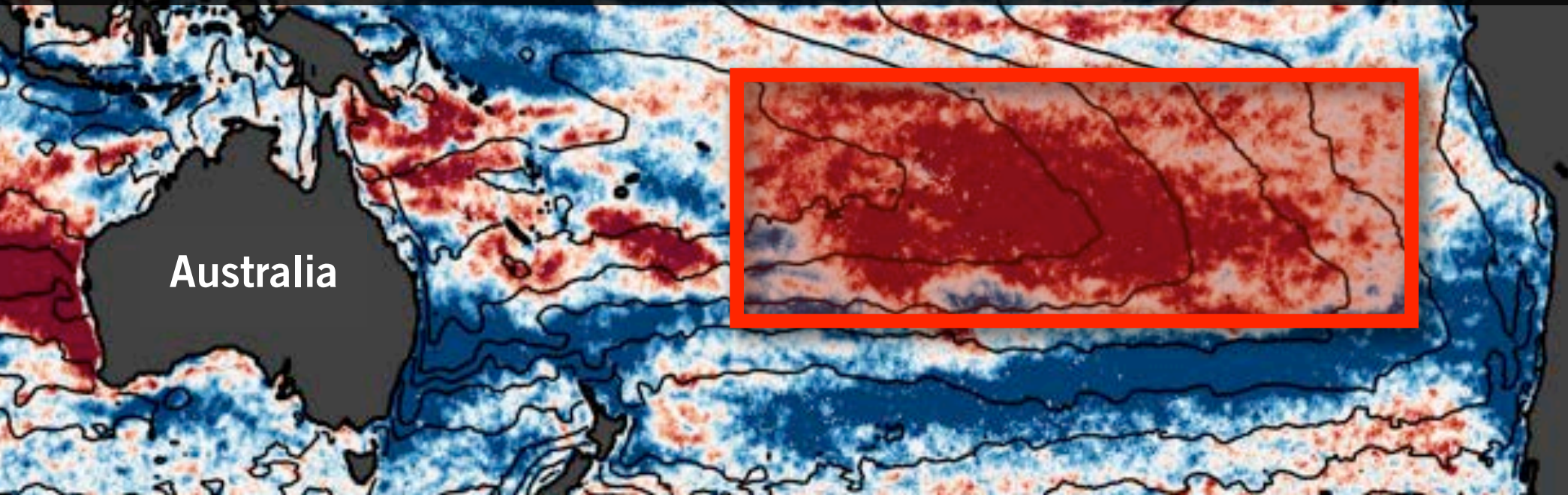
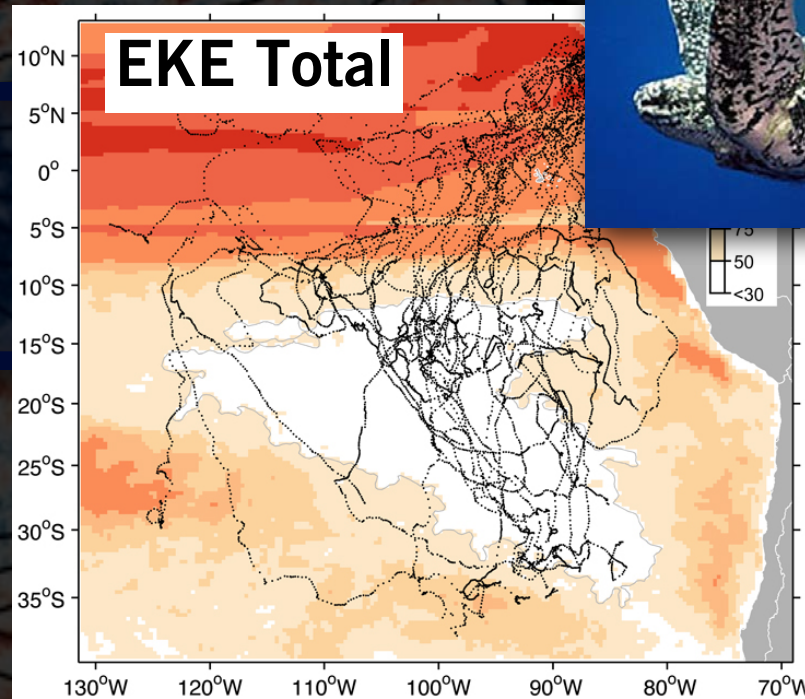
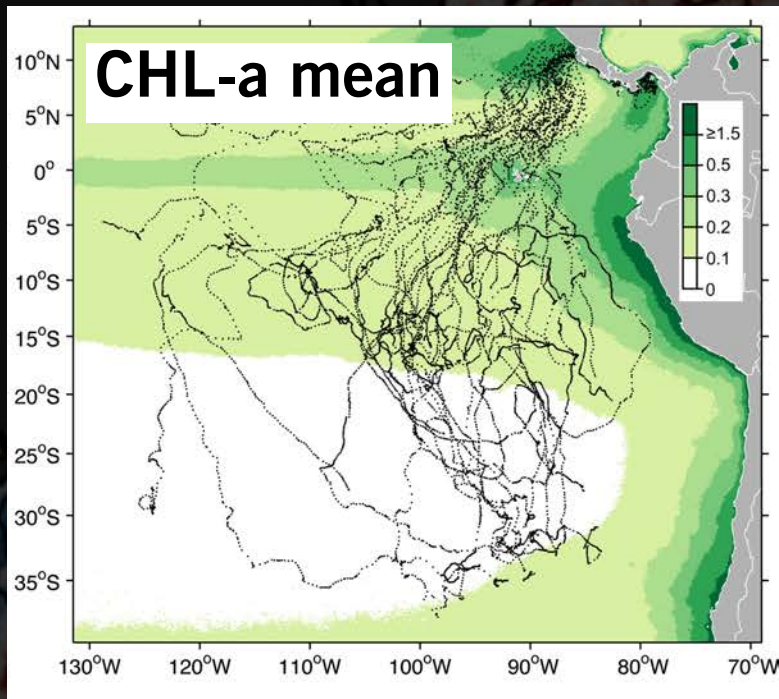
Asia

North America

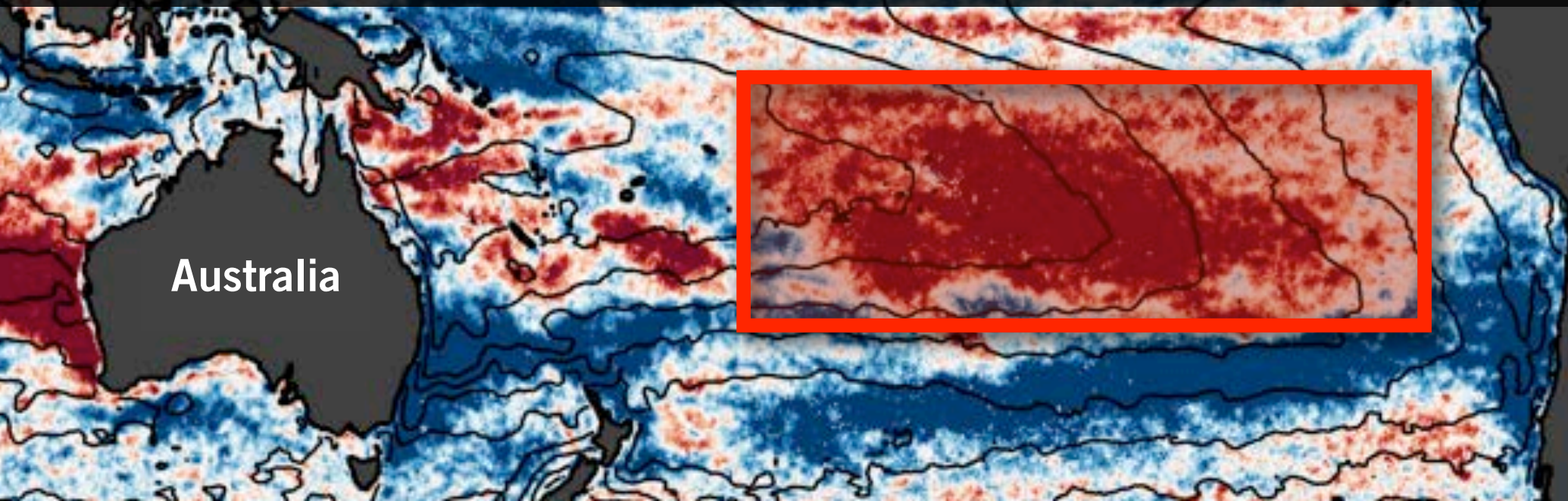
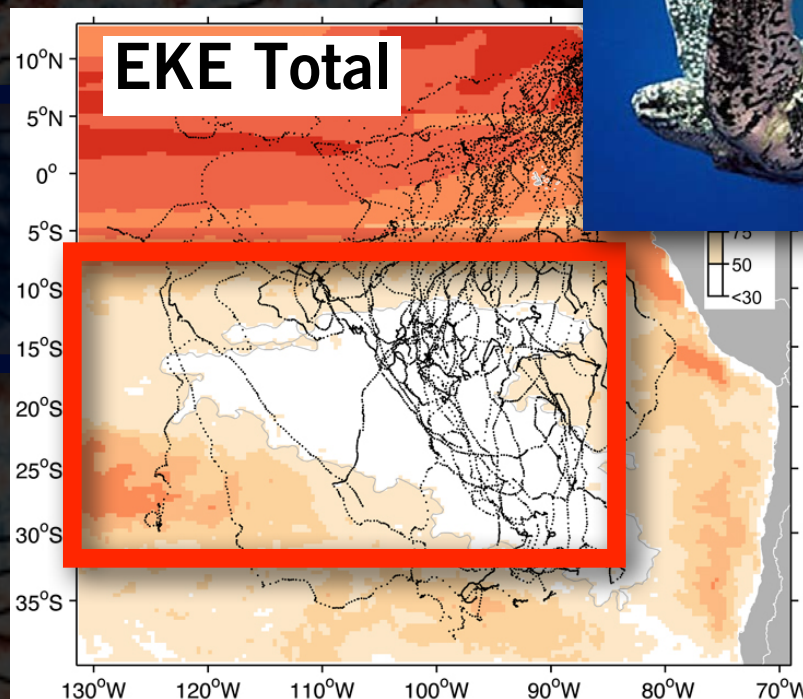
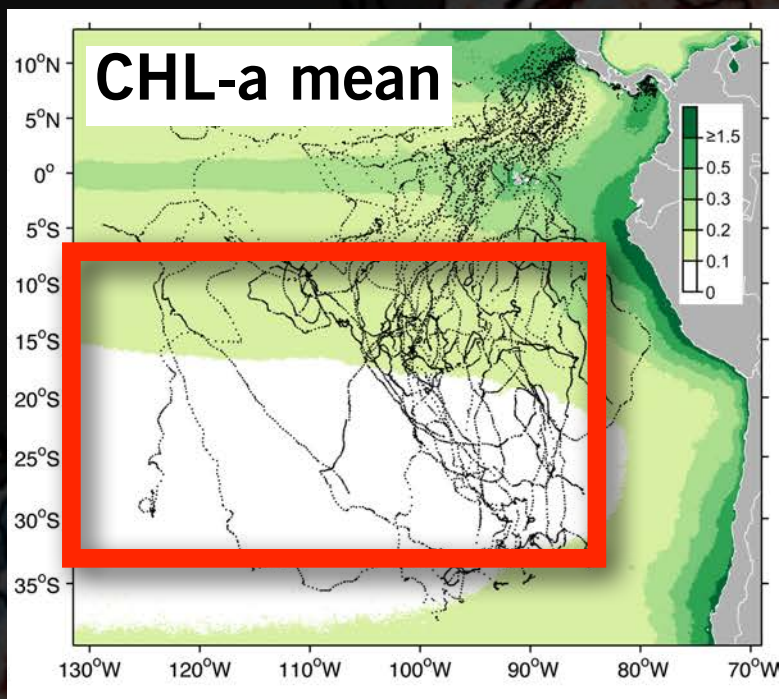
Australia



Trajectories of Leatherback Turtle



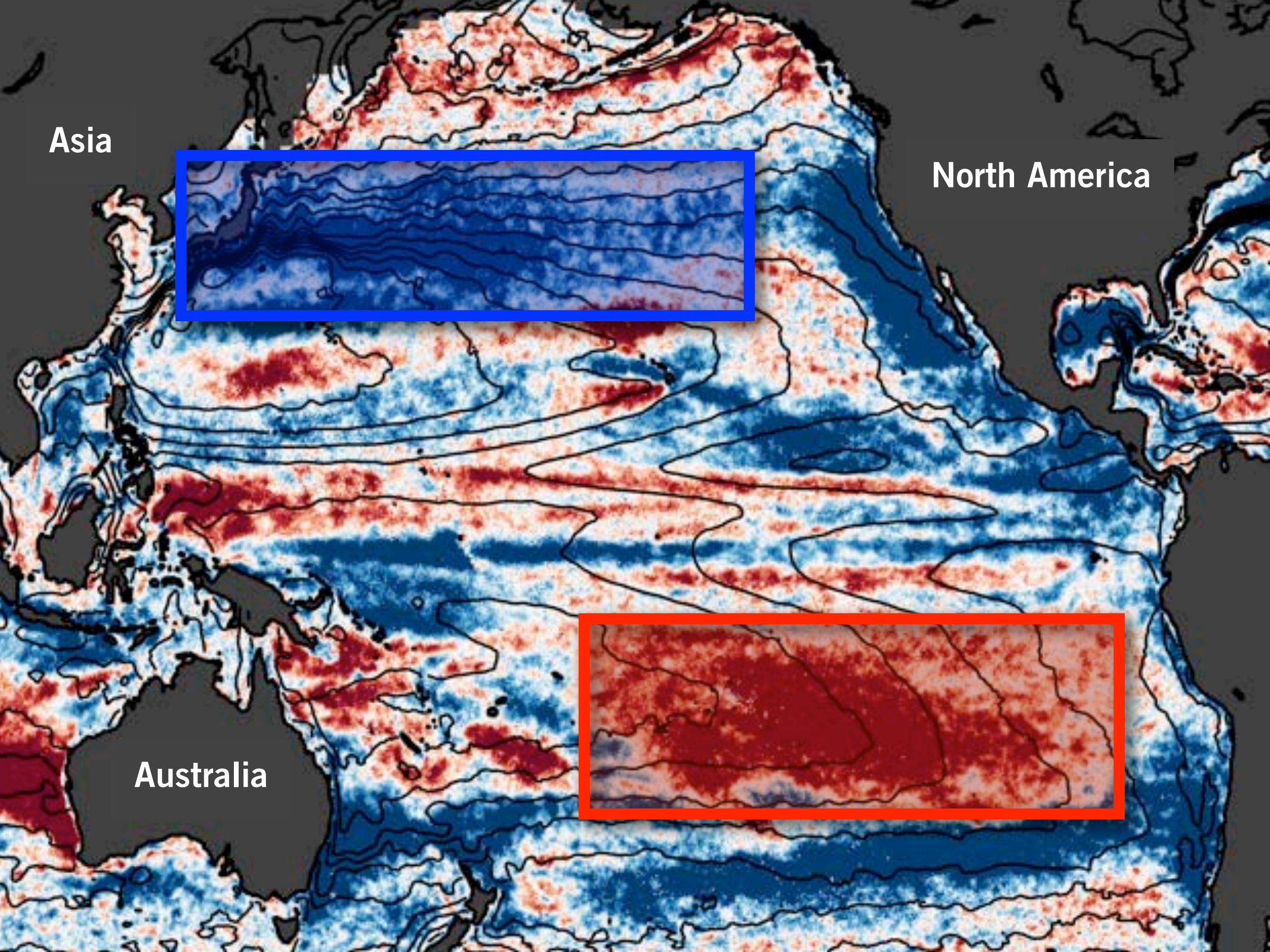
Trajectories of Leatherback Turtle



Asia

North America

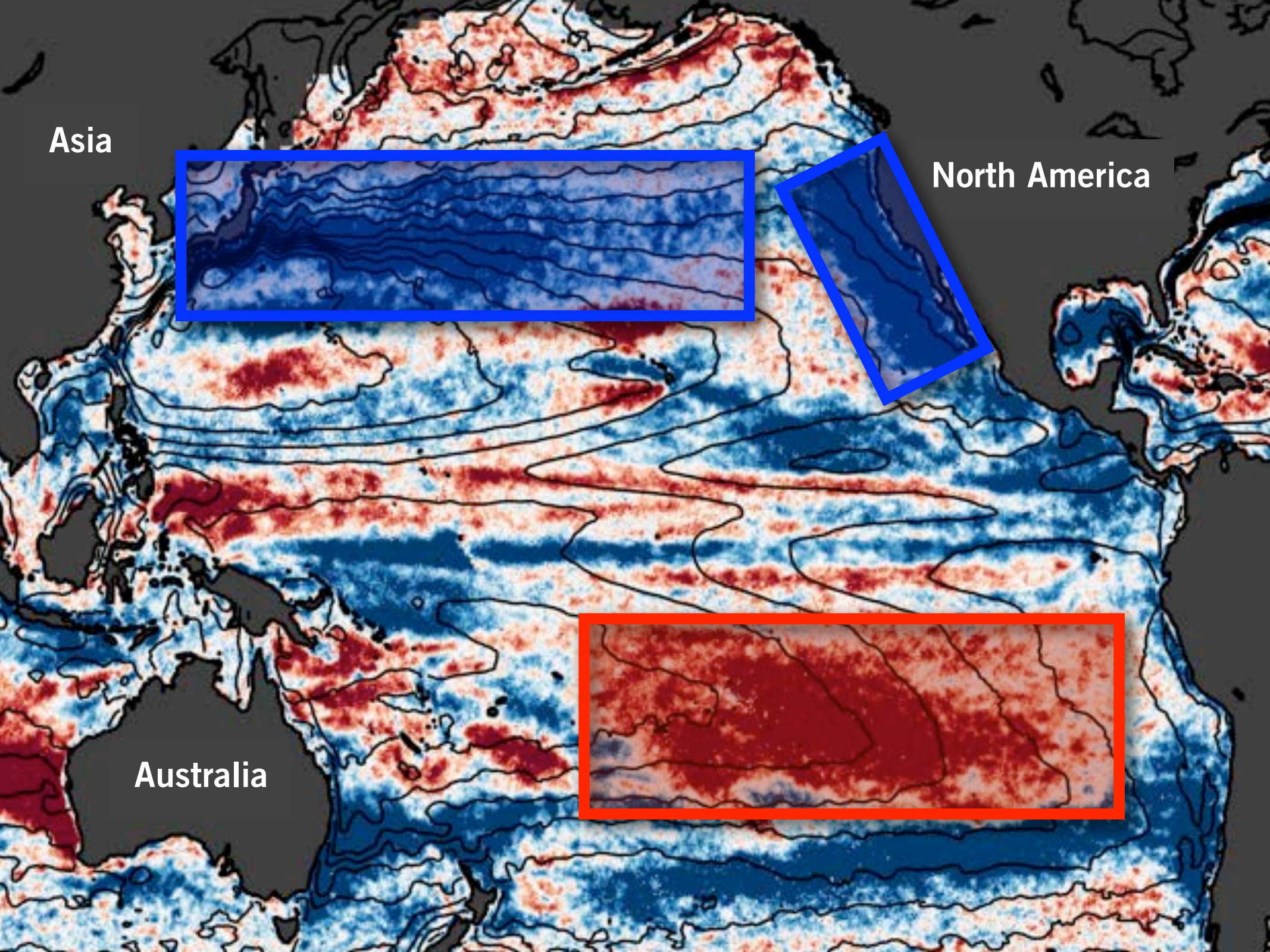
Australia



Asia

North America

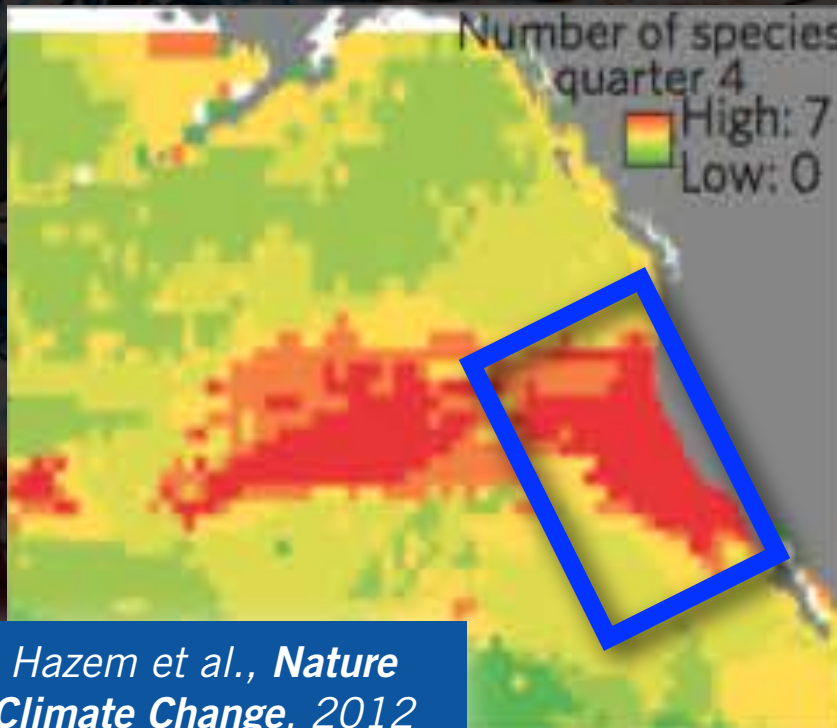
Australia



Asia

North America

Species Richness

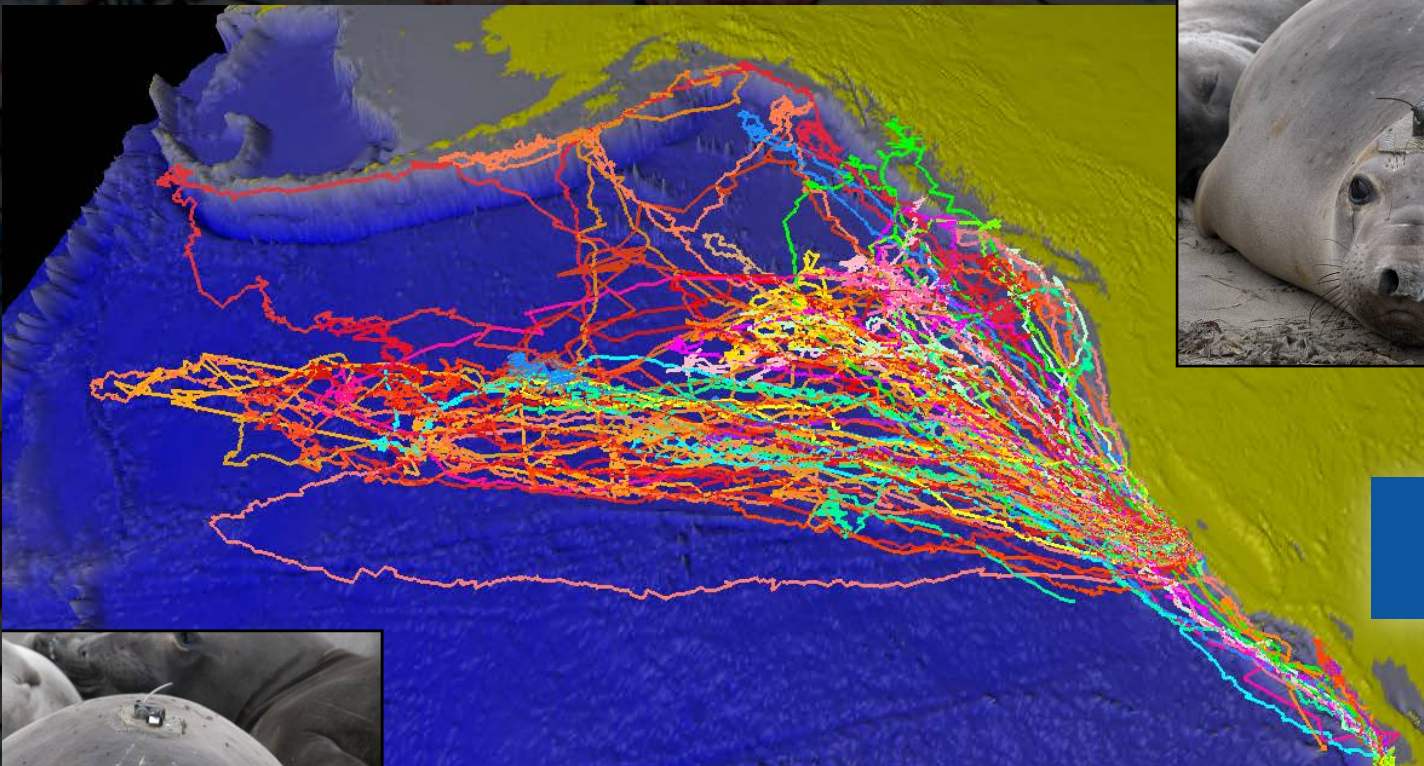


*Hazem et al., Nature
Climate Change, 2012*

Asia

North America

Seal Trajectories

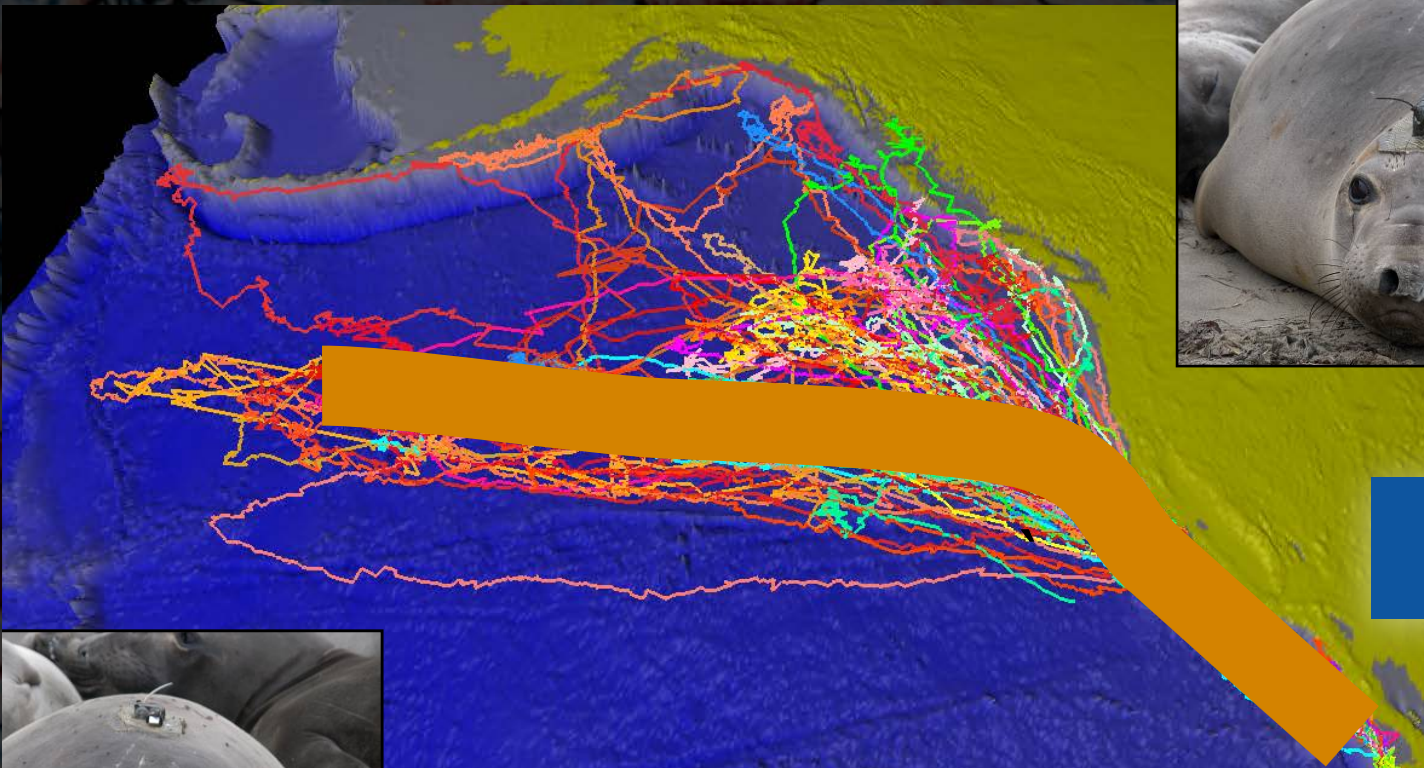


*Costa Lab
2003-2006*

Asia

North America

Seal Trajectories



*Costa Lab
2003-2006*



Asia

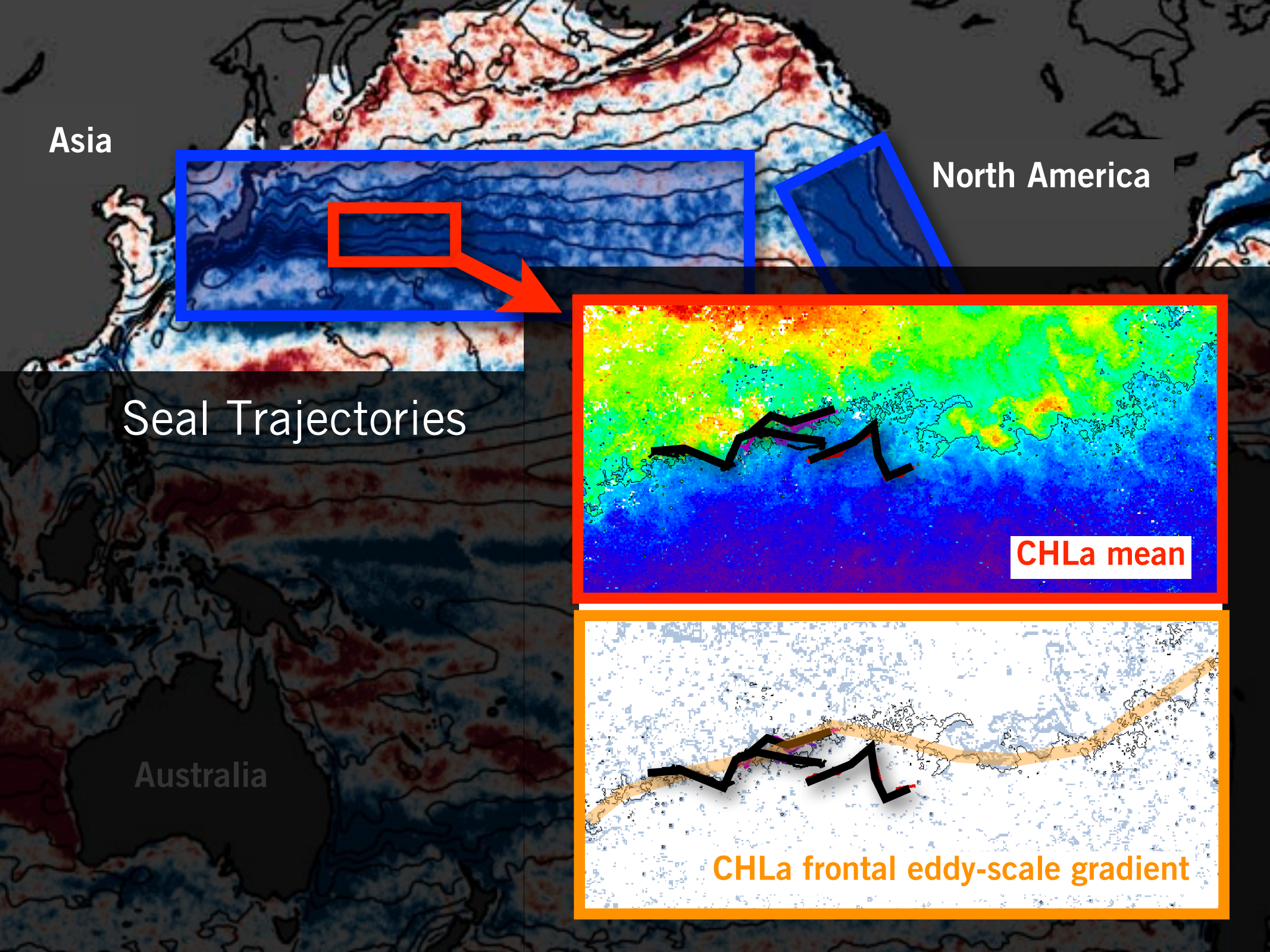
North America

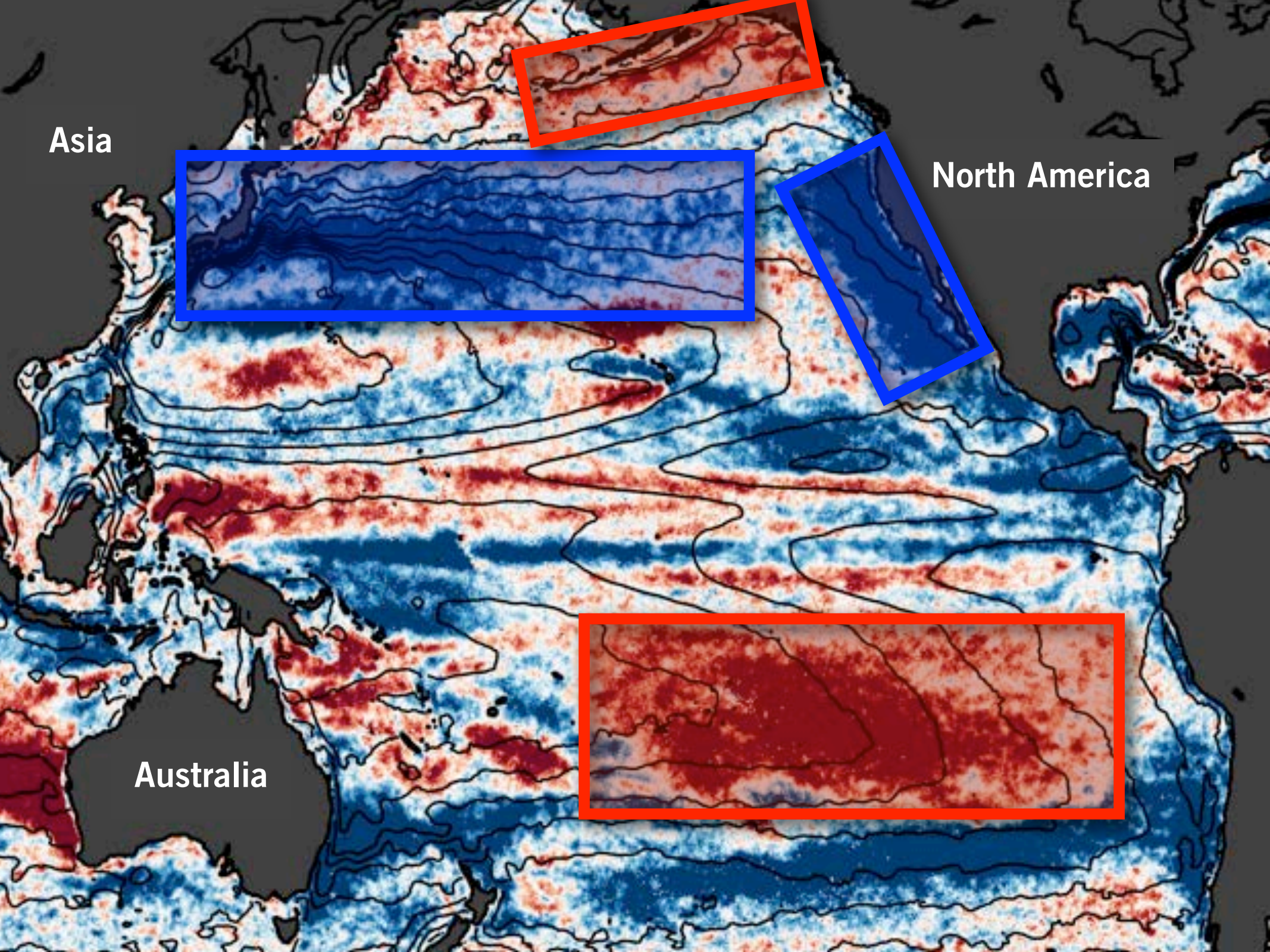
Seal Trajectories

CHLa mean

CHLa frontal eddy-scale gradient

Australia





Asia

North America

Australia



Asia

North America

We can use SSH/CHl a covariance as indicators of “ecologically relevant” PTAs

Australia

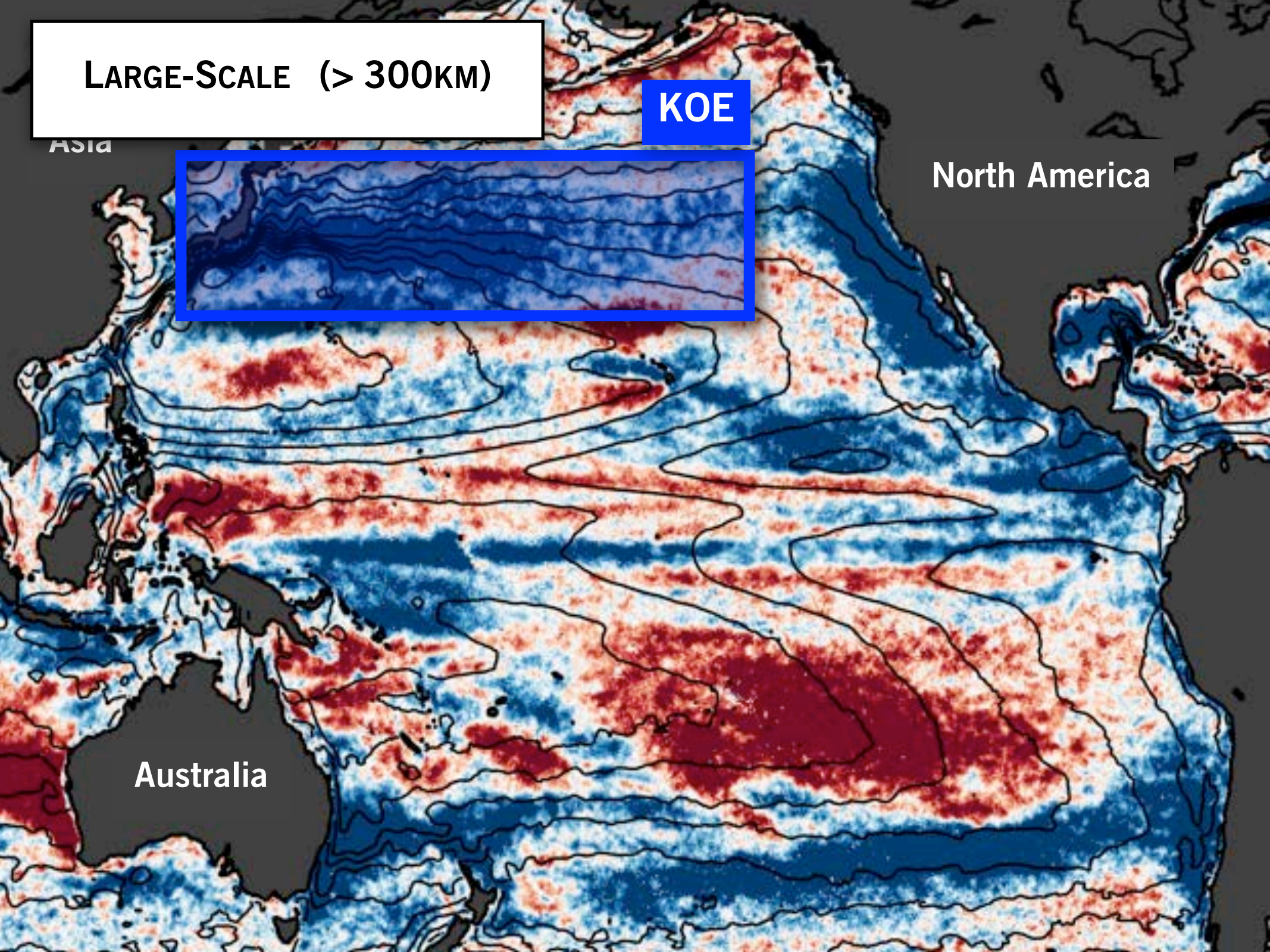
LARGE-SCALE (> 300KM)

KOE

ASIA

North America

Australia

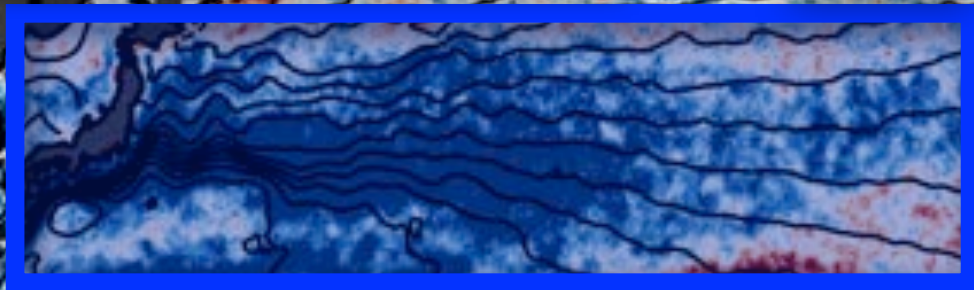


LARGE-SCALE (> 300KM)

KOE

North America

Asia

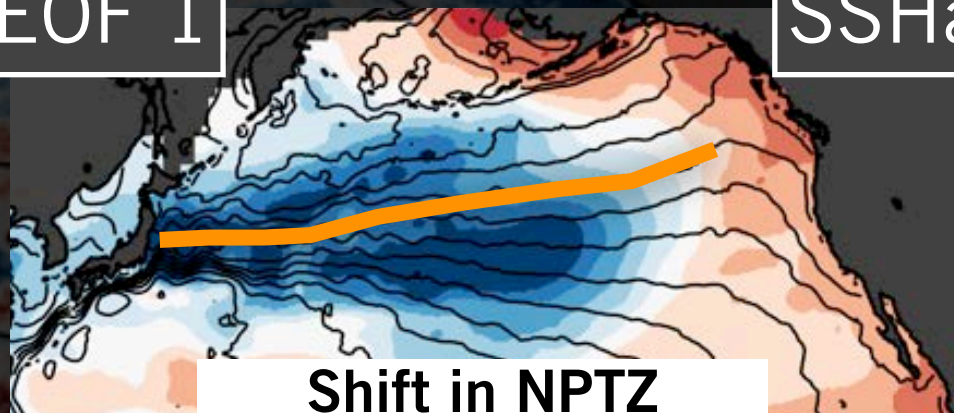


EOF 1

SSHa

Dominant Modes

Covariability SSH/CHLa

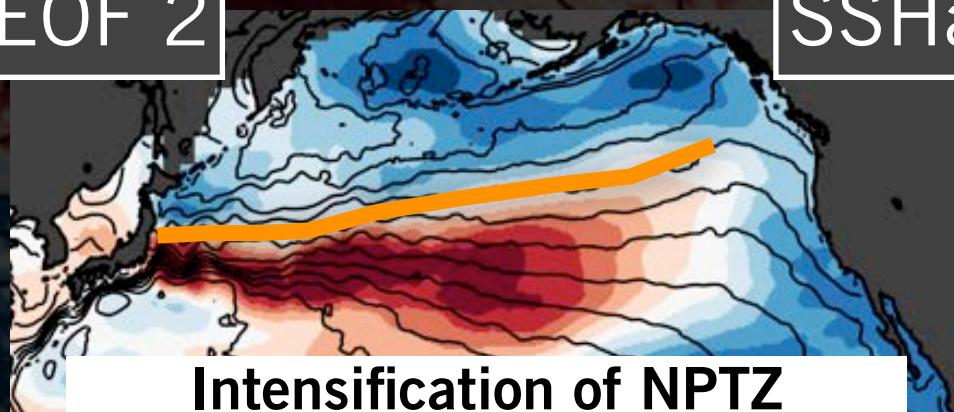


Shift in NPTZ

EOF 2

SSHa

Australia



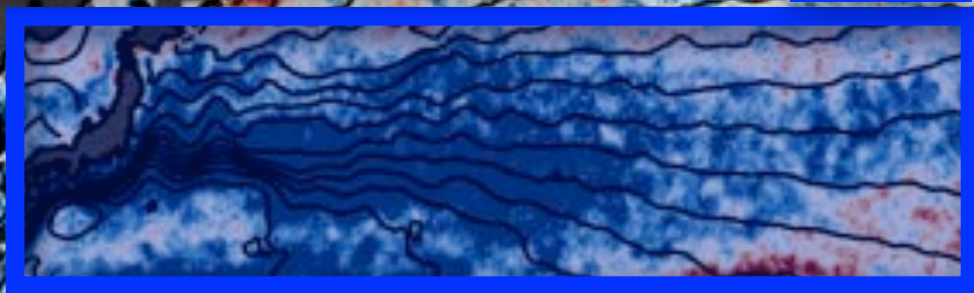
Intensification of NPTZ

LARGE-SCALE (> 300KM)

KOE

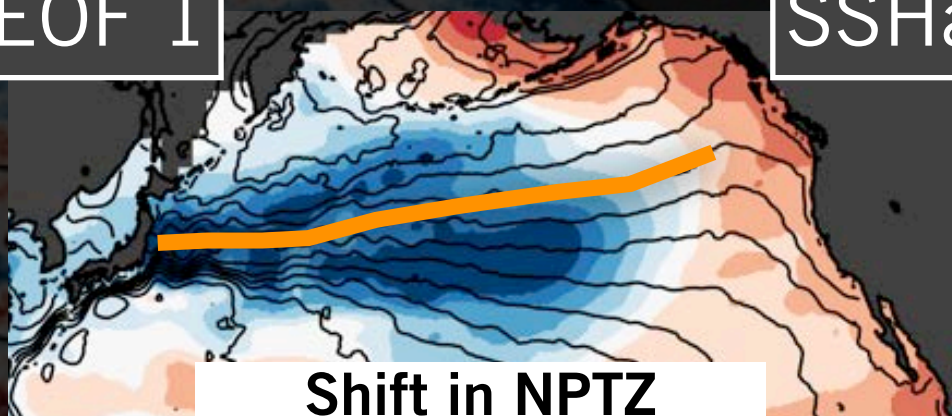
Asia

North America



EOF 1

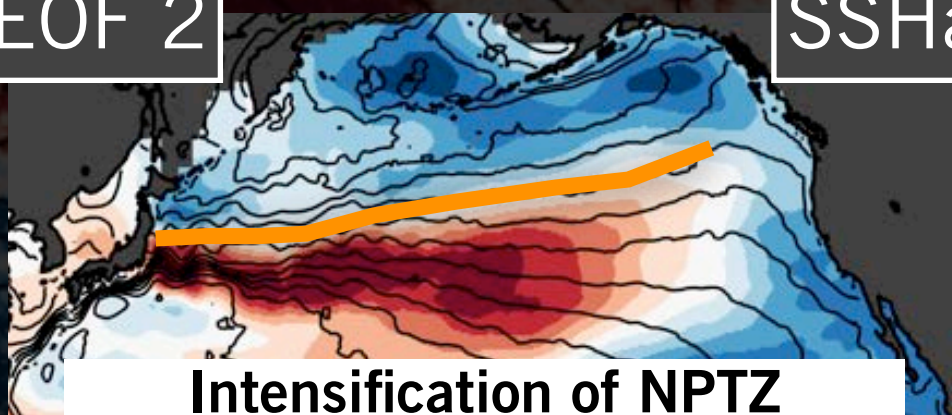
SSHa



Shift in NPTZ

EOF 2

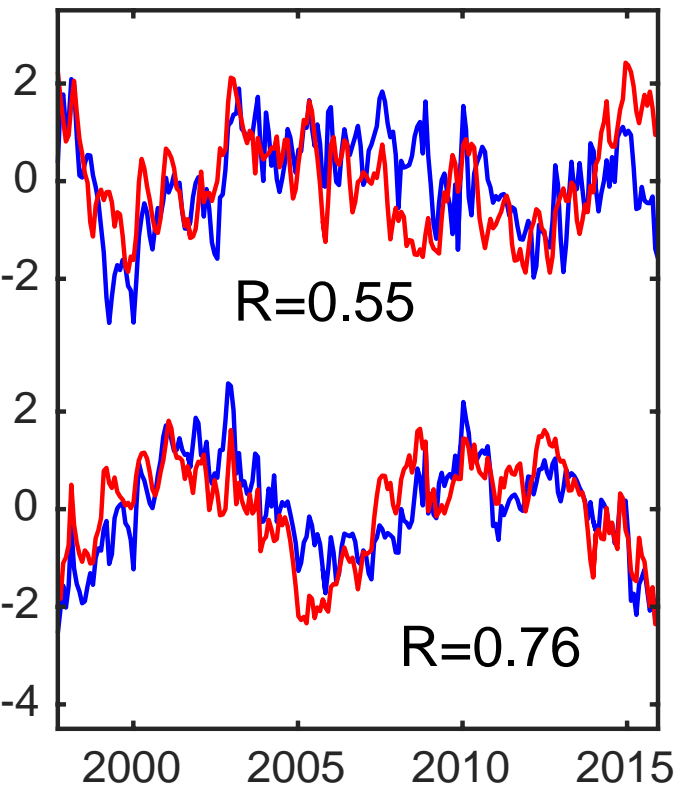
SSHa



Intensification of NPTZ

EOF1
PDO

EOF2
NPGO



LARGE-SCALE (> 300KM)

KOE

North America

QUESTIONS

How will climate change impact the

LARGE-SCALE KOE dynamics?

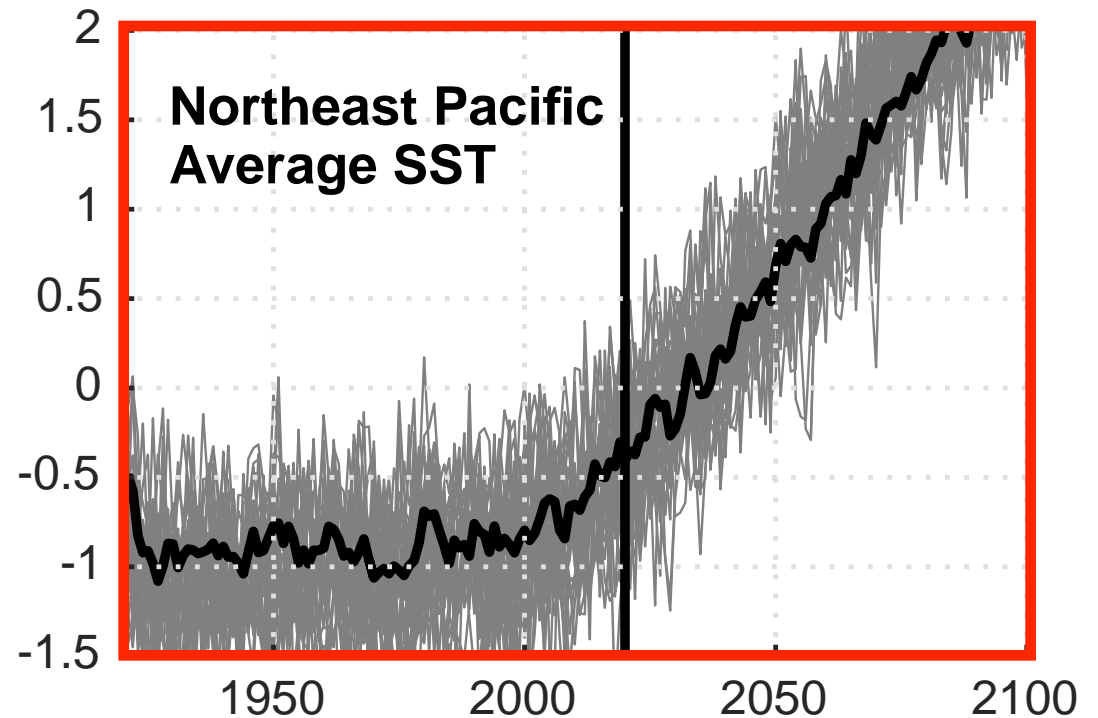
LARGE-SCALE (> 300KM)

Climate Model Projections

Community Earth System Model

CESM Large-Ensemble (n=30)

1920-2100 RCP8.5



QUESTIONS

How will climate change impact the

LARGE-SCALE KOE dynamics?

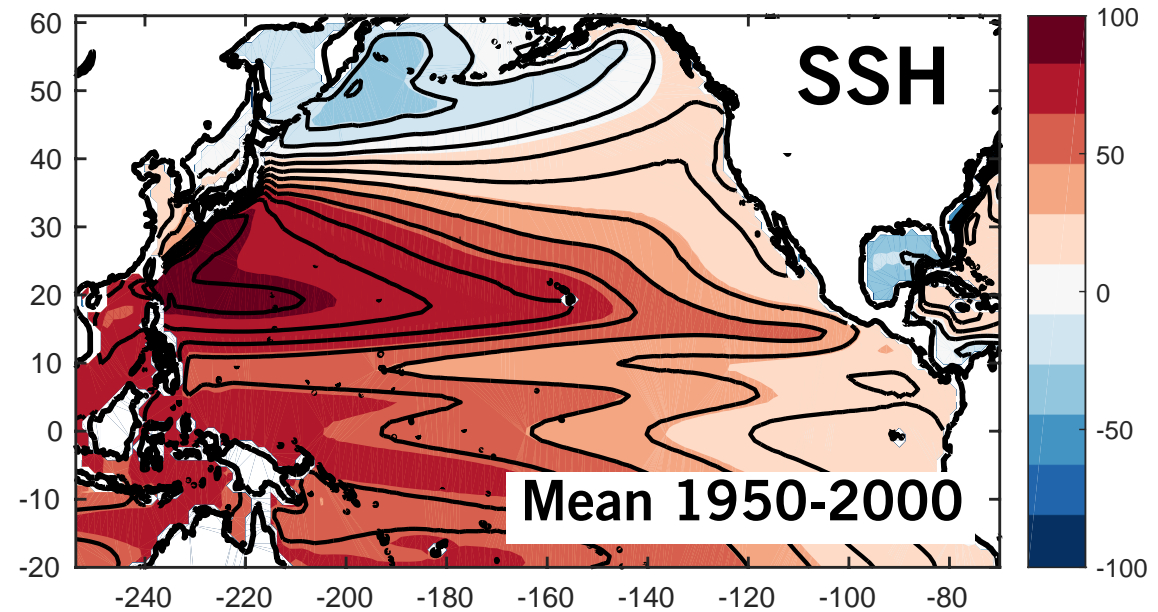
LARGE-SCALE (> 300KM)

Climate Model Projections

Community Earth System Model

CESM Large-Ensemble (n=30)

1920-2100 RCP8.5



QUESTIONS

How will climate change impact the

LARGE-SCALE KOE dynamics?

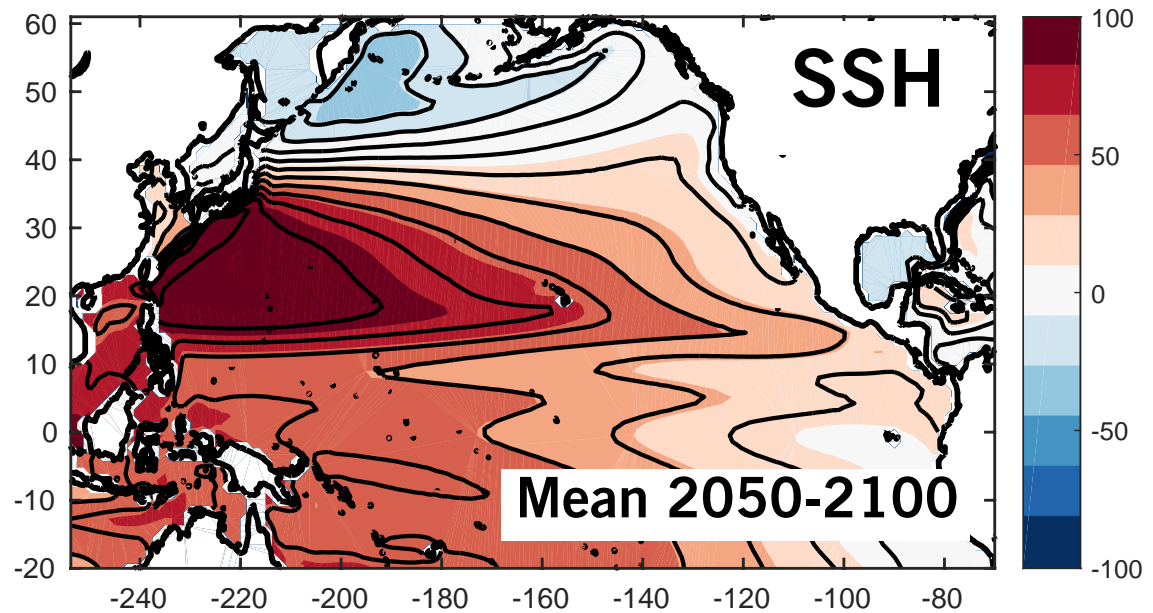
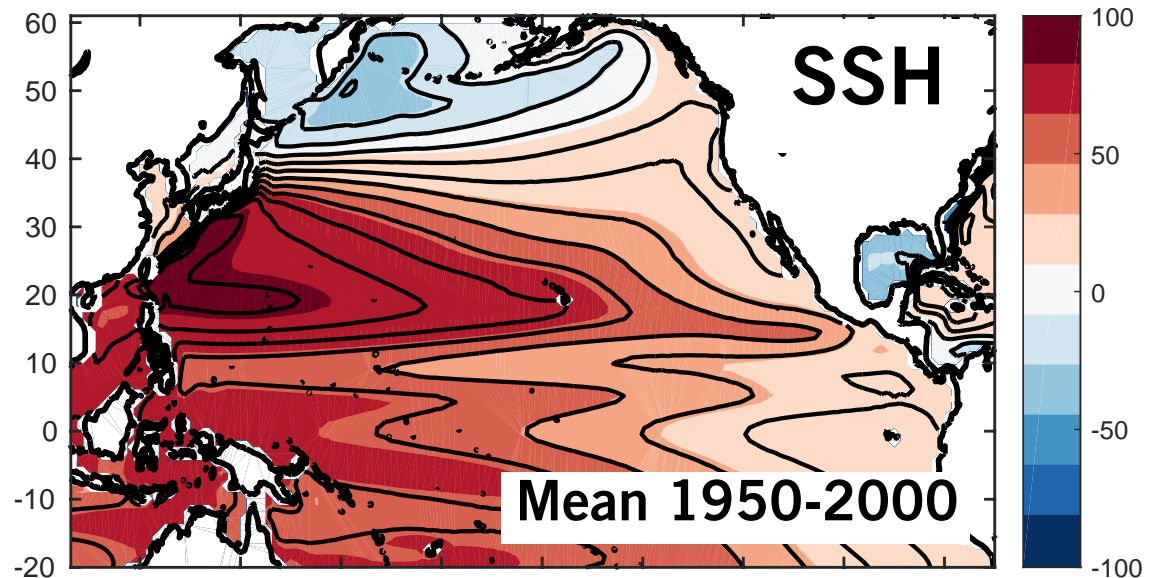
LARGE-SCALE (> 300KM)

Climate Model Projections

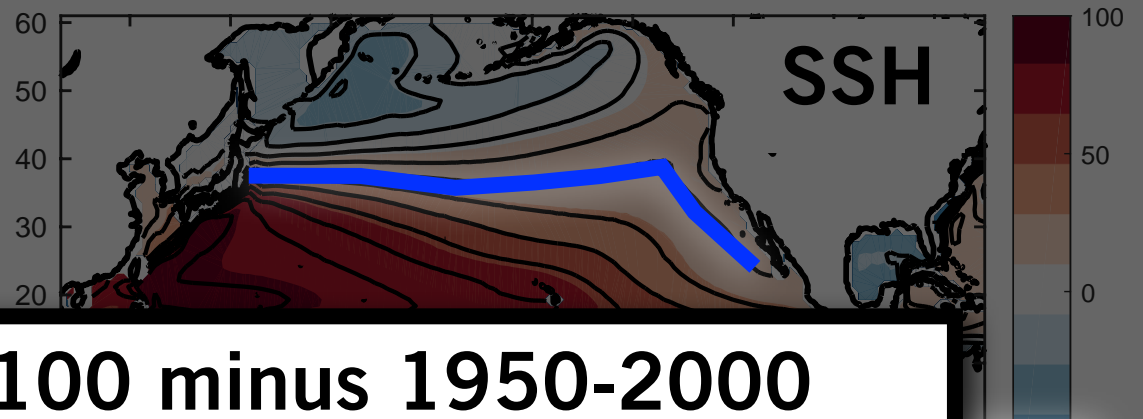
Community Earth System Model

CESM Large-Ensemble (n=30)

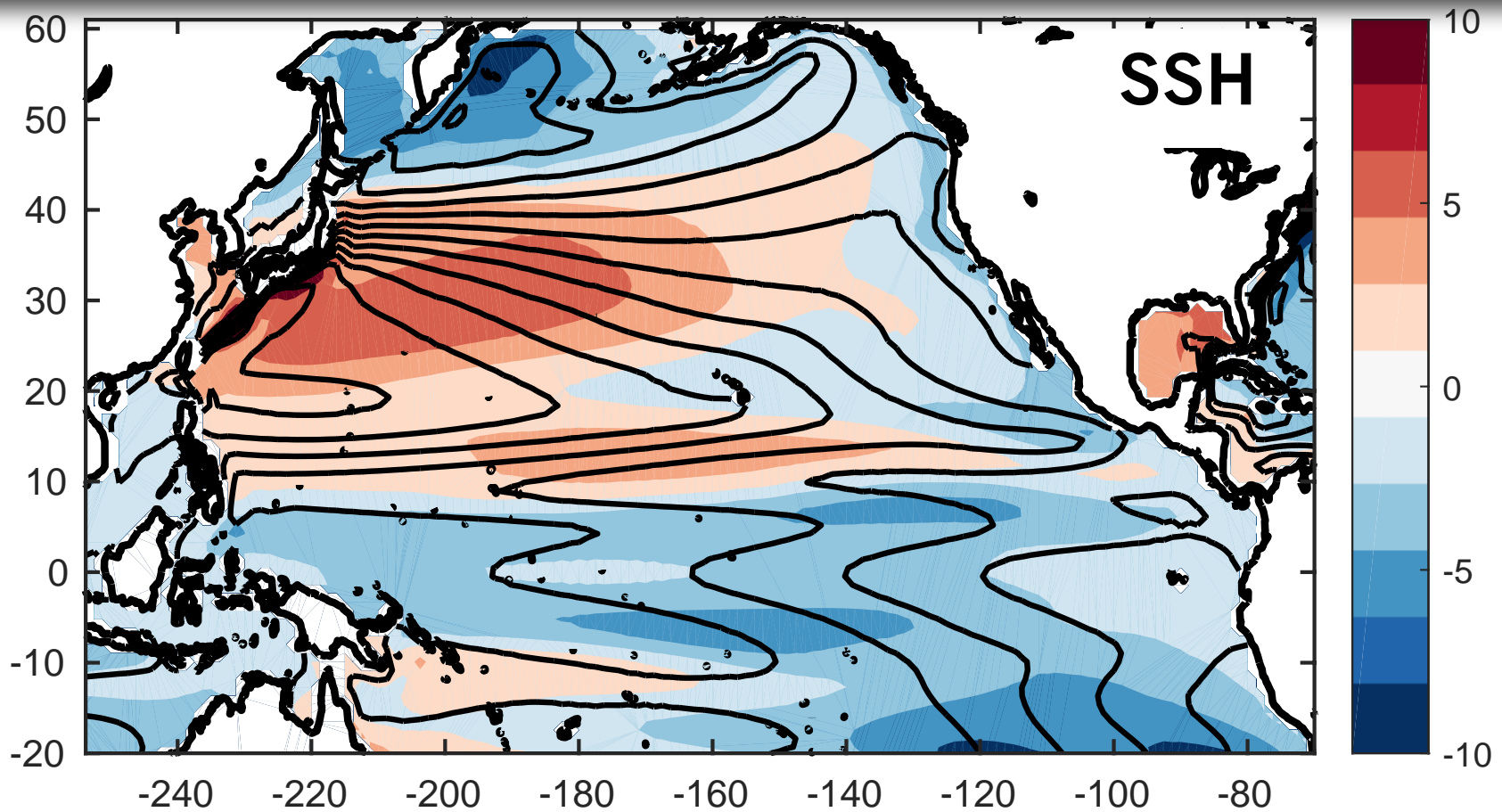
1920-2100 RCP8.5



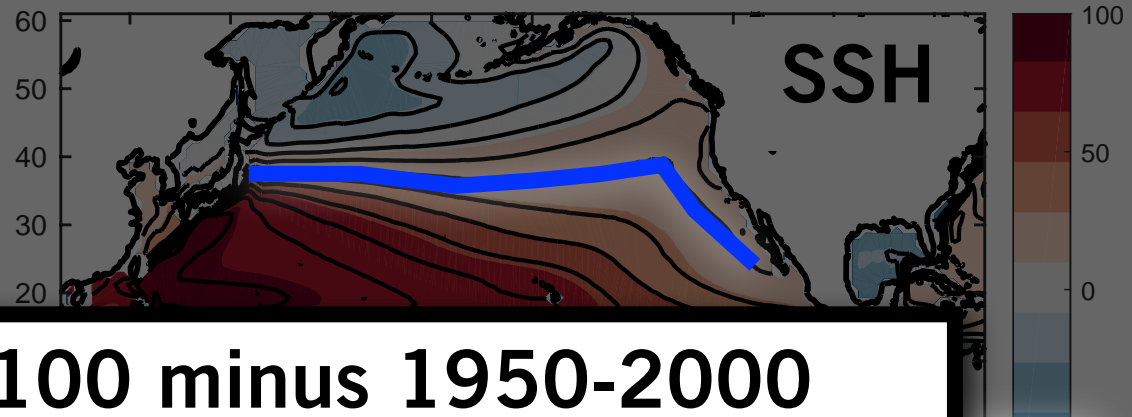
Community Earth System Model
CESM Large-Ensemble (n=30)
1920-2100 RCP8.5



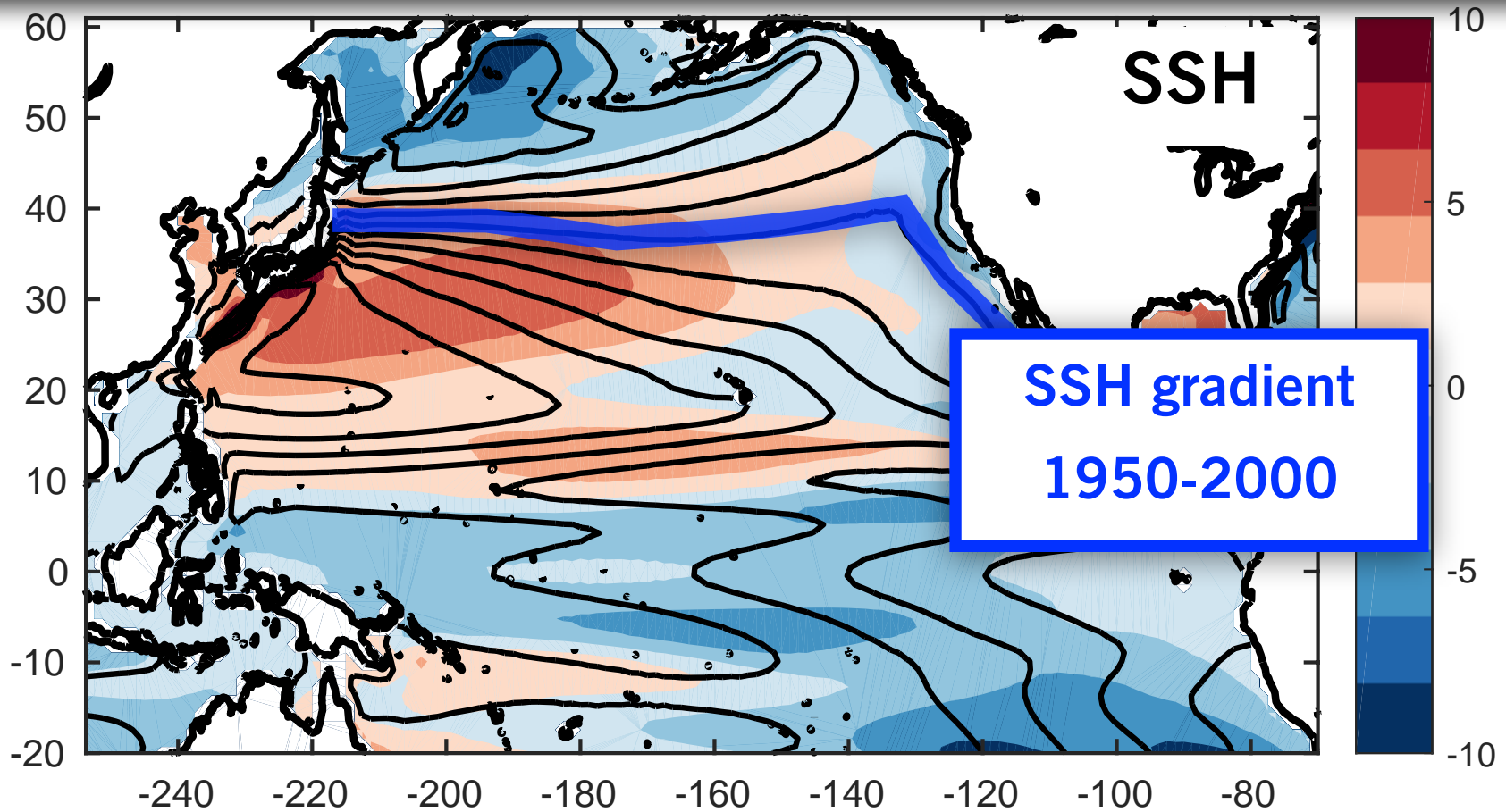
difference 2050-2100 minus 1950-2000



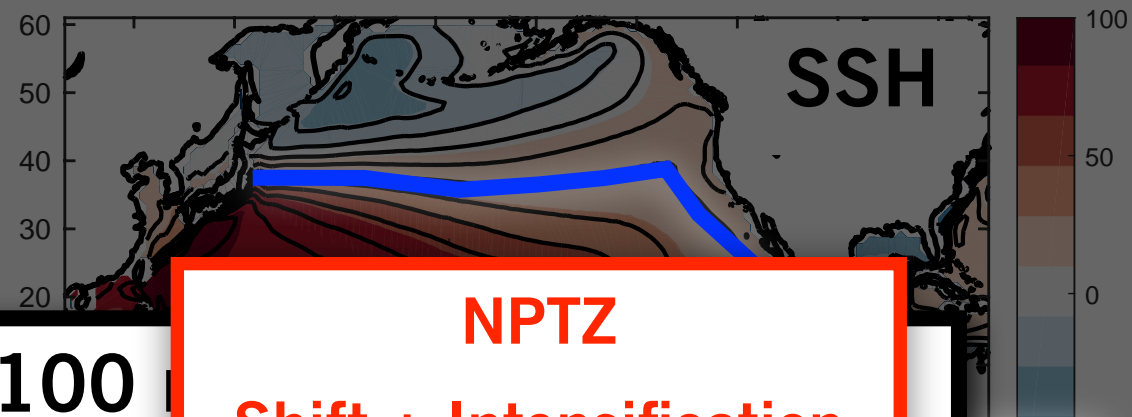
Community Earth System Model
CESM Large-Ensemble (n=30)
1920-2100 RCP8.5



difference 2050-2100 minus 1950-2000

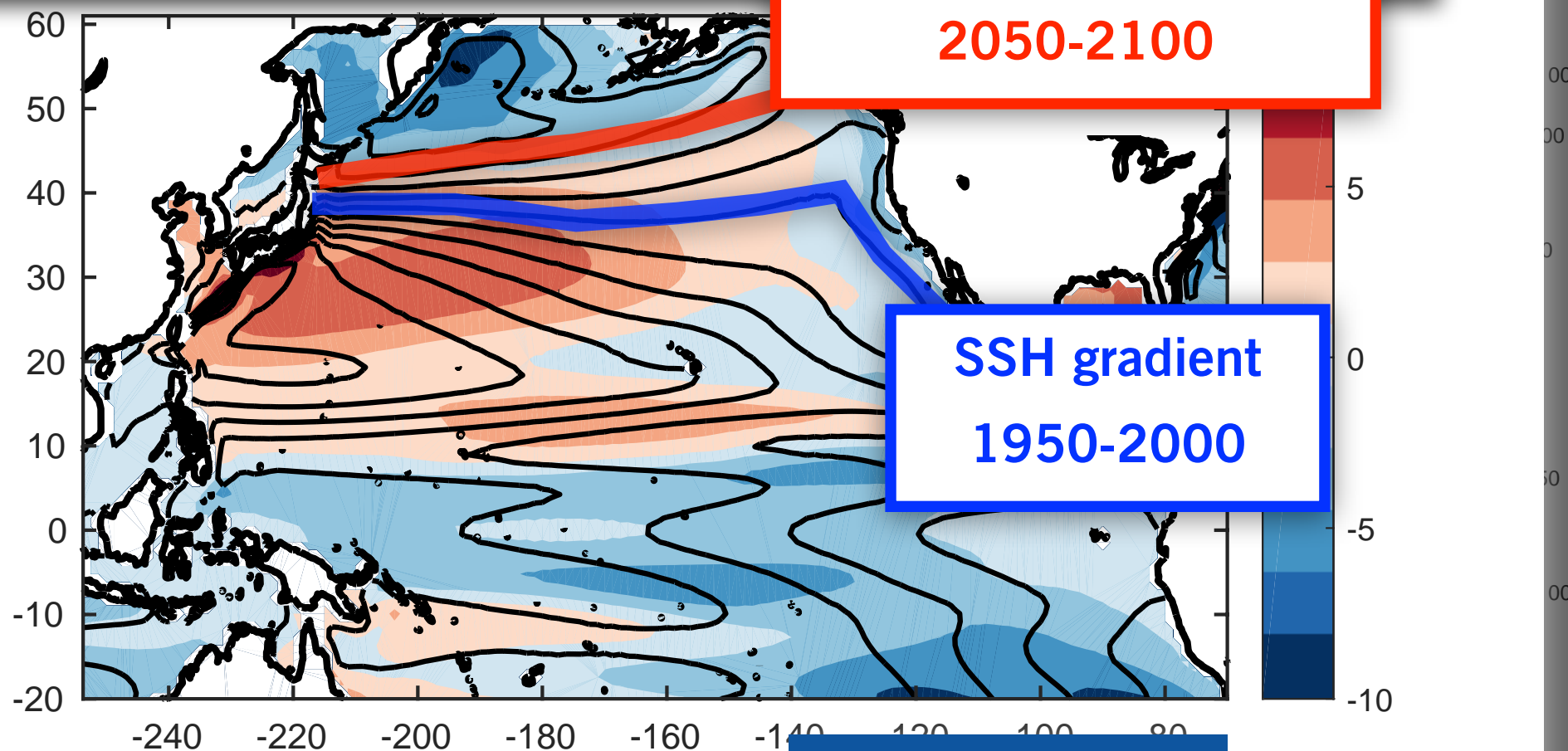


Community Earth System Model
CESM Large-Ensemble (n=30)
1920-2100 RCP8.5



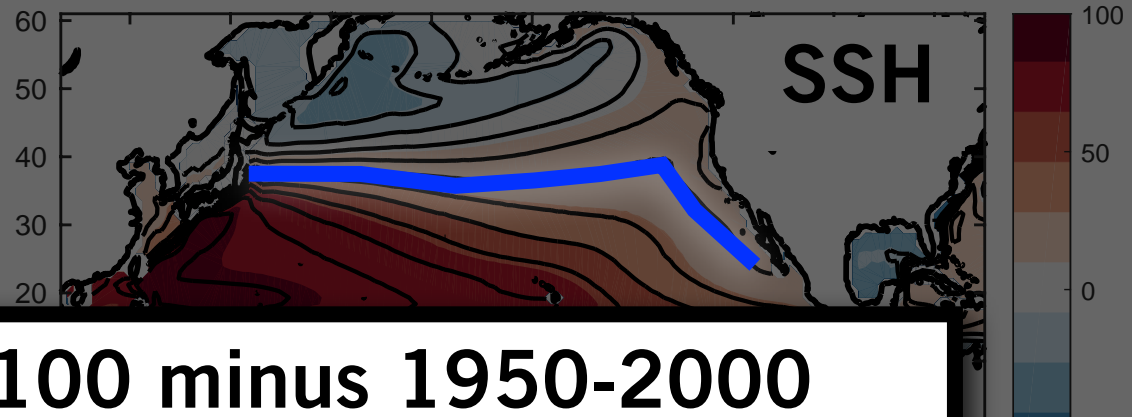
difference 2050-2100

NPTZ
Shift + Intensification
2050-2100

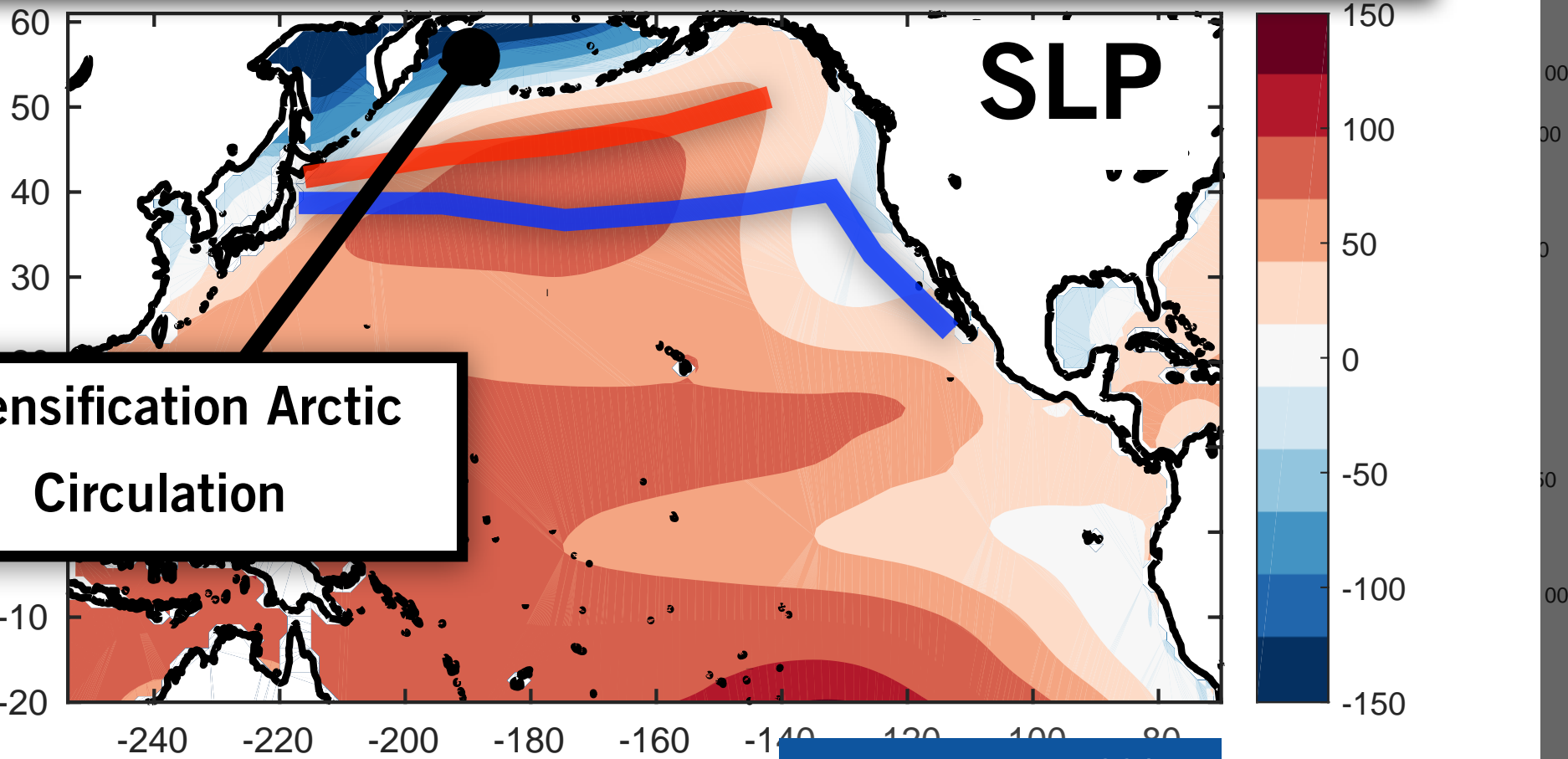


Hu et al. Nature, 2015;
Hu et al. JGR, 2017

Community Earth System Model
CESM Large-Ensemble (n=30)
1920-2100 RCP8.5



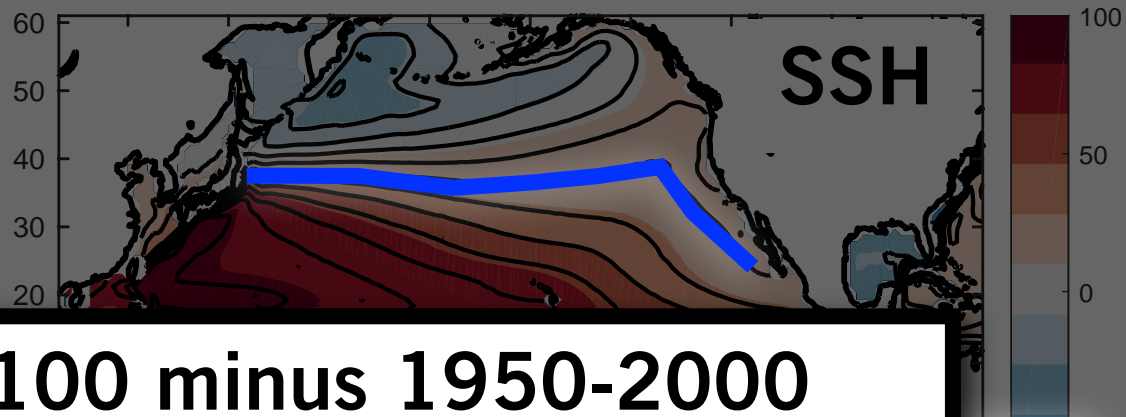
difference 2050-2100 minus 1950-2000



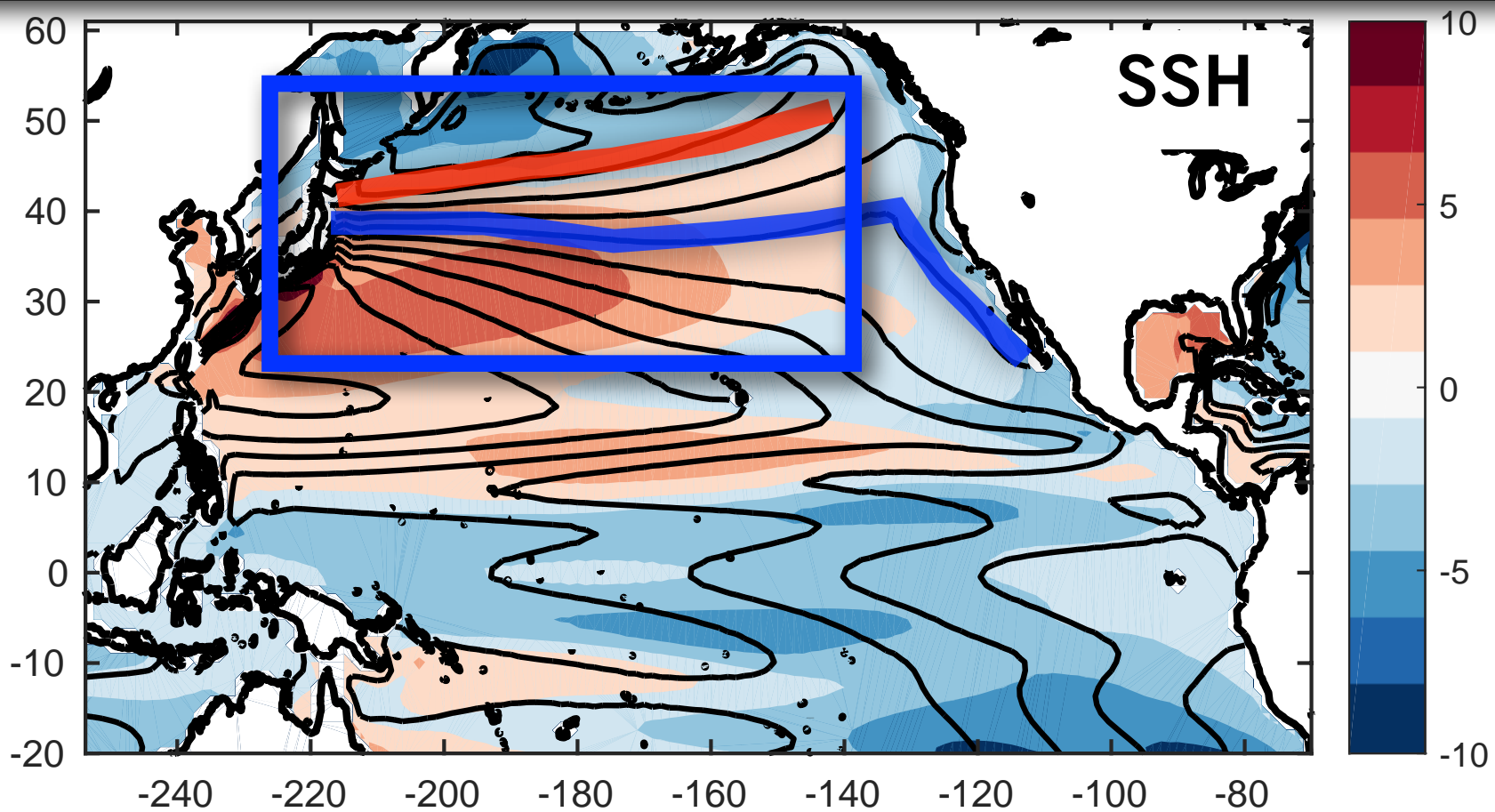
**Intensification Arctic
Circulation**

Hu et al. Nature, 2015;
Hu et al. JGR, 2017

Community Earth System Model
CESM Large-Ensemble (n=30)
1920-2100 RCP8.5



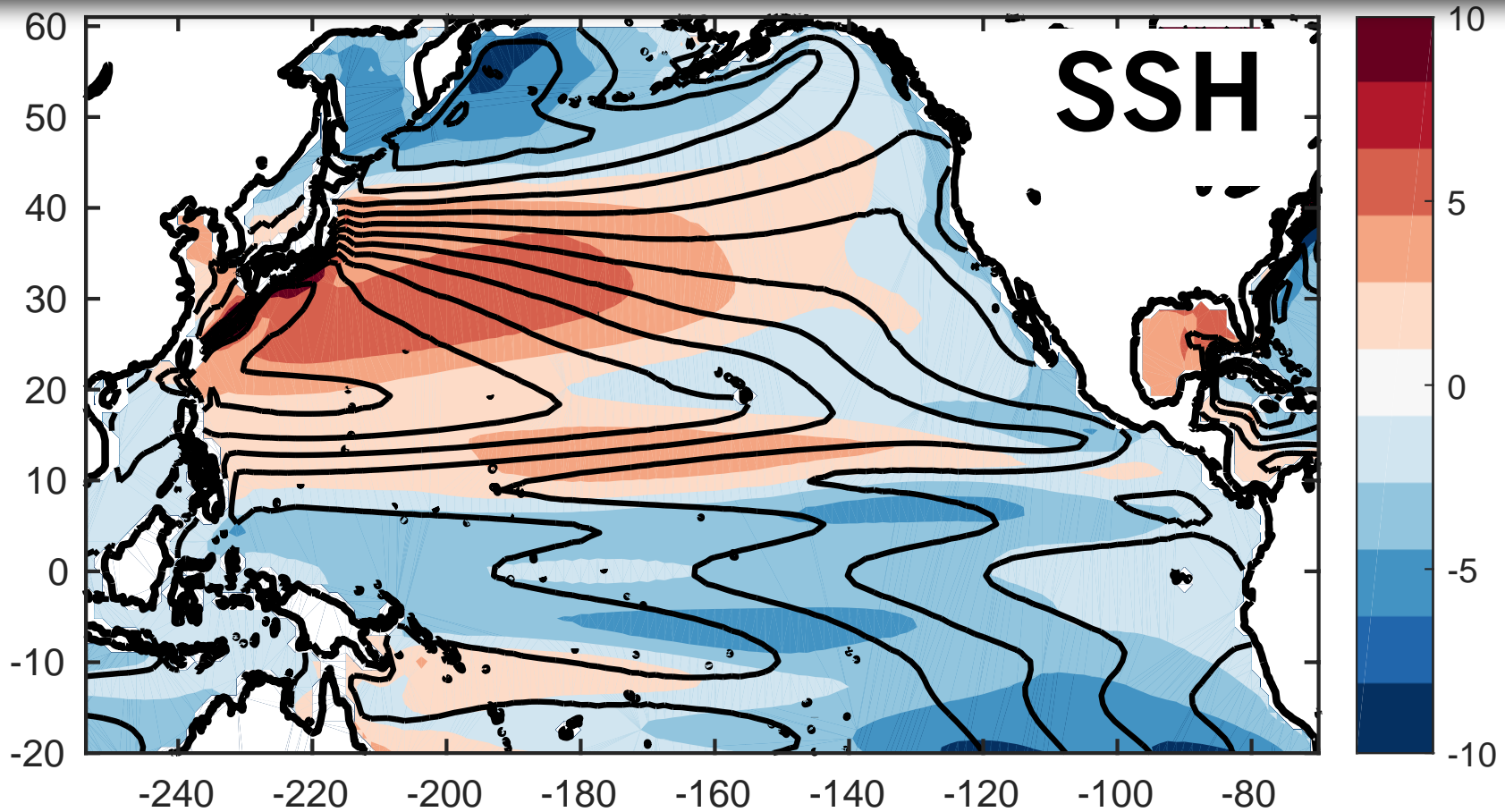
difference 2050-2100 minus 1950-2000



QUESTIONS

How about changes in **LARGE-SCALE** variance in KOE?

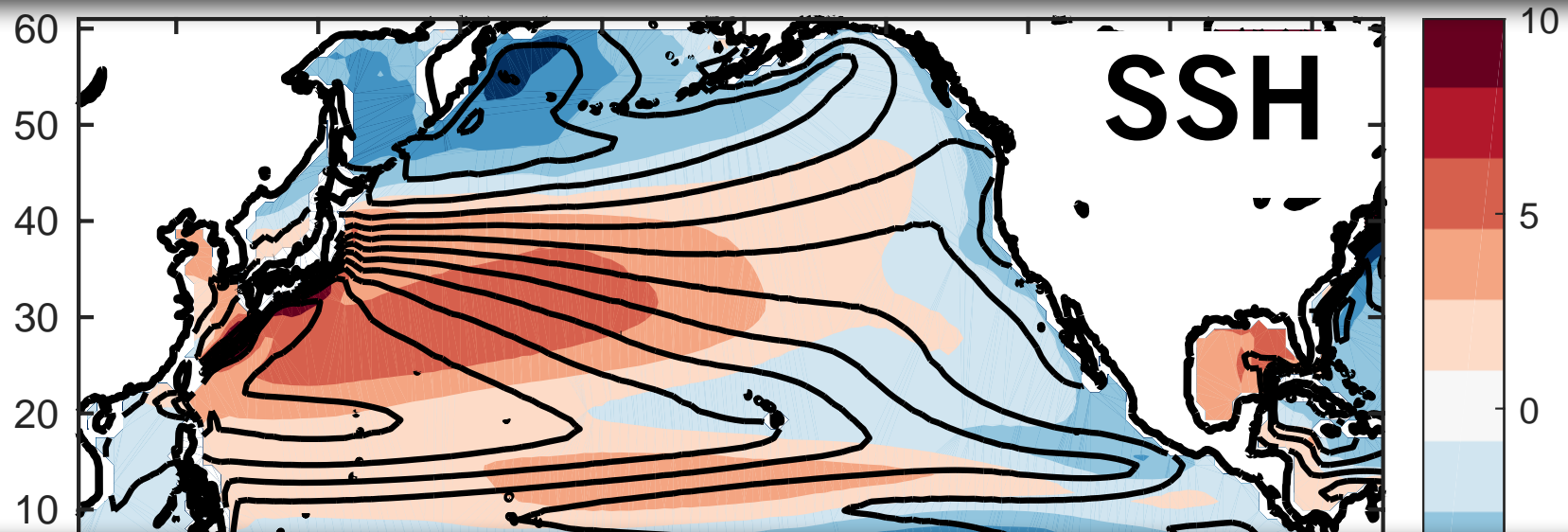
difference 2050-2100 minus 1950-2000



QUESTIONS

How about changes in **LARGE-SCALE** variance in KOE?

difference 2050-2100 minus 1950-2000



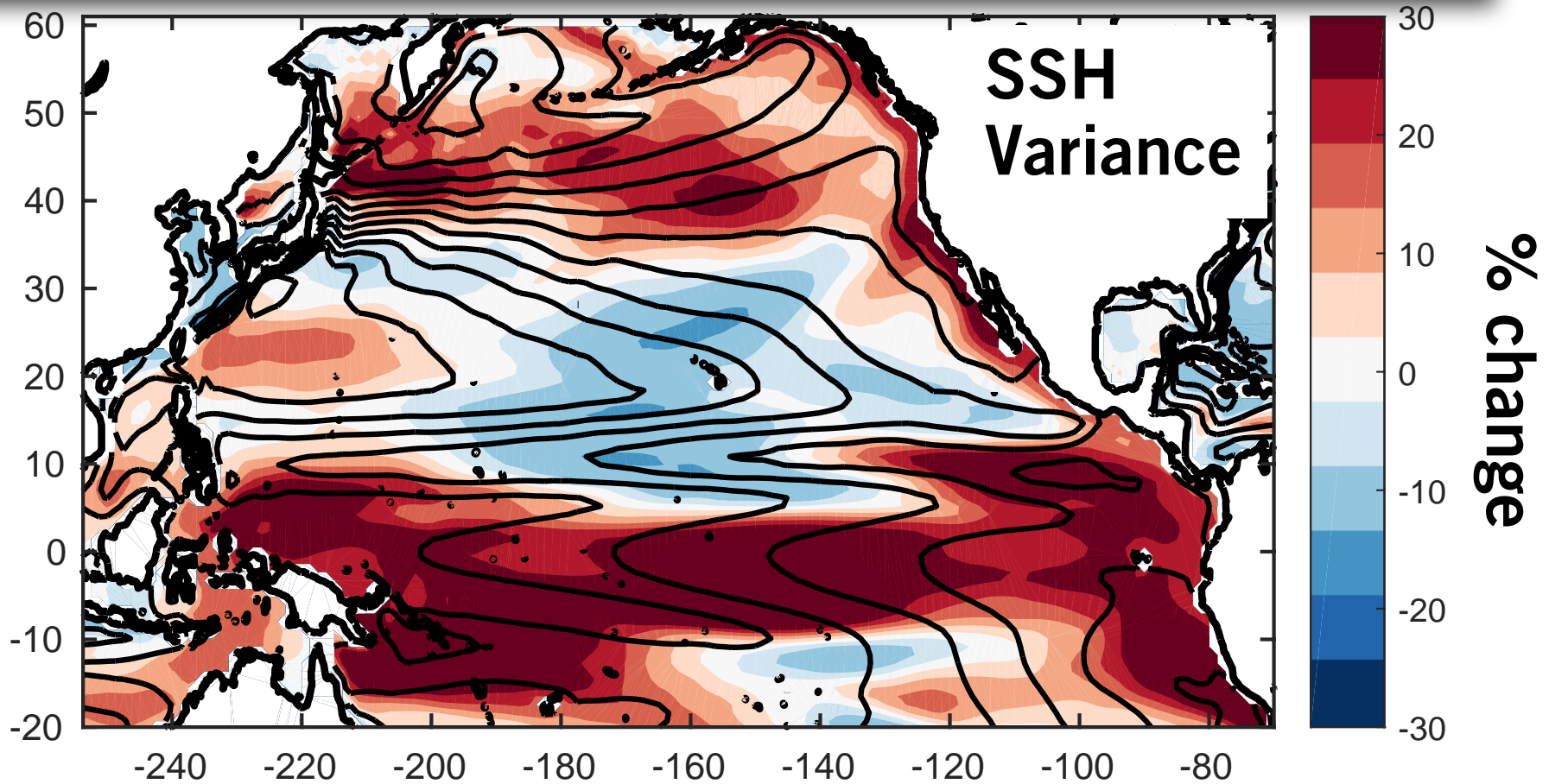
NOTE

We remove the anthropogenic signal first by removing the ensemble mean trajectory at each point.

QUESTIONS

How about changes in **LARGE-SCALE** variance in KOE?

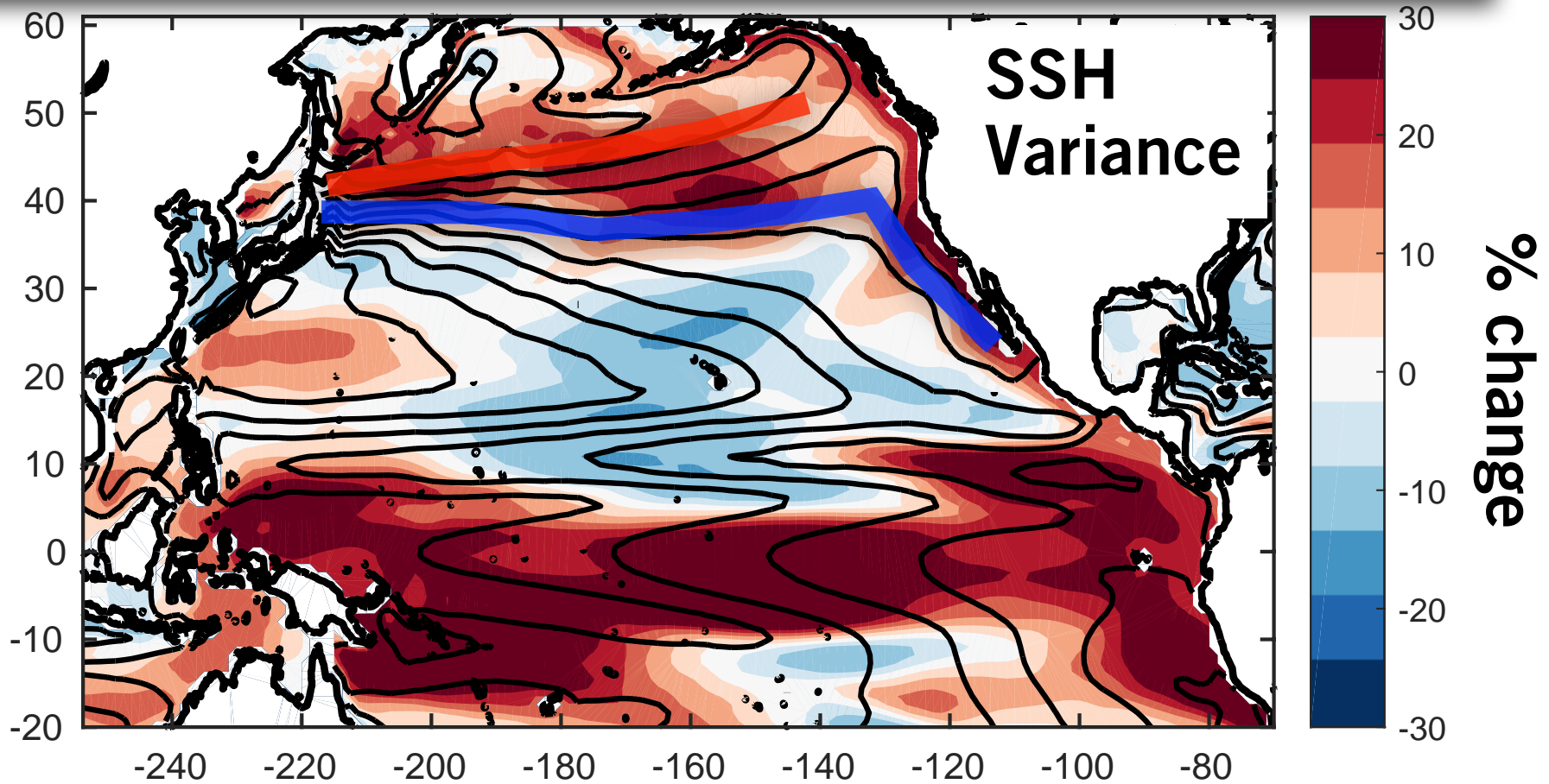
difference 2050-2100 minus 1950-2000



QUESTIONS

How about changes in **LARGE-SCALE** variance in KOE?

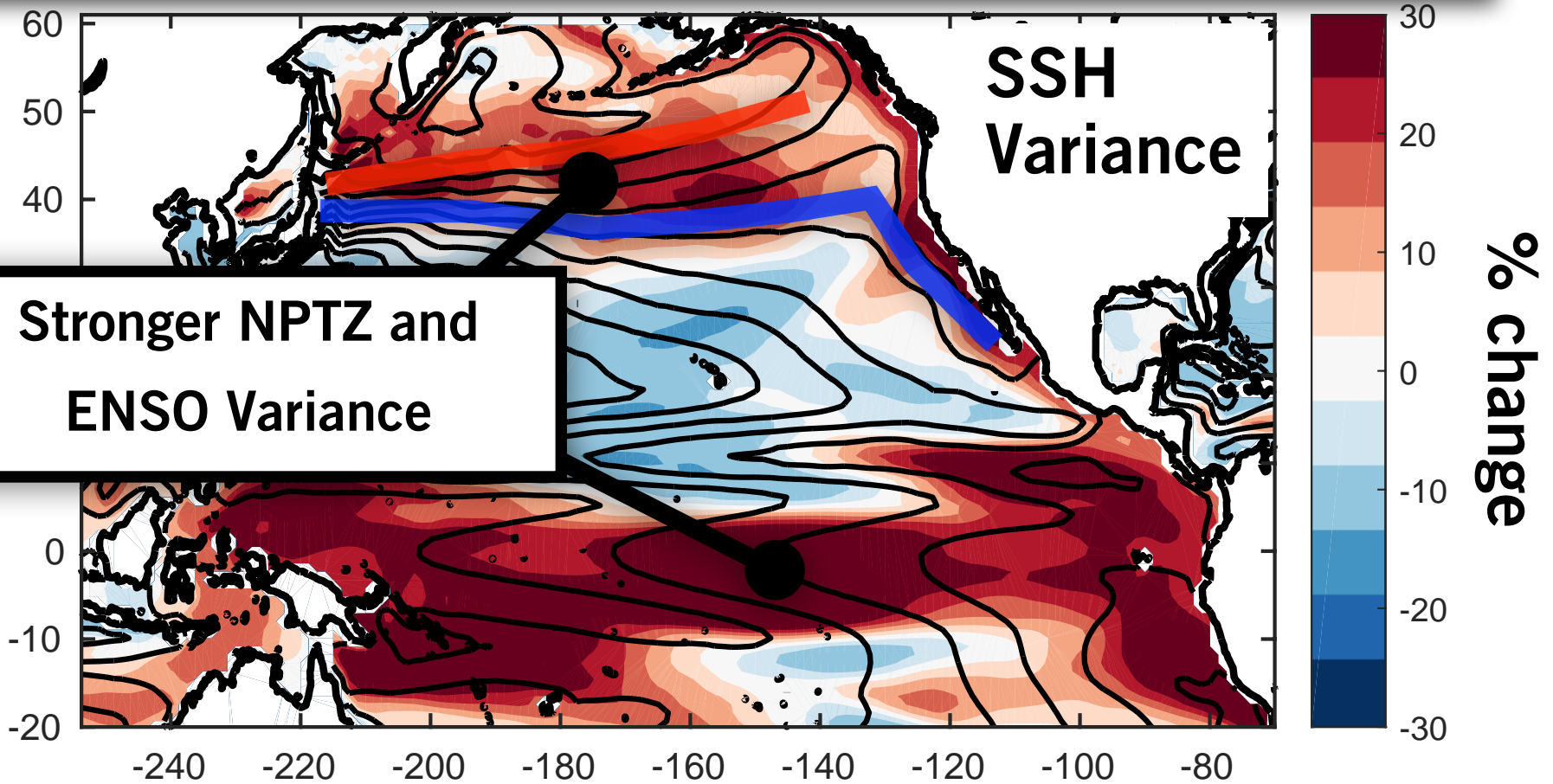
difference 2050-2100 minus 1950-2000



QUESTIONS

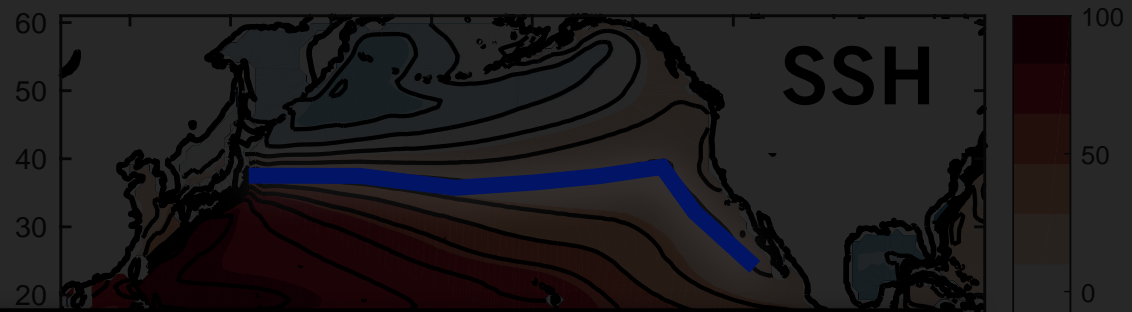
How about changes in **LARGE-SCALE** variance in KOE?

difference 2050-2100 minus 1950-2000

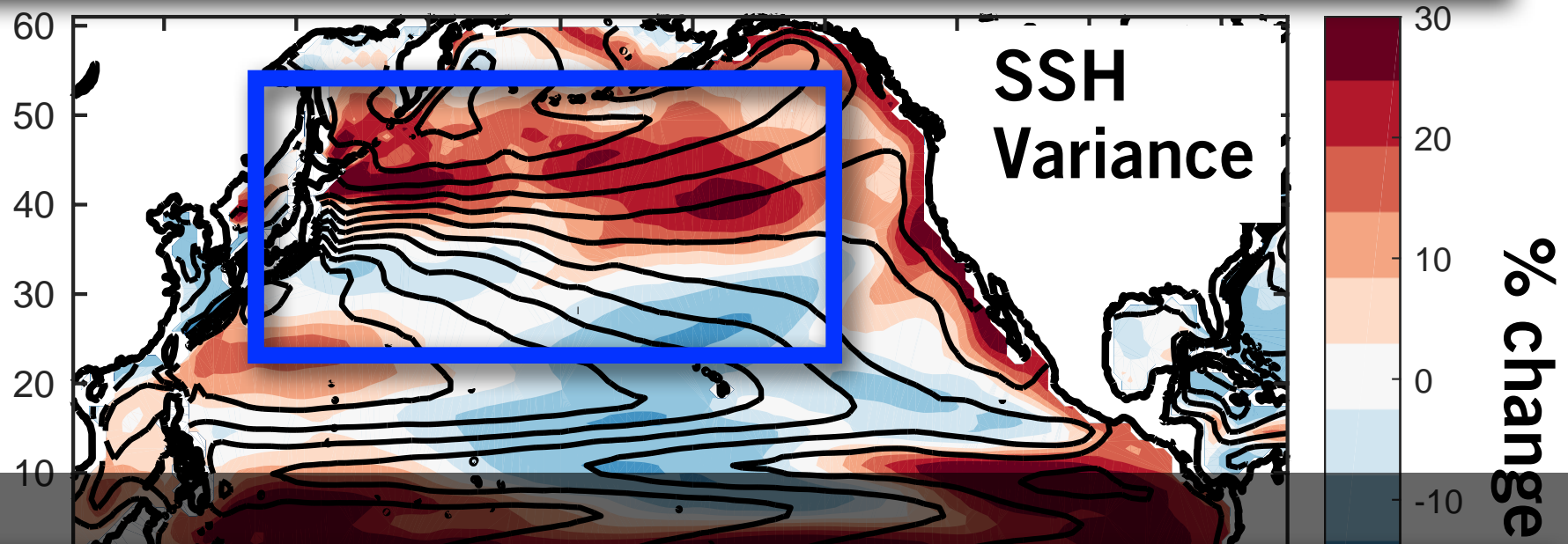


LARGE-SCALE (> 300KM)

1920-2100 RCP8.5



difference 2050-2100 minus 1950-2000



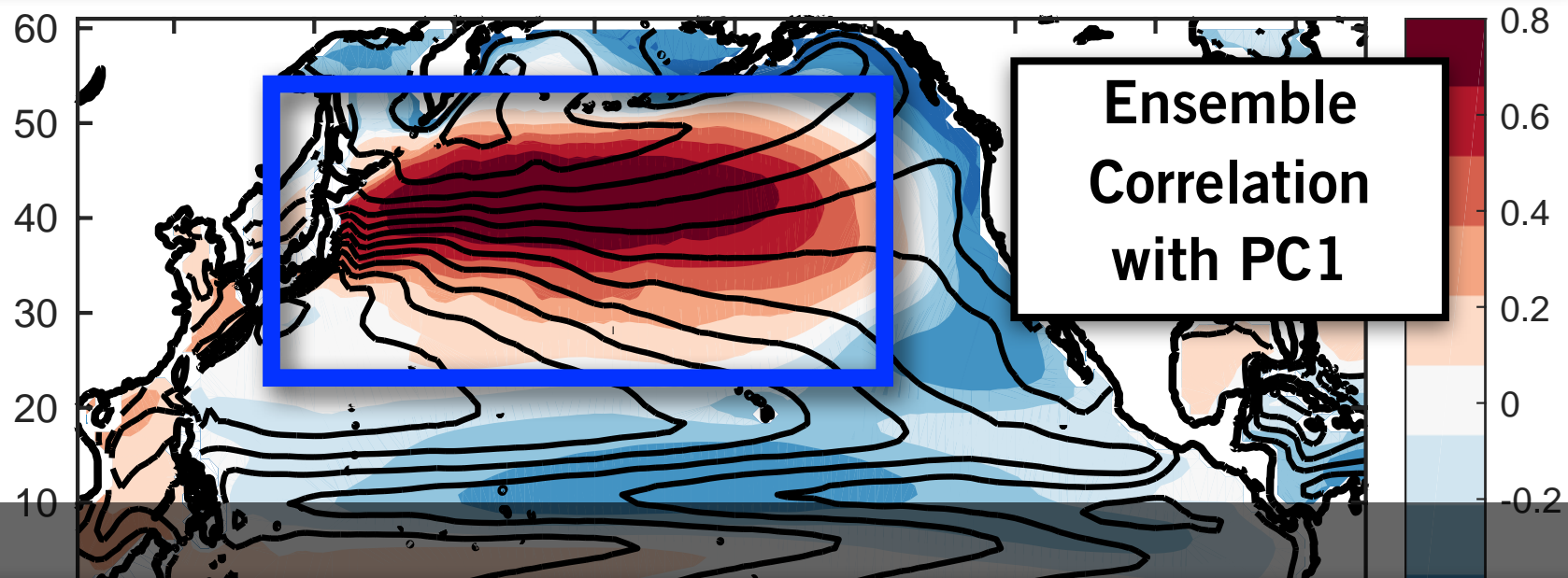
APPROACH

Decompose the KOE variance using EOFs/PCA analysis

LARGE-SCALE (> 300KM)

1920-2100 RCP8.5

EOF 1 52% of SSH variance ensemble mean



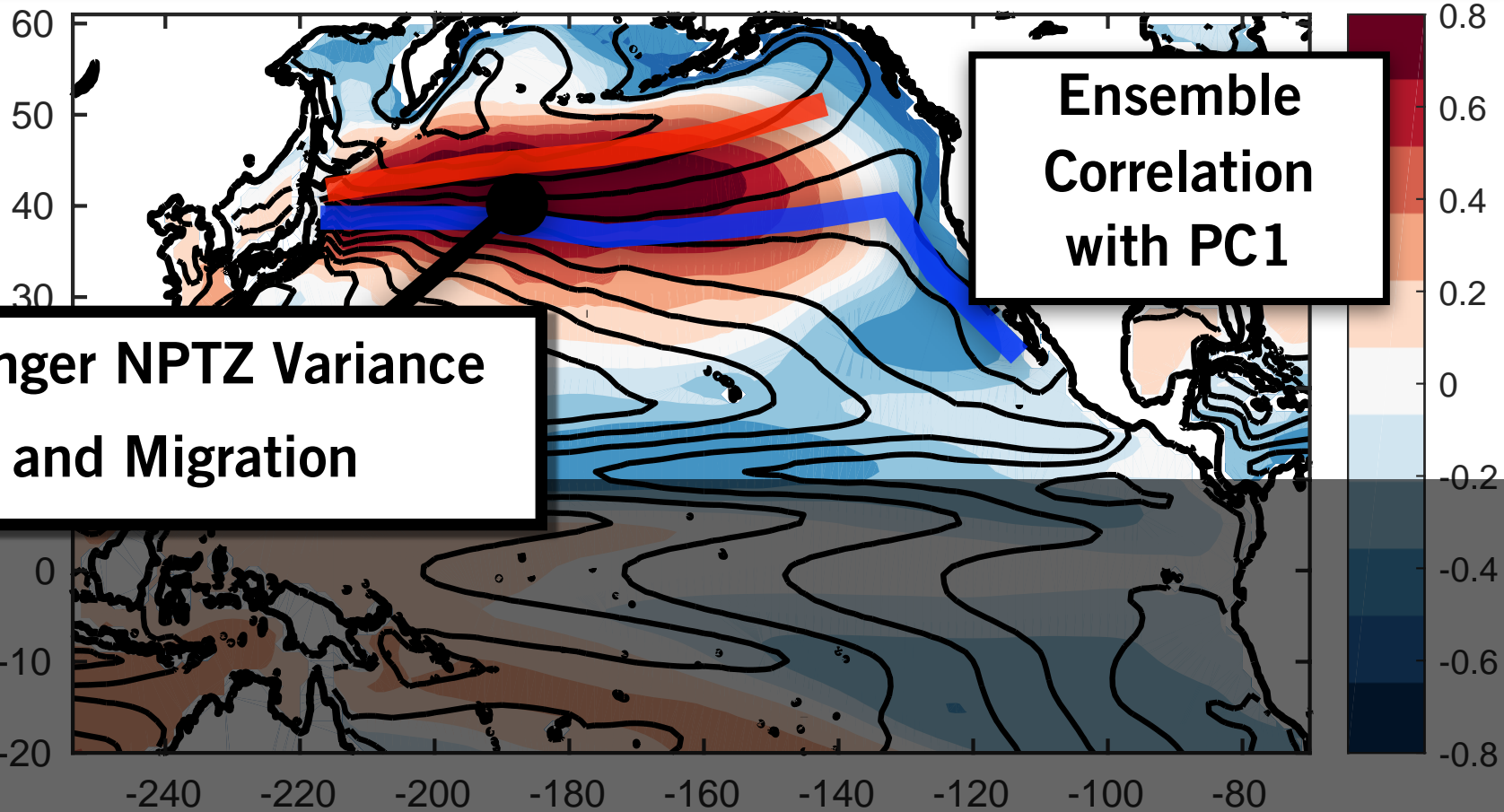
APPROACH

Decompose the KOE variance using EOFs/PCA analysis

LARGE-SCALE (> 300KM)

1920-2100 RCP8.5

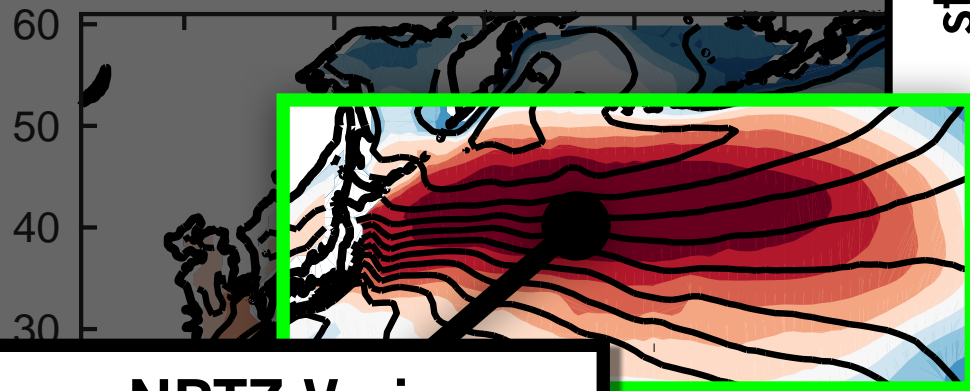
EOF 1 52% of SSH variance ensemble mean



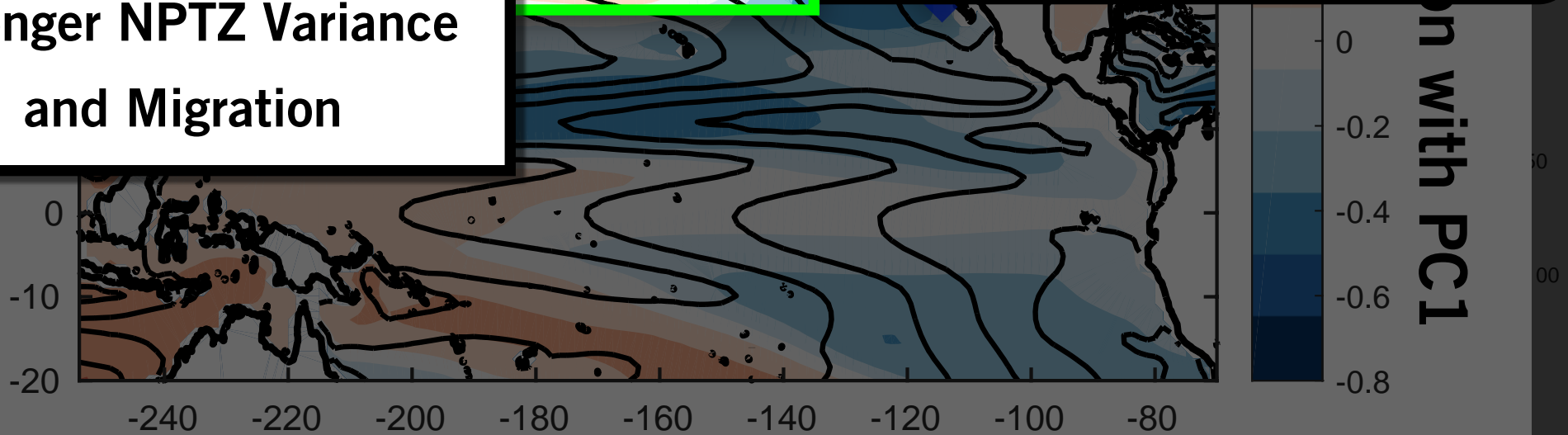
LARGE-SCALE (> 300KM)

1920-2100 RCP8.5

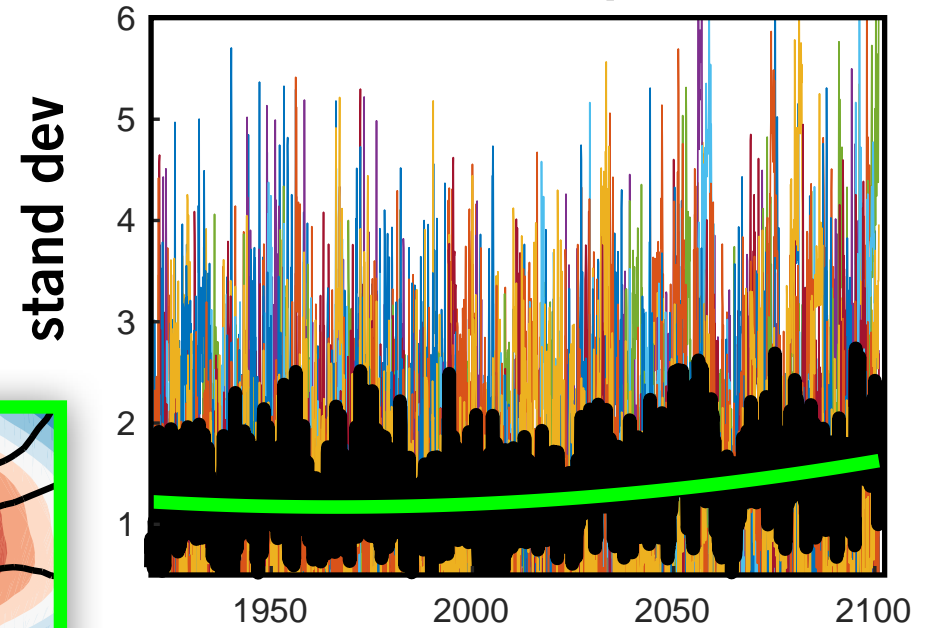
EOF 1 52% of SSH variability



**Stronger NPTZ Variance
and Migration**



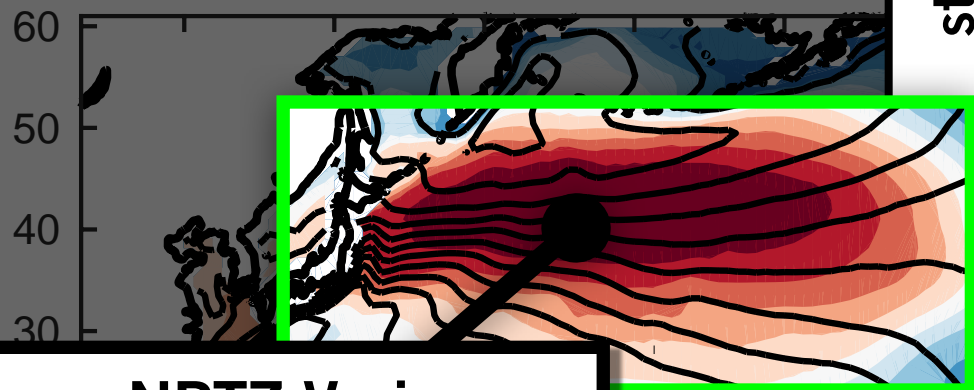
SSHa PC1 Variance (all members)



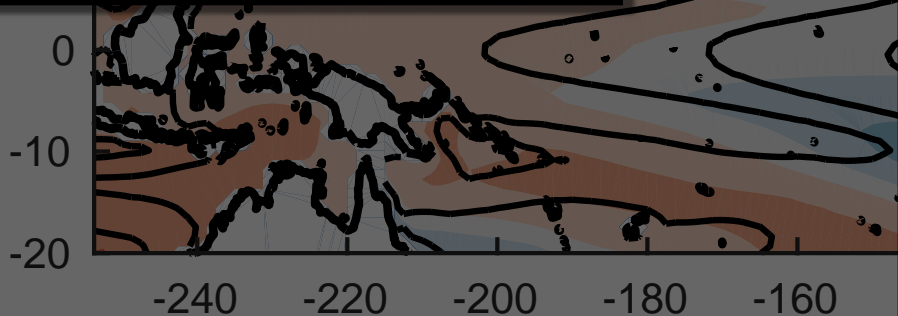
LARGE-SCALE (> 300KM)

1920-2100 RCP8.5

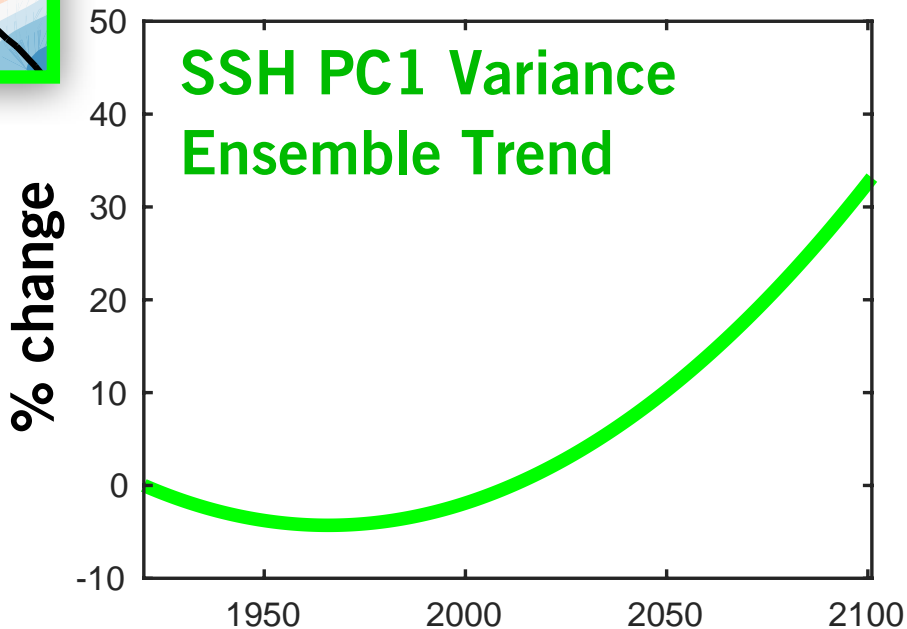
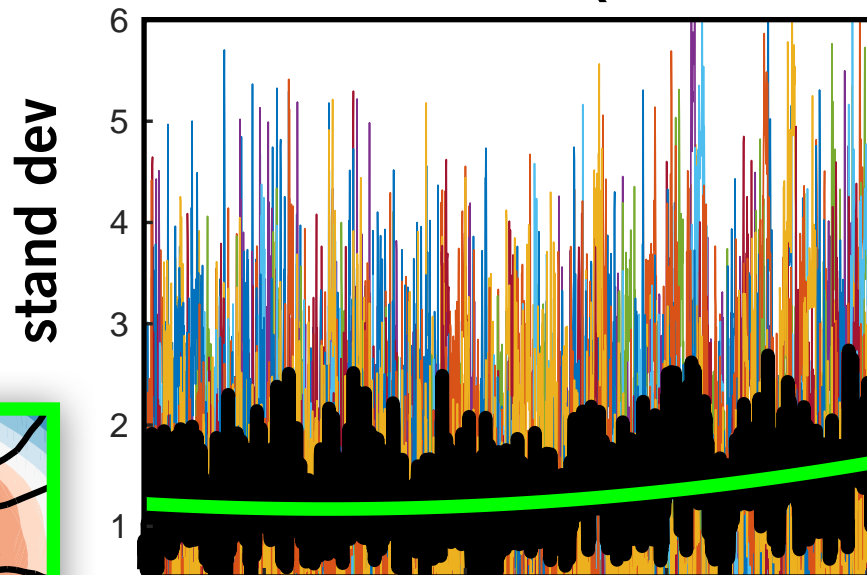
EOF 1 52% of SSH variability



Stronger NPTZ Variance and Migration



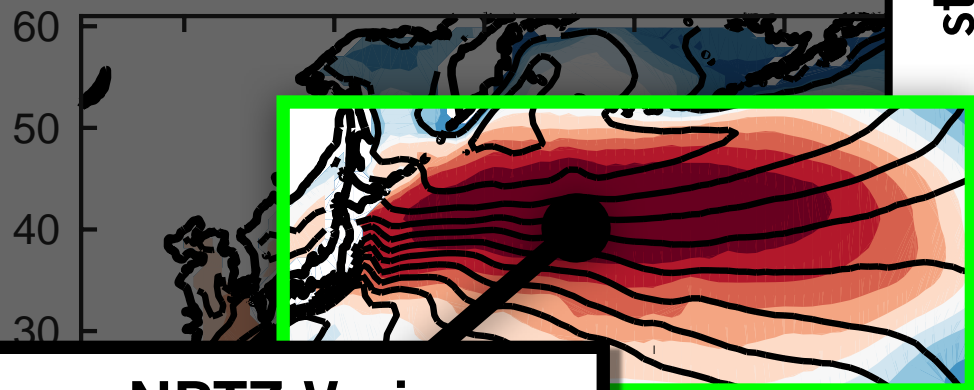
SSHa PC1 Variance (all members)



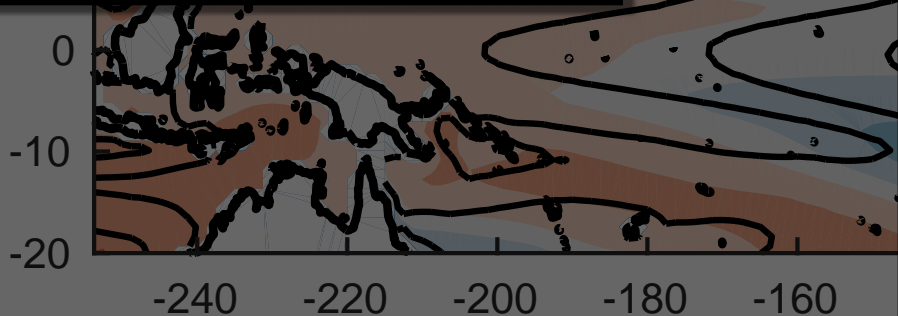
LARGE-SCALE (> 300KM)

1920-2100 RCP8.5

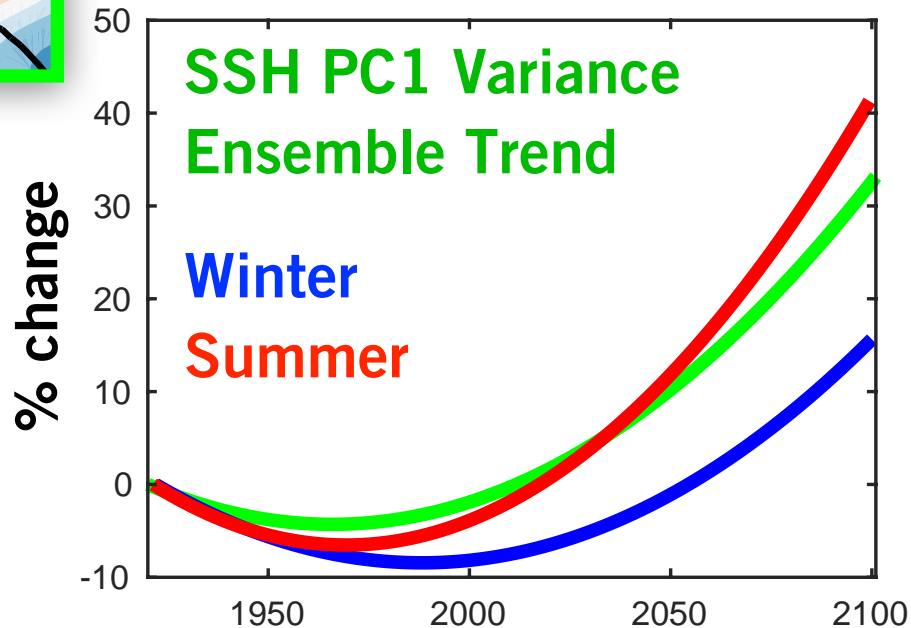
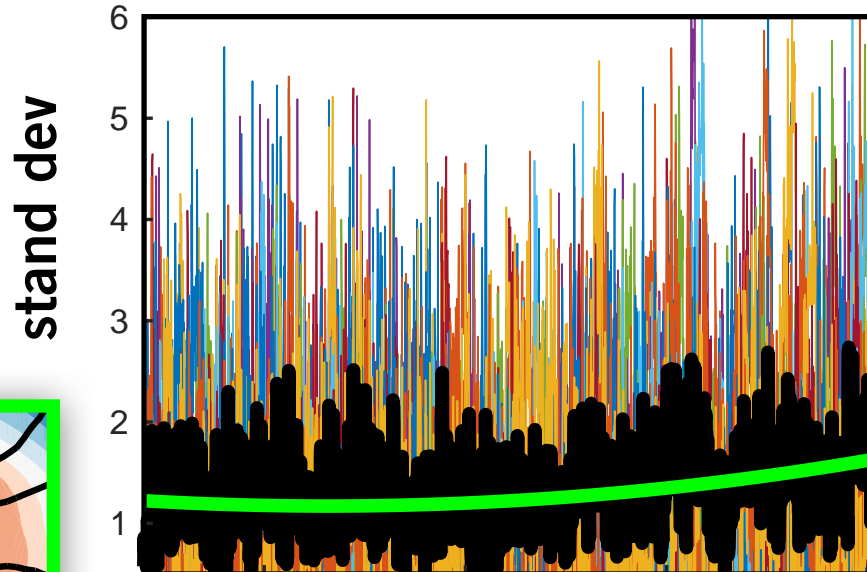
EOF 1 52% of SSH variability



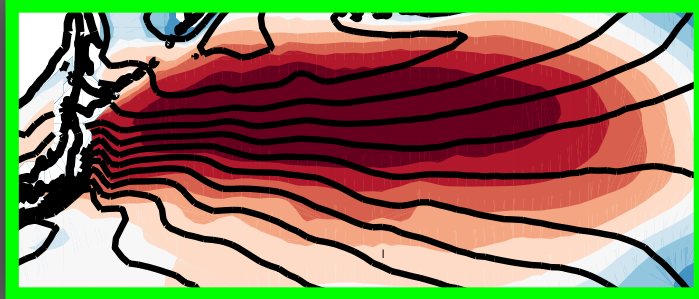
Stronger NPTZ Variance and Migration



SSHa PC1 Variance (all members)



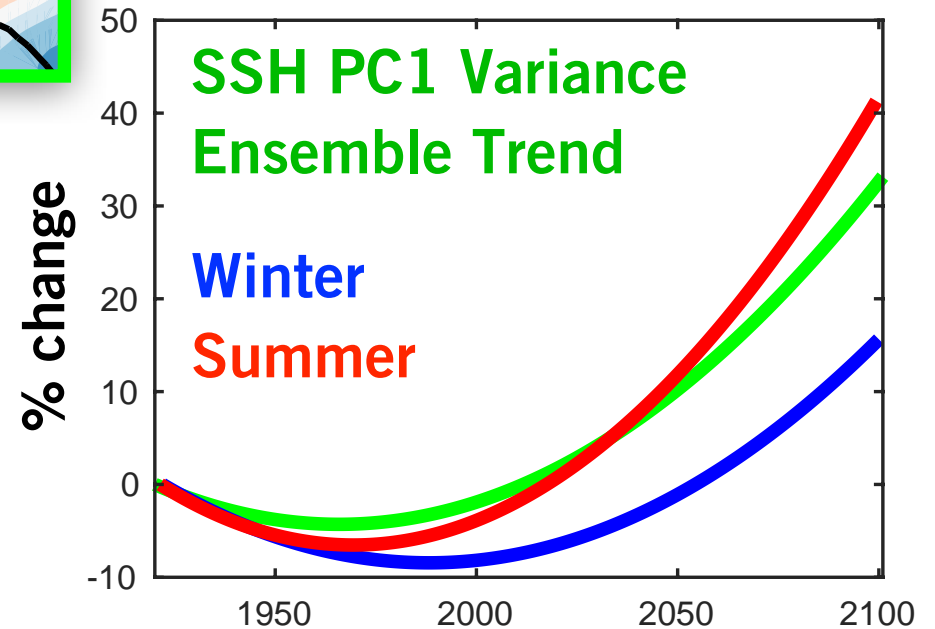
LARGE-SCALE (> 300KM)



Stronger NPTZ Variance
and Seasonal Migration
(e.g. **PDO-mode**)

CESM

**Climate Model Projections
PC 1 Changes in Variance**



LARGE-SCALE (> 300KM)

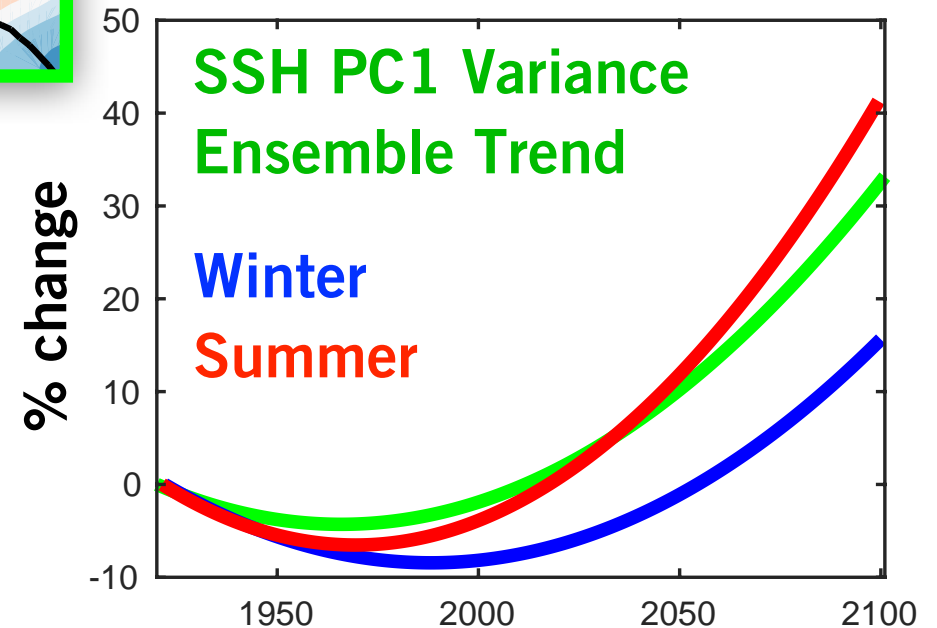
KOE EOF1
Satellite SSHa/CHLa

KOE

North America

CESM

Climate Model Projections
PC 1 Changes in Variance



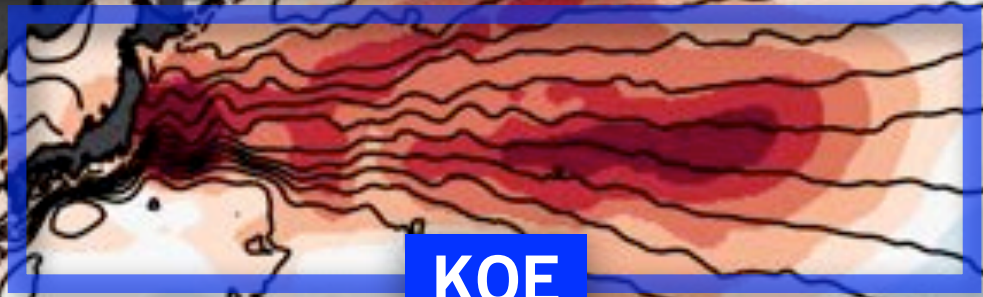
Stronger NPTZ Variance
and Seasonal Migration
(e.g. **PDO-mode**)

LARGE-SCALE (> 300KM)

KOE EOF1
Satellite SSHa/CHLa

ASIA

North America



KOE

Stronger NPTZ Variance ✓
and Seasonal Migration
(e.g. **PDO-mode**)

LARGE-SCALE (> 300KM)

KOE EOF1
Satellite SSHa/CHLa

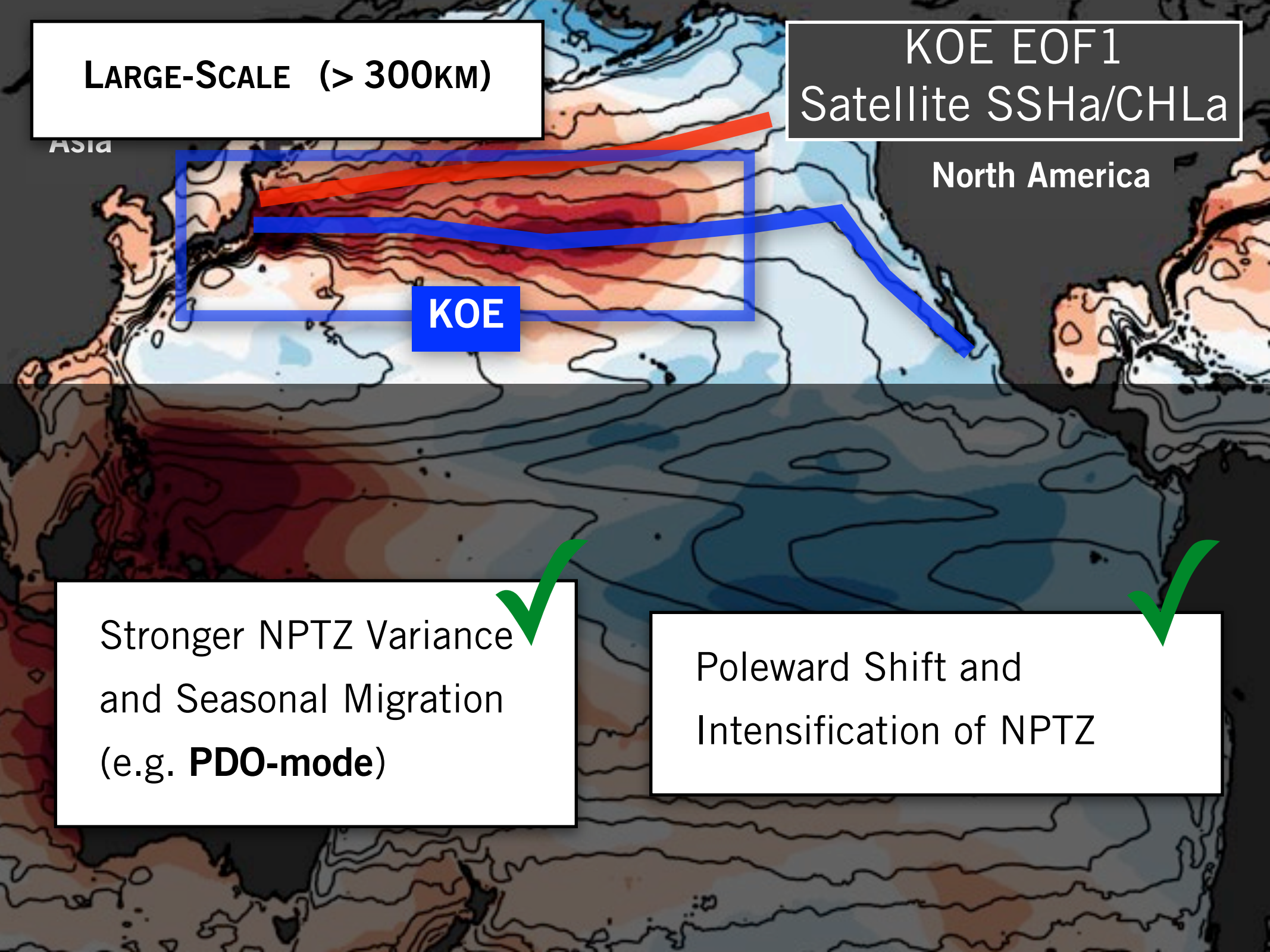
ASIA

North America

KOE

Stronger NPTZ Variance
and Seasonal Migration
(e.g. **PDO-mode**)

Poleward Shift and
Intensification of NPTZ



LARGE-SCALE (> 300KM)

Satellite Covariance
SSHa/CHLa

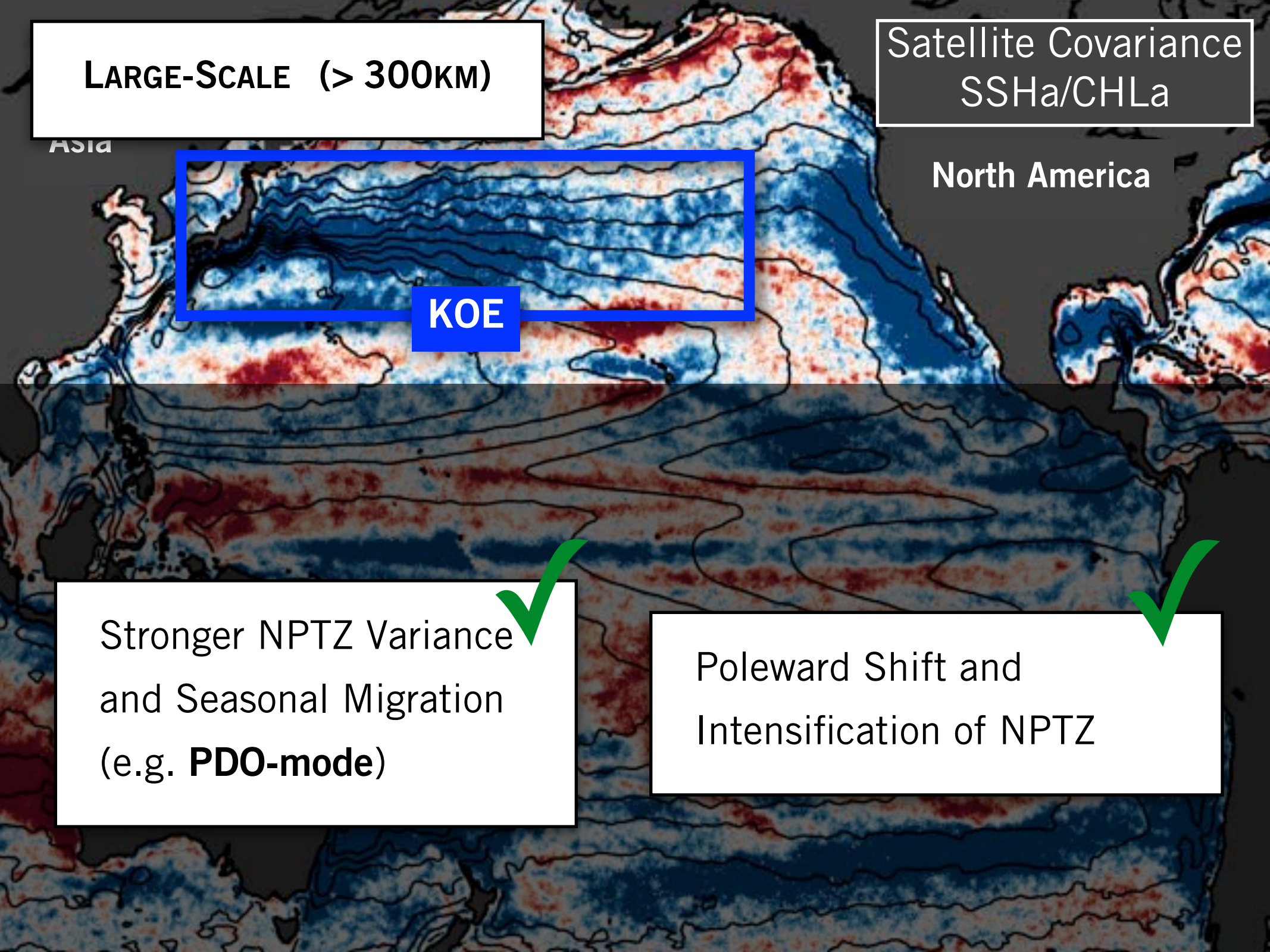
ASIA

North America

KOE

Stronger NPTZ Variance
and Seasonal Migration
(e.g. **PDO-mode**)

Poleward Shift and
Intensification of NPTZ



EDDY-SCALE (< 300KM)

Satellite Covariance
SSHa/CHLa

ASIA

North America

KOE

QUESTIONS

How does climate impact the **EDDY-SCALE** variance in the
KOE?

EDDY-SCALE (< 300KM)

Satellite Covariance
SSHa/CHLa

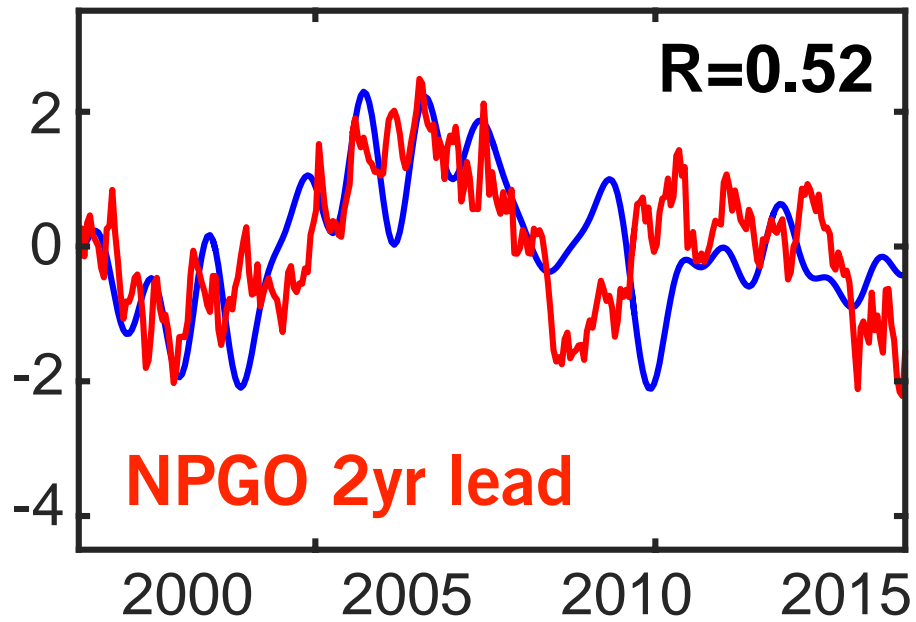
Asia

North America



KOE

Eddy Kinetic Energy KOE



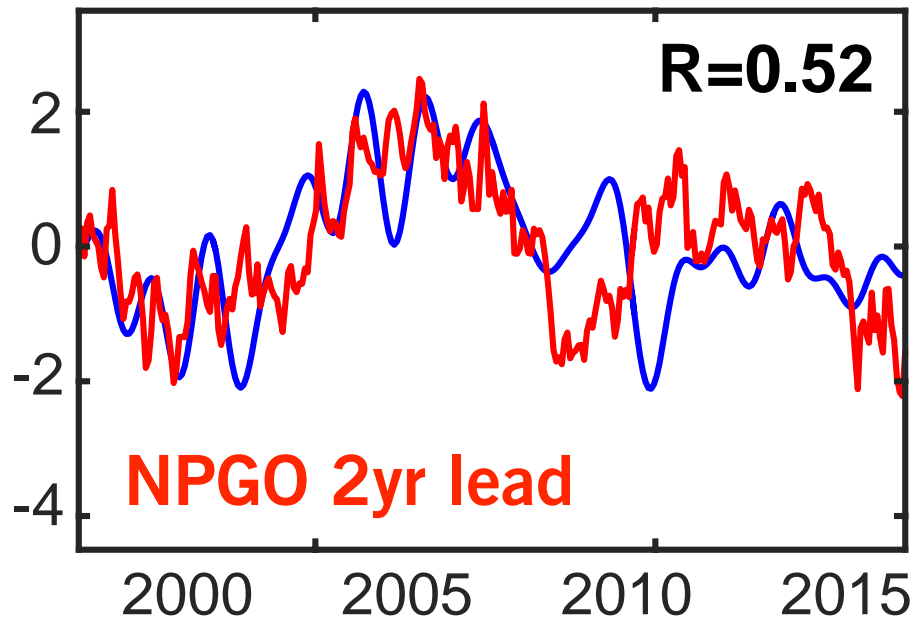
NPGO
response

KOE EOF2
Satellite SSHa/CHLa

North America

KOE

Eddy Kinetic Energy KOE

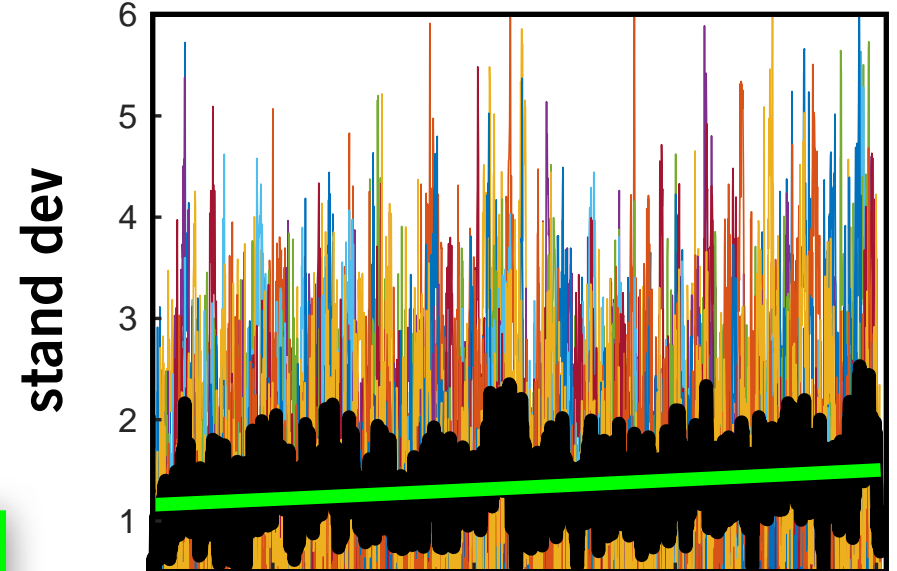


NPGO
response

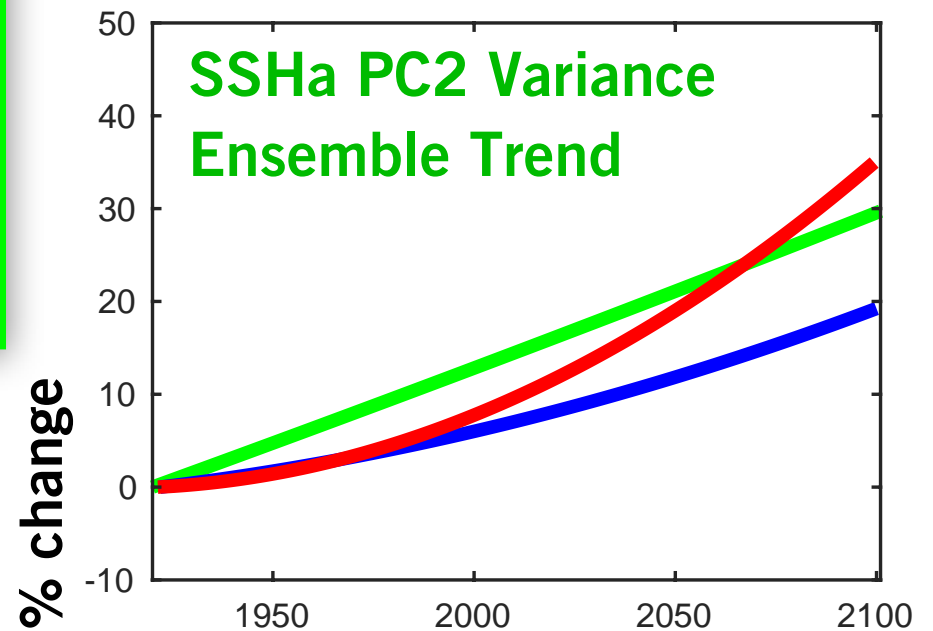
KOE

KOE EOF2
Satellite SSHa/CHI₂

SSHa PC2 Variance (all members)



SSHa PC2 Variance
Ensemble Trend



CESM

Climate Model Projections

NPGO
response

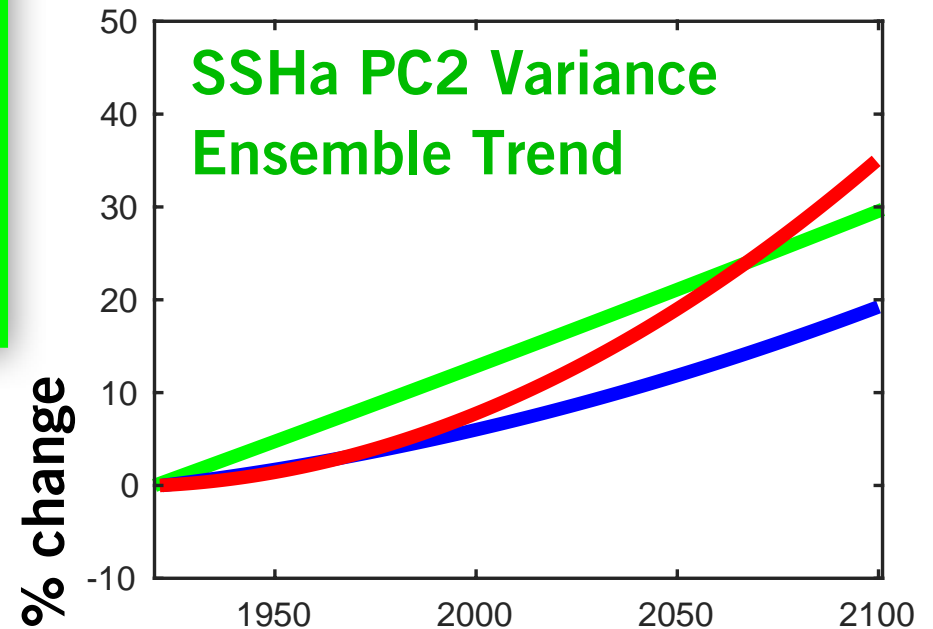
KOE EOF2
Satellite SSHa/CHLa

North America

KOE

CESM

Climate Model Projections



Significant changes in
the eddy-scale variance
(e.g. **NPGO-mode**)

Summary

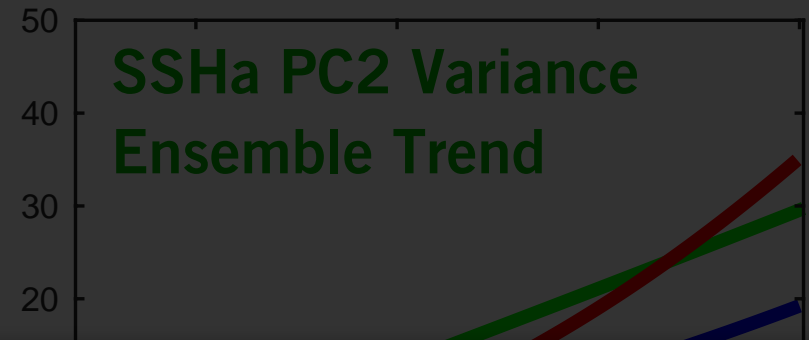
KOE EOF2
Satellite SSHa/CHLa

North America

KOE

CESM

Climate Model Projections



EDDY-SCALE (< 300km)

Significant changes in
the eddy-scale variance
(e.g. **NPGO-mode**)



Summary

Climate Change Impact on PTAs

KOE EOF2
Satellite SSHa/CHLa

Stronger NPTZ Variance
and Seasonal Migration
(e.g. **PDO-mode**) ✓

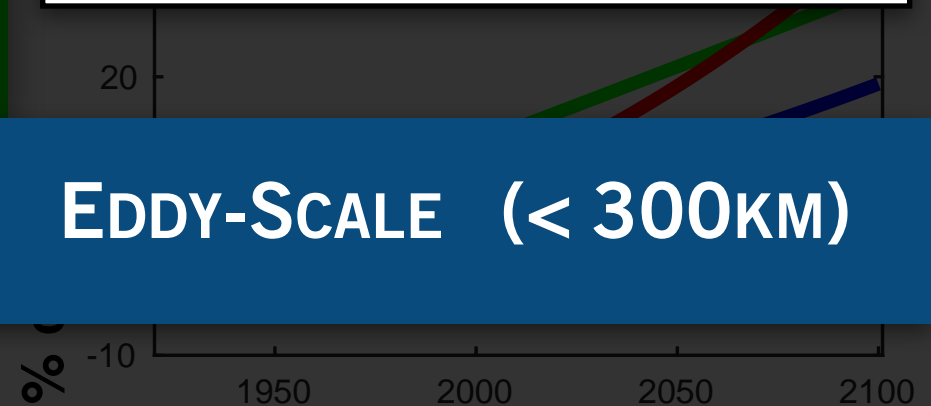
LARGE-SCALE (< 300KM)

CESM

Poleward Shift and
Intensification of NPTZ ✓

Significant changes in
the eddy-scale variance
(e.g. **NPGO-mode**) ✓

EDDY-SCALE (< 300KM)



WINTER (JFM)

SS

Summary Climate Change Impact on PTAs

Significant intensification
and poleward shift in the
mean KOE



LARGE-SCALE (< 300KM)

Significant changes in the
variance of seasonal



QUESTION:

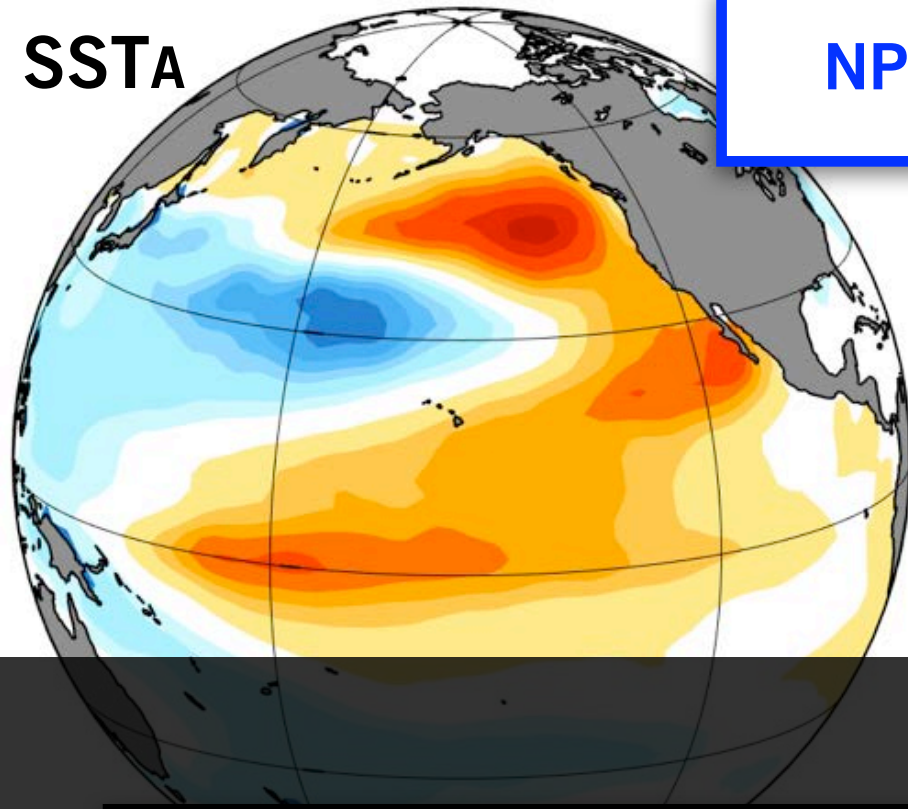
Why are the mode PDO and NPGO modes getting stronger in CESM under anthropogenic forcing?

(e.g. NPGO-mode)



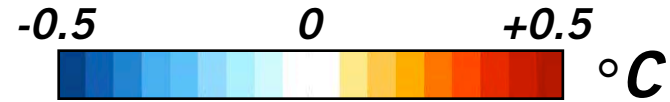
WINTER (JFM)

SSTA



NPGO

SST ANOMALY

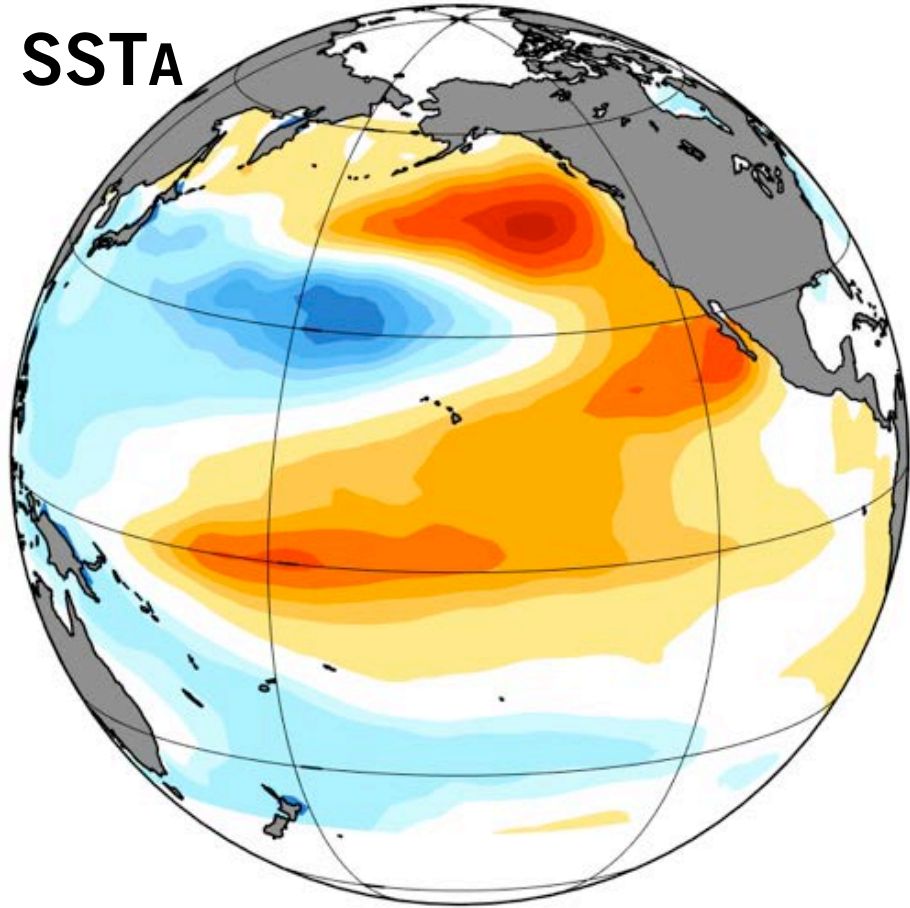


QUESTION:

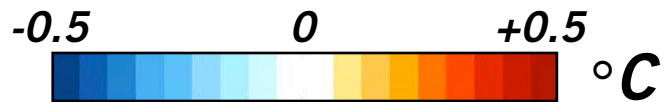
Why are the mode PDO and NPGO modes getting stronger in CESM under anthropogenic forcing?

WINTER (JFM)

SSTA

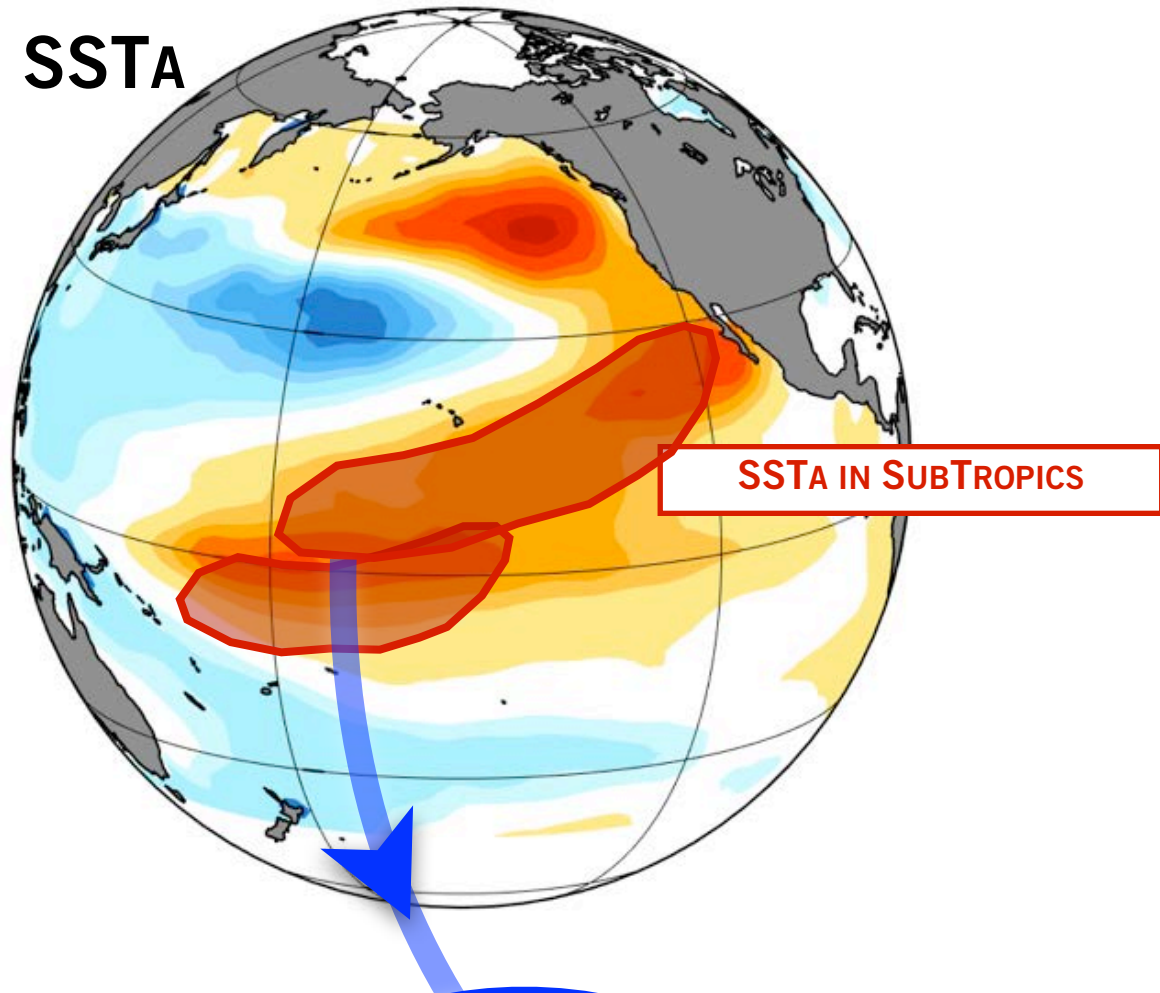


SSTA ANOMALY



WINTER (JFM)

SSTA



SSTA IN SUBTROPICS

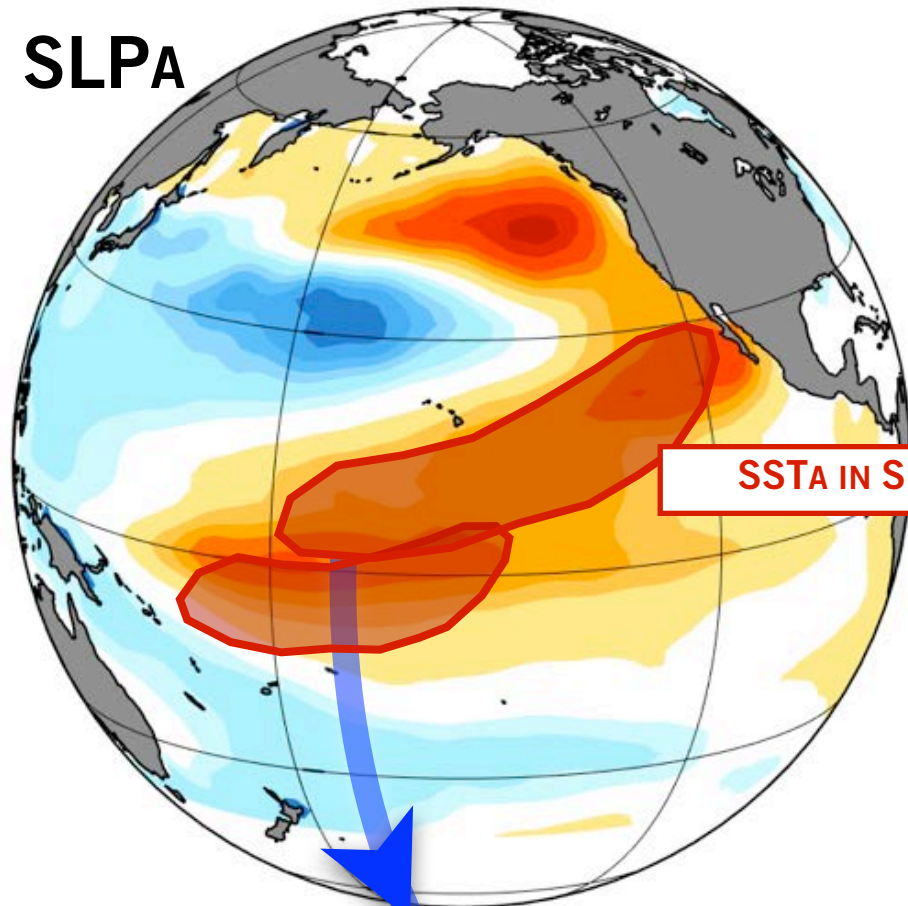
ENSO
Precursors
Dynamics

SPRING (AMJ)

*Vimont et al., 2001, Anderson, 2003,
Alexander et al., 2011; Anderson et al. 2013*

WINTER (JFM)

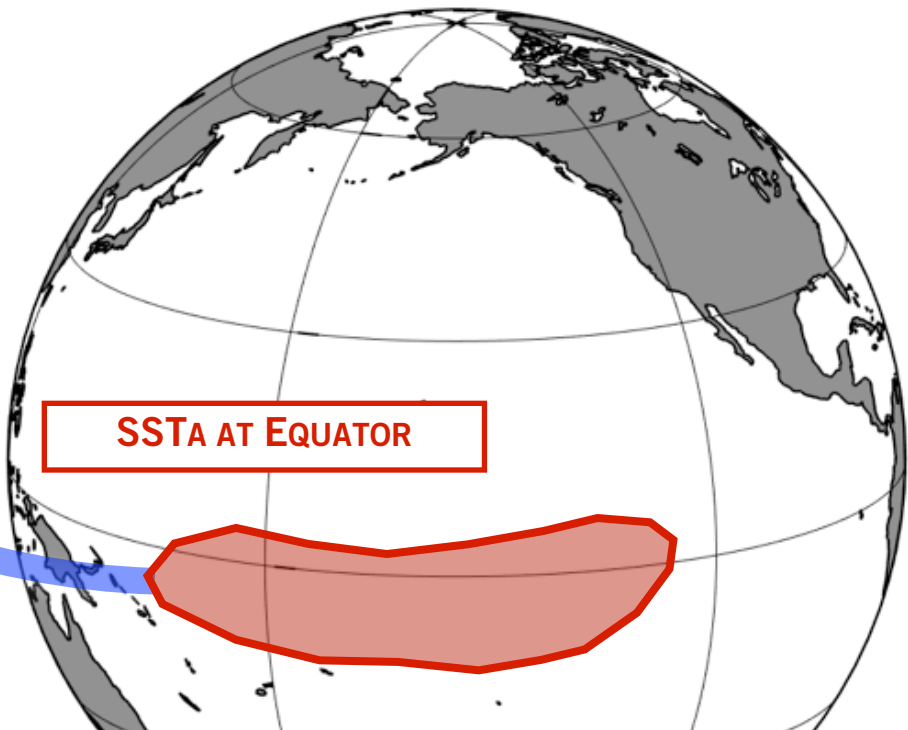
SLPA



SSTA IN SUBTROPICS

**ENSO
Precursors
Dynamics**

SPRING (AMJ)

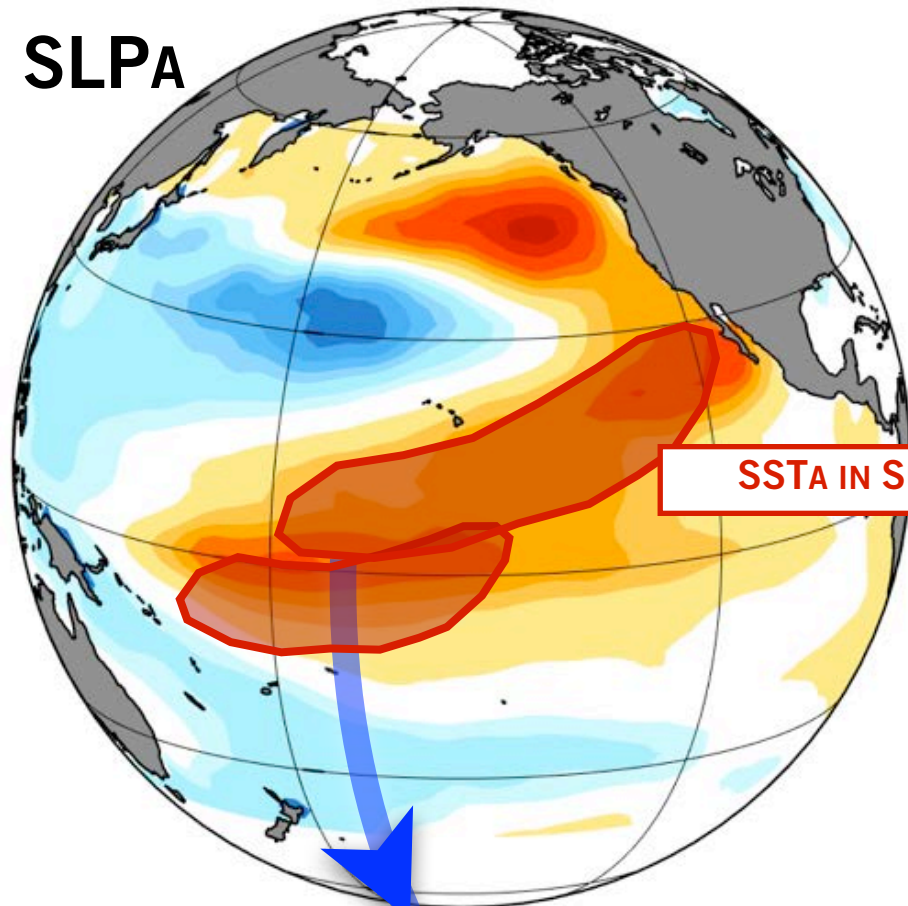


SSTA AT EQUATOR

*Vimont et al., 2001, Anderson, 2003,
Alexander et al., 2011; Anderson et al. 2013*

WINTER (JFM)

SLPA



SSTA IN SUBTROPICS

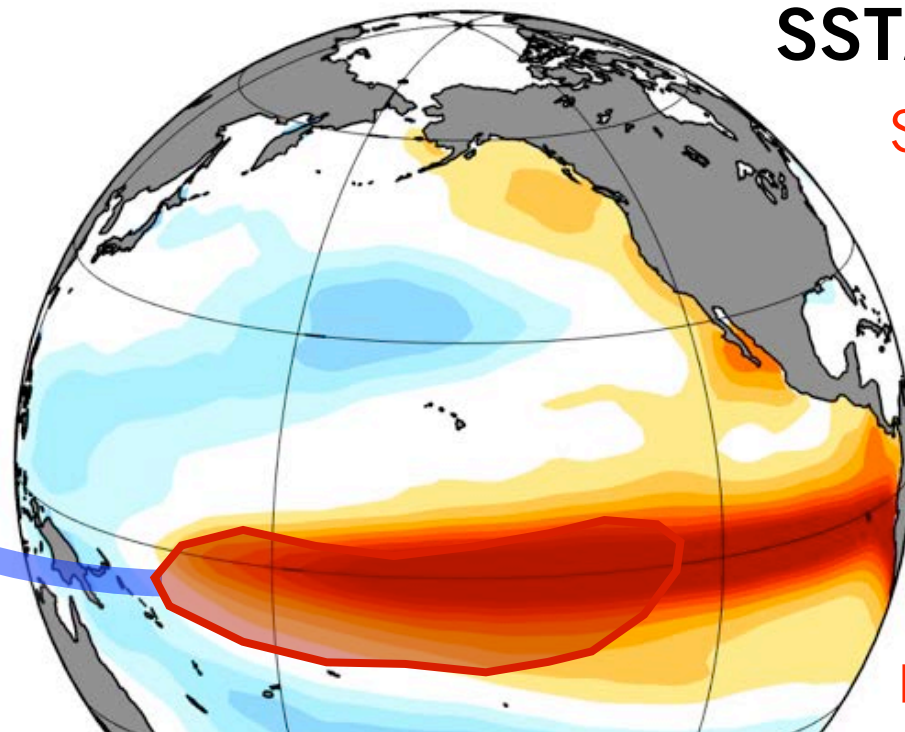
ENSO
Precursors
Dynamics

SPRING (AMJ)

*Vimont et al., 2001, Anderson, 2003,
Alexander et al., 2011; Anderson et al. 2013*

EL NIÑO
SSTA

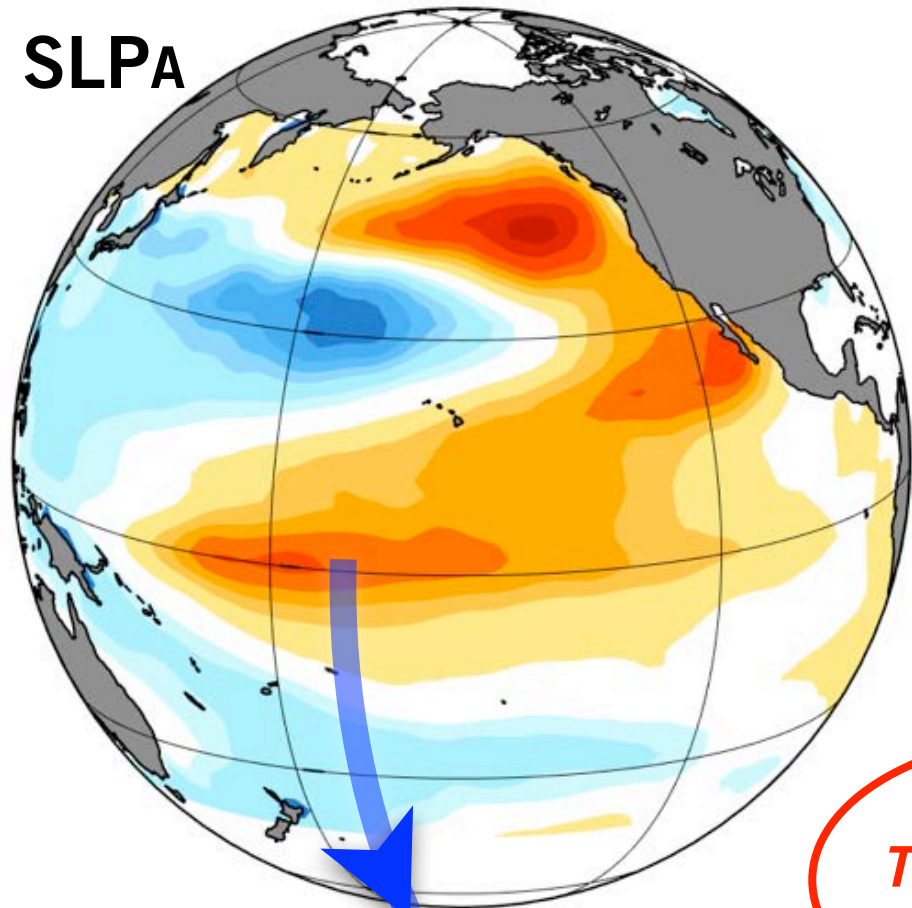
SUMMER
& FALL



SSTA
RANGE
[-1C +1C]

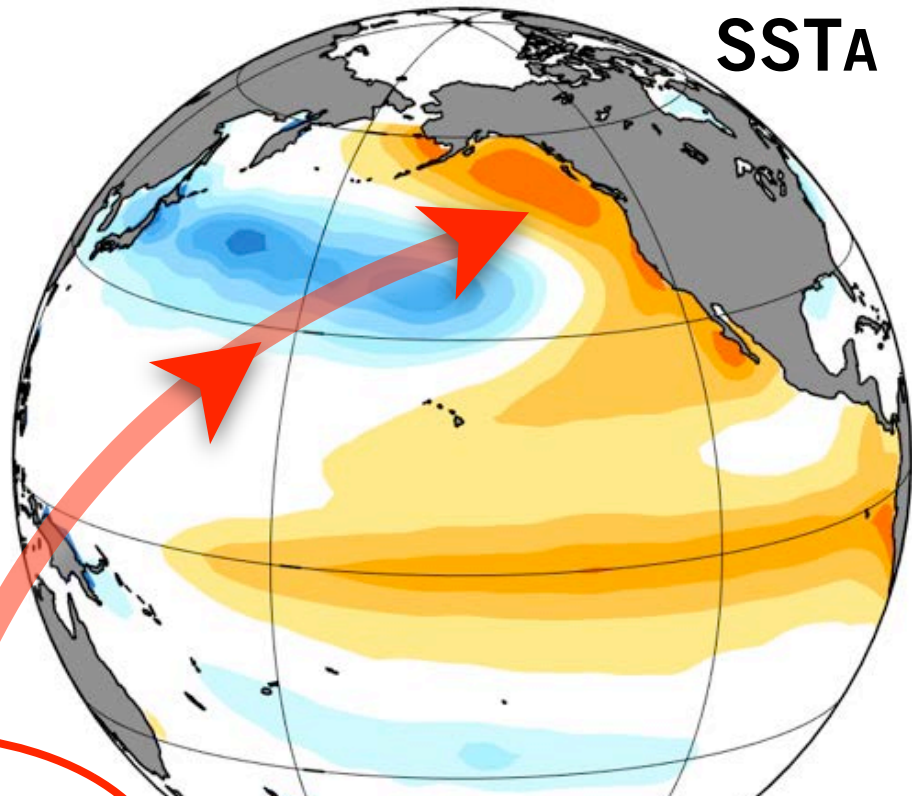
WINTER (JFM)

SLPA



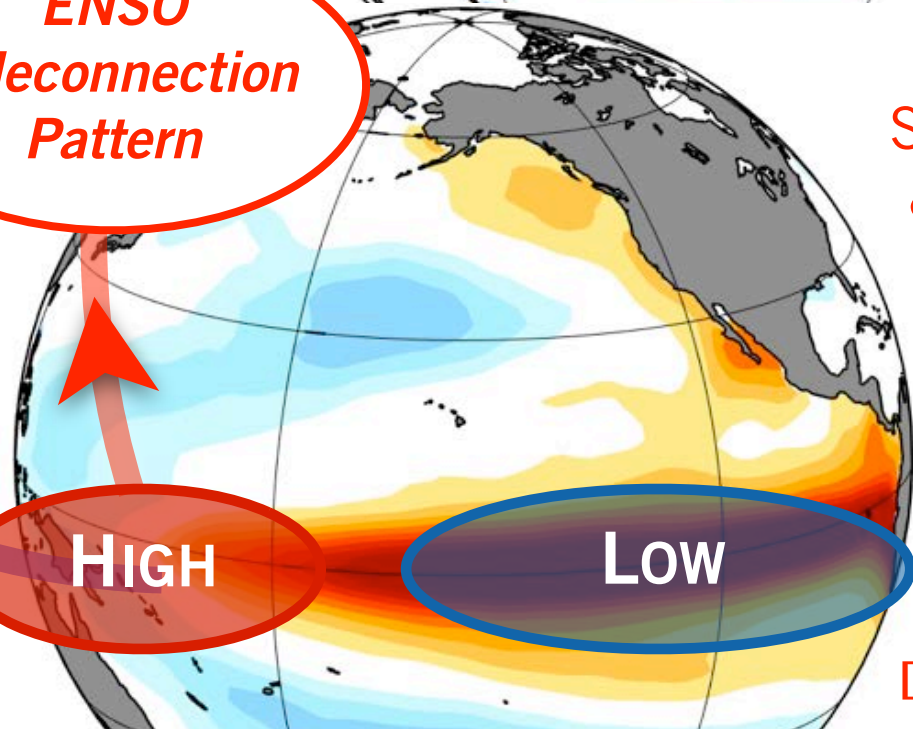
WINTER (JFM) NEXT YEAR

SSTA



*ENSO
Teleconnection
Pattern*

SUMMER
& FALL



*ENSO
Precursors
Dynamics*

SPRING (AMJ)

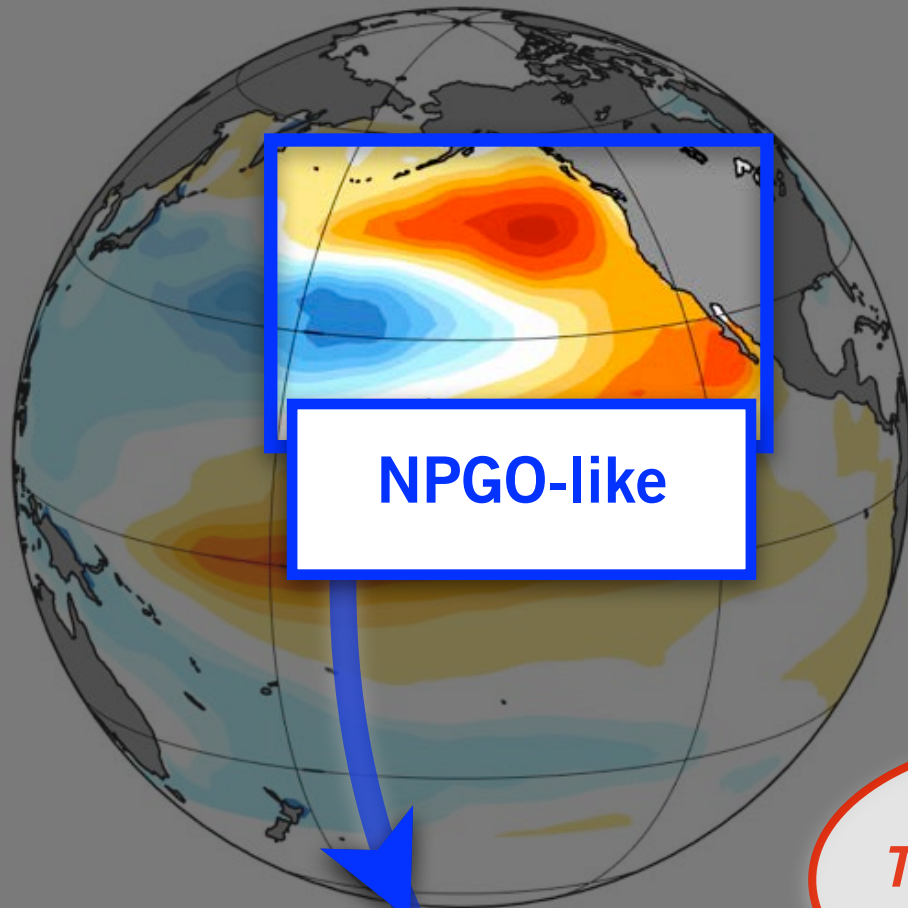
HIGH

LOW

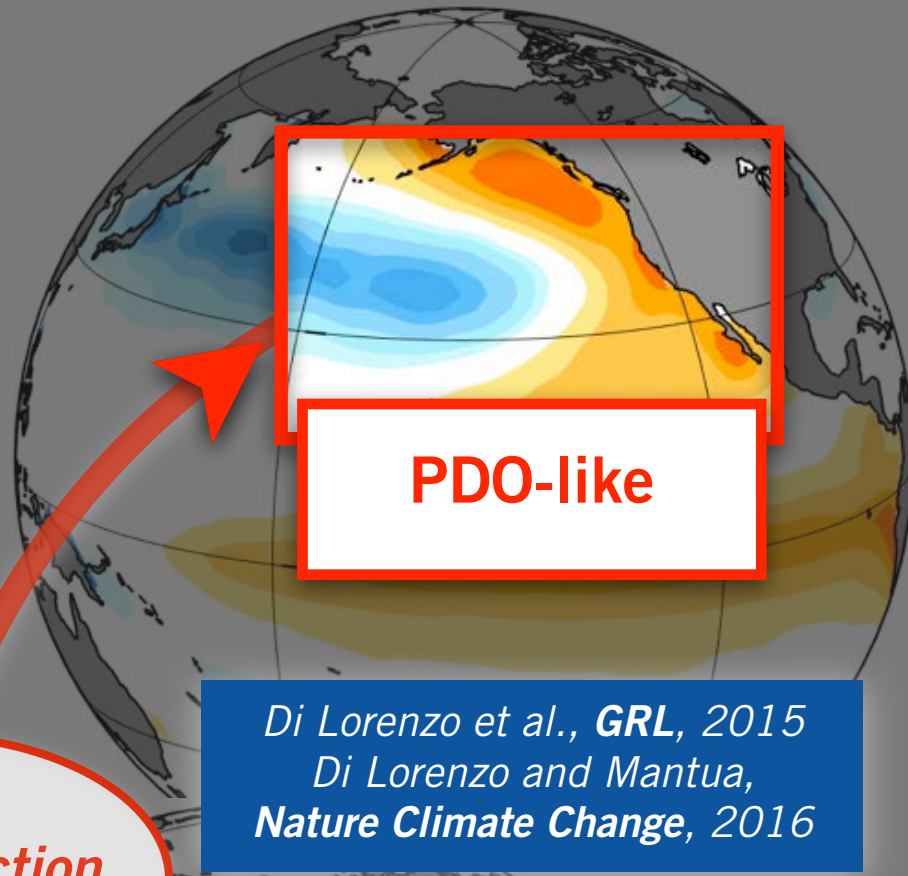
SSTA
RANGE
[-1C +1C]

WINTER (JFM)

WINTER (JFM) NEXT YEAR



NPGO-like

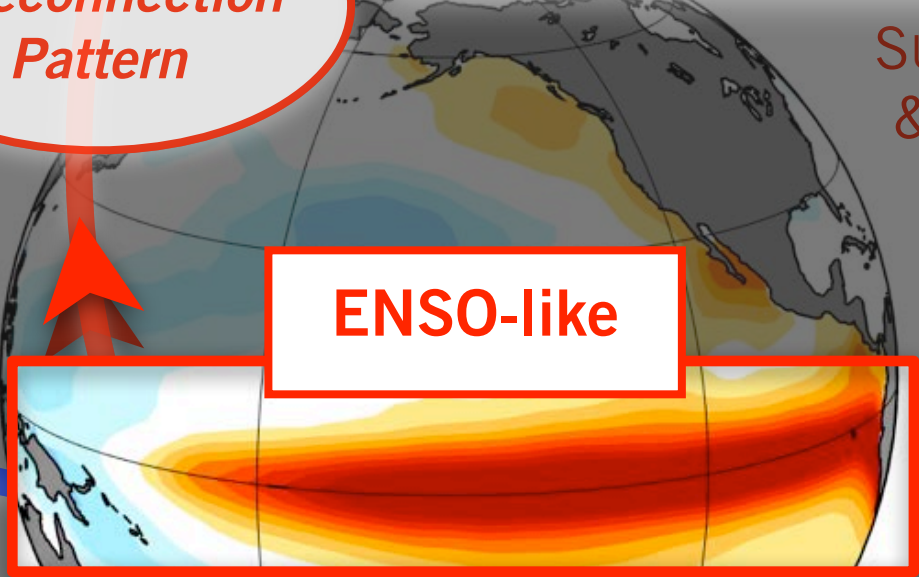


PDO-like

*Di Lorenzo et al., GRL, 2015
Di Lorenzo and Mantua,
Nature Climate Change, 2016*

**ENSO
Precursors
Dynamics**

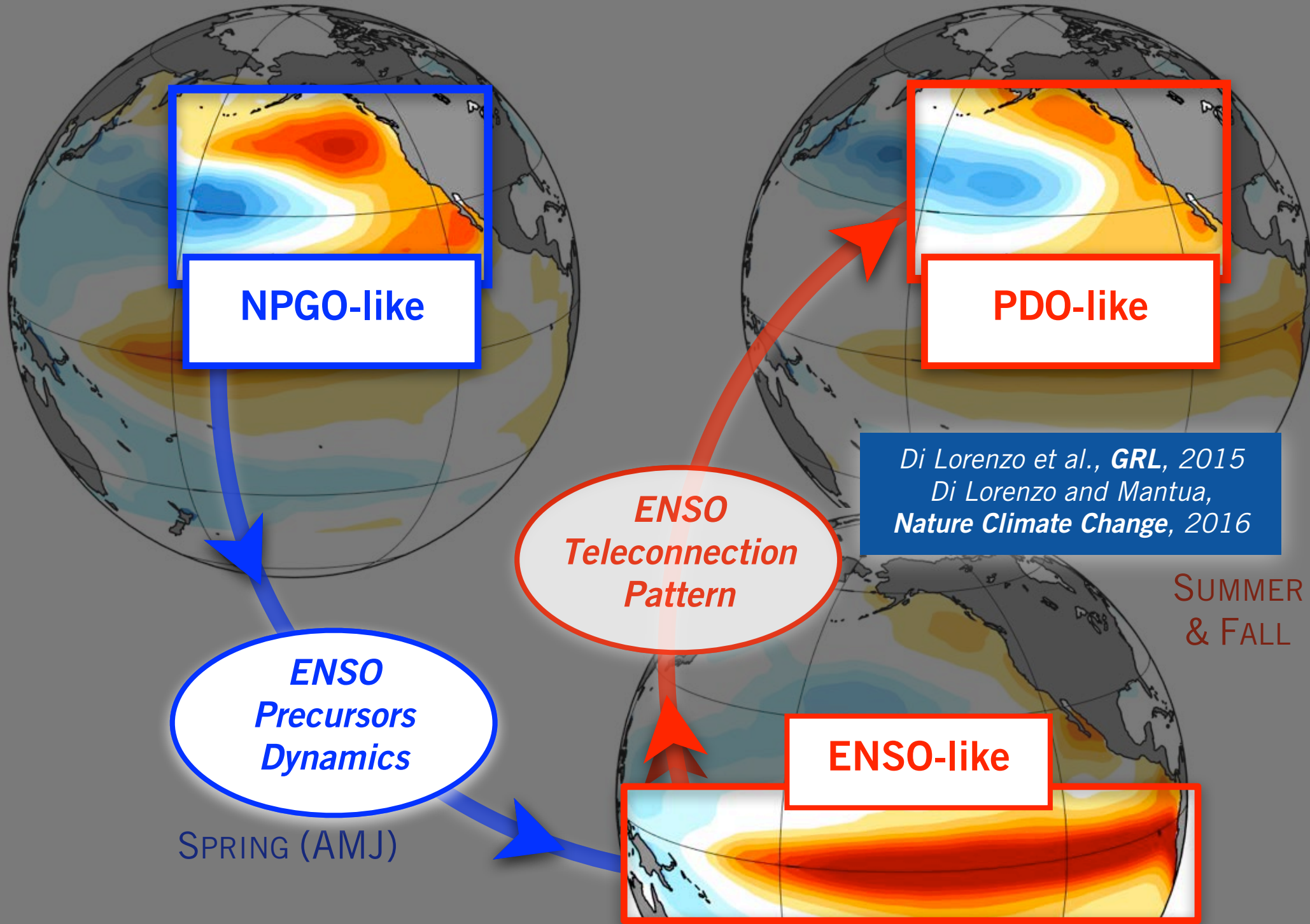
**ENSO
Teleconnection
Pattern**



ENSO-like

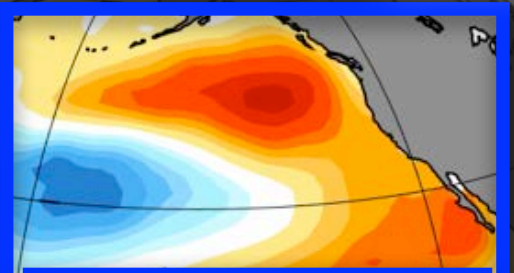
SUMMER
& FALL

SPRING (AMJ)



WINTER (JFM)

Liguori and Di Lorenzo,
GRL, 2018

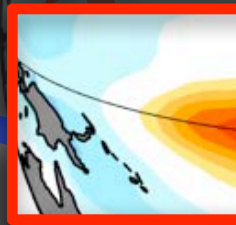


NPGO-like

Trends in
Variance

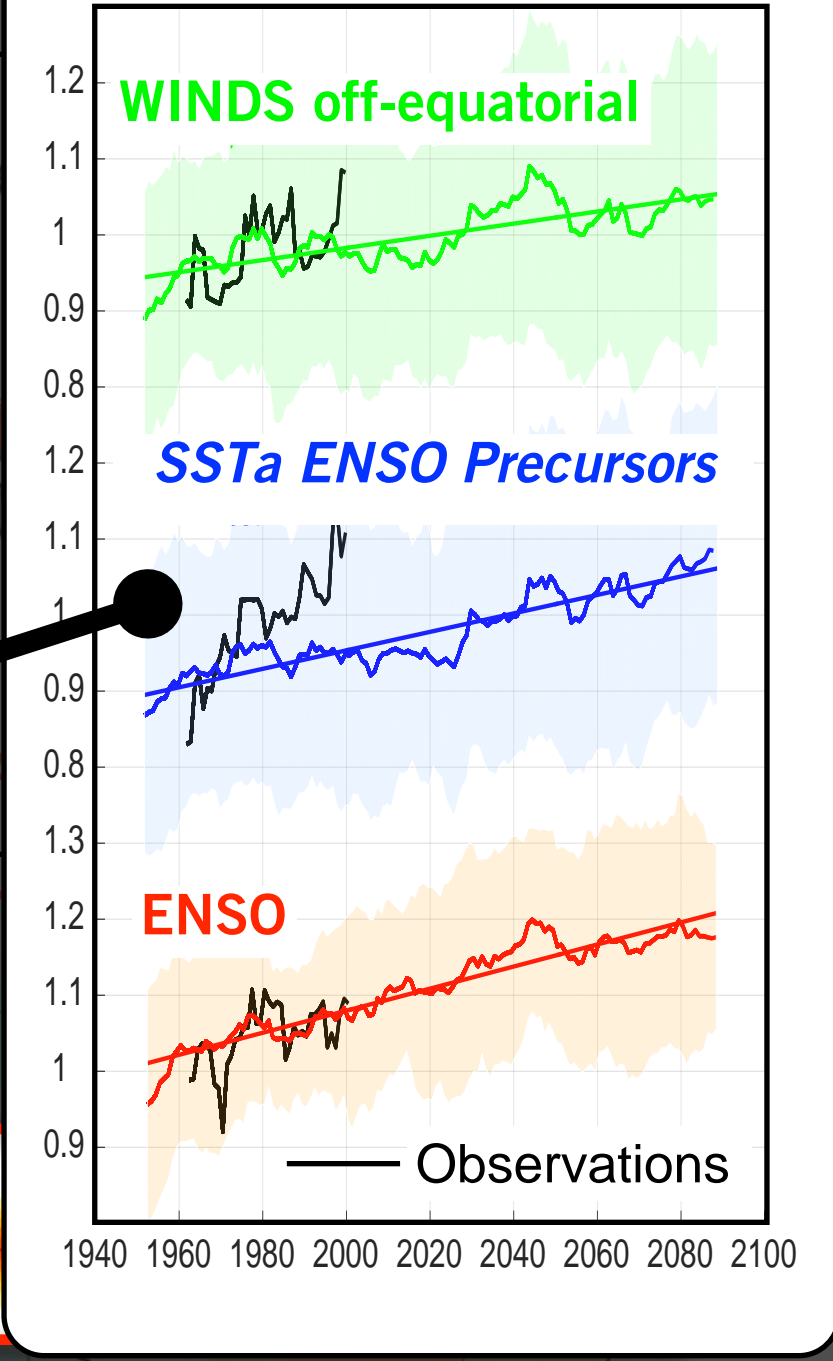
ENSO
Precursors
Dynamics

SPRING (AMJ)



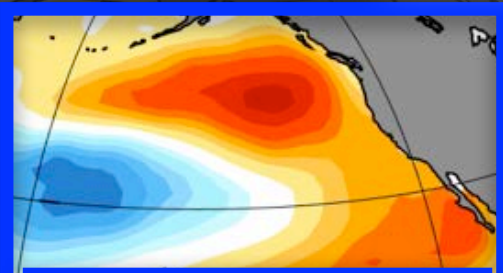
WINTER (JFM) NEXT YEAR

Climate Model Ensemble
CESM-LENS RCP8.5



WINTER (JFM)

Liguori and Di Lorenzo, GRL, 2018

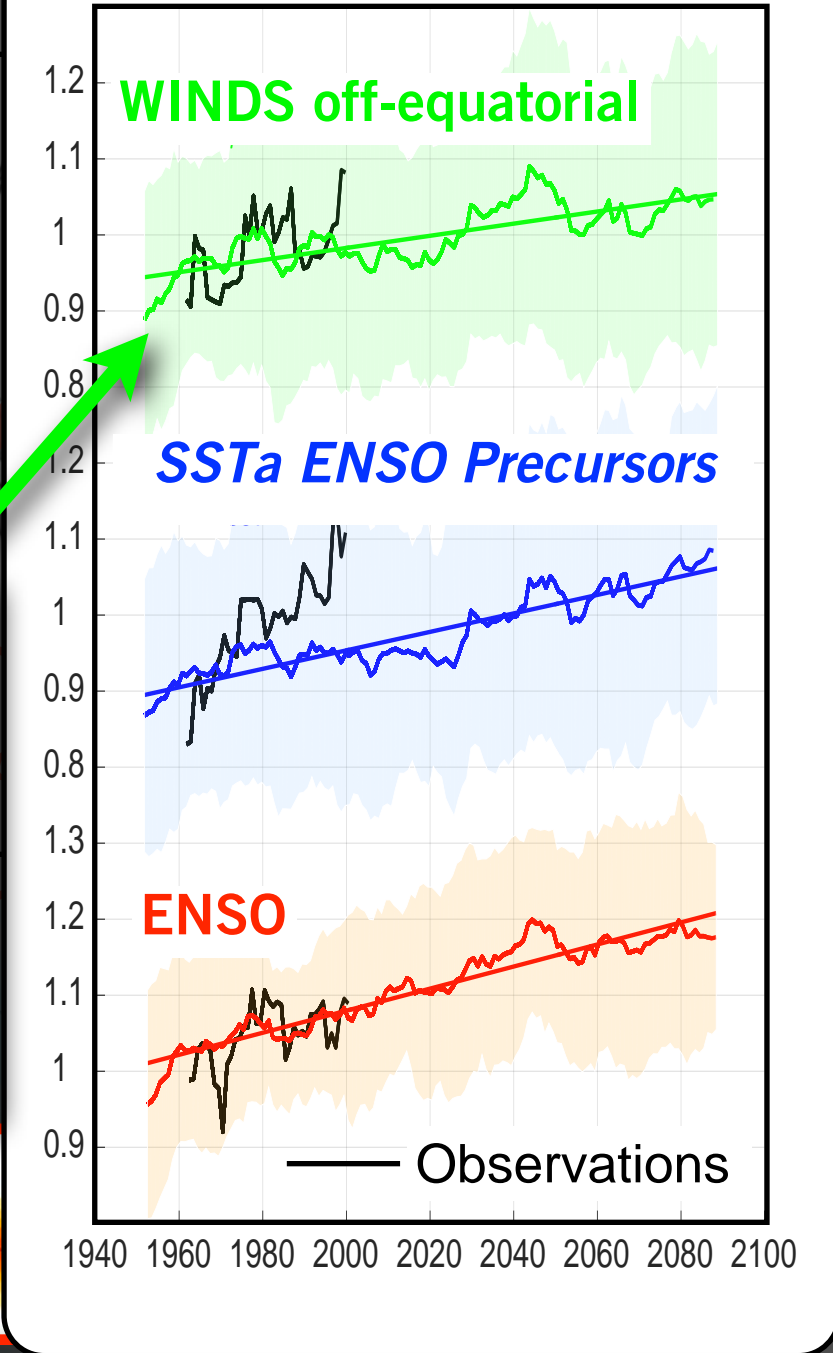


NPGO-like

Normalized Units

WINTER (JFM) NEXT YEAR

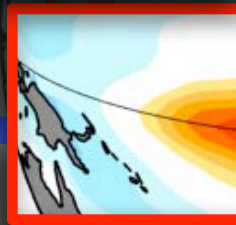
Climate Model Ensemble
CESM-LENS RCP8.5



Variance SSTa of ENSO Precursors

$$\text{var}(SSTa) \approx \frac{\underbrace{\text{Sensitivity of SST to WINDS}}_{\alpha^2} \cdot \underbrace{\text{Variance of WINDS}}_{\text{var}(WINDS)}}{1 - \underbrace{(1-\gamma)^2}_{\text{Ocean Memory}}}$$

SPRING (AMJ)

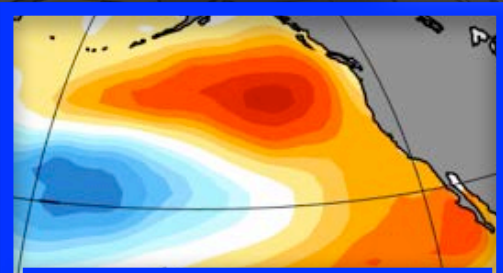


WINTER (JFM)

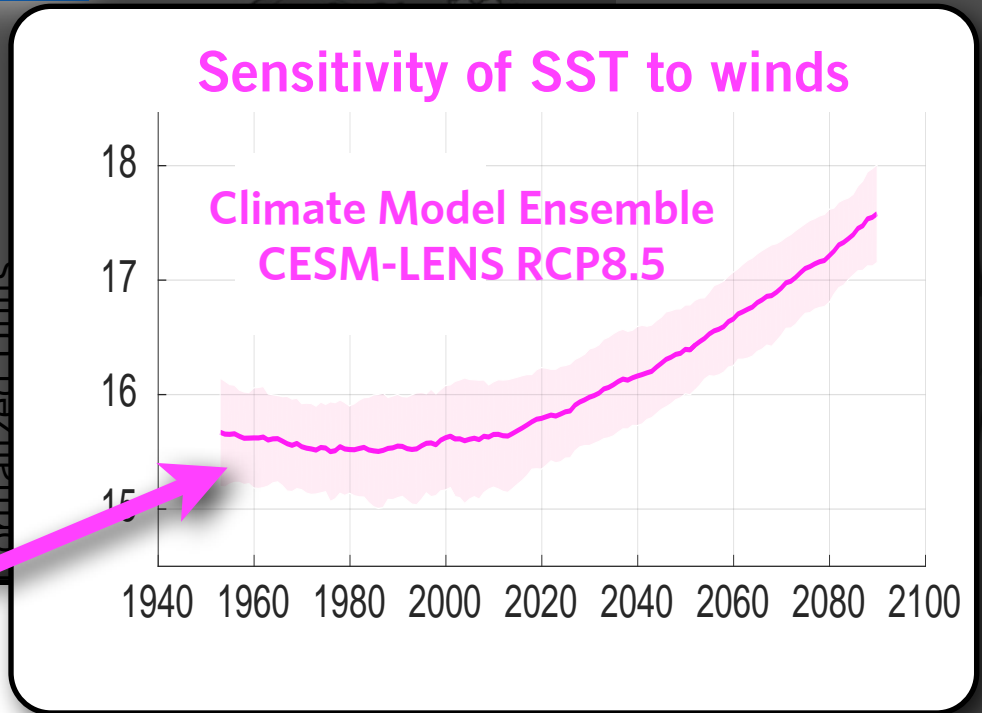
Liguori and Di Lorenzo, GRL, 2018

WINTER (JFM) NEXT YEAR

WIN 2015



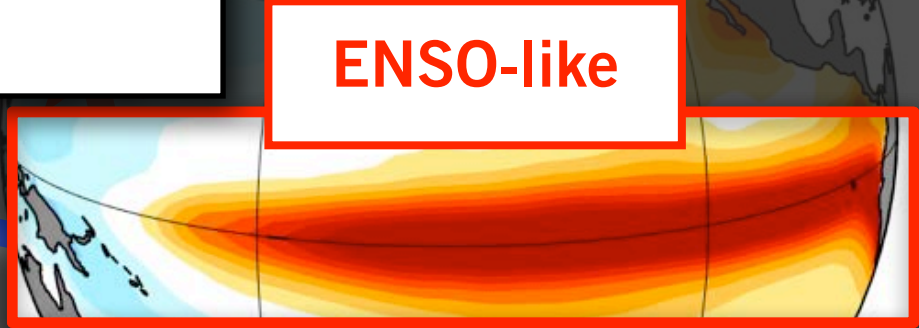
NPGO-like



Variance SSTa of ENSO Precursors

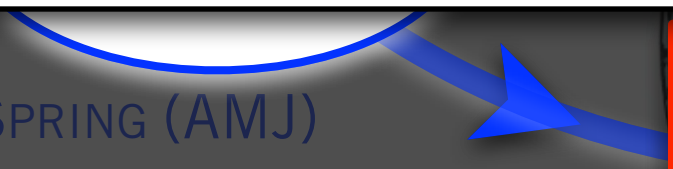
$$\text{var}(SSTa) \approx \frac{\underbrace{\text{Sensitivity of SST to WINDS}}_{\alpha^2} \cdot \underbrace{\text{Variance of WINDS}}_{\text{var}(WINDS)}}{1 - \underbrace{(1-\gamma)^2}_{\text{Ocean Memory}}}$$

SUMMER & FALL



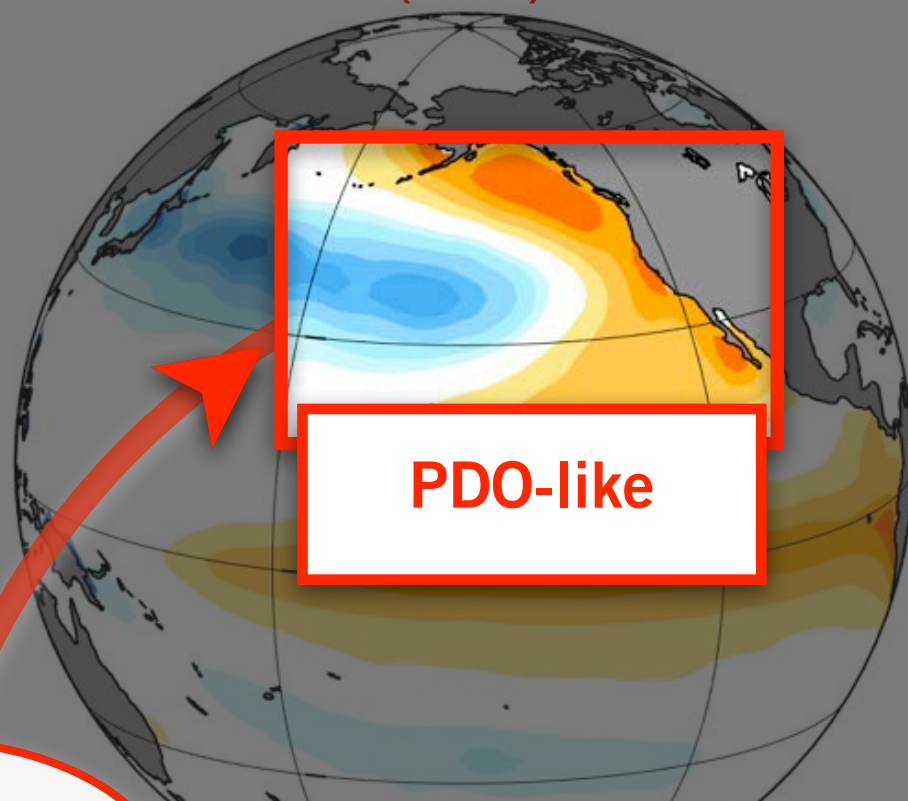
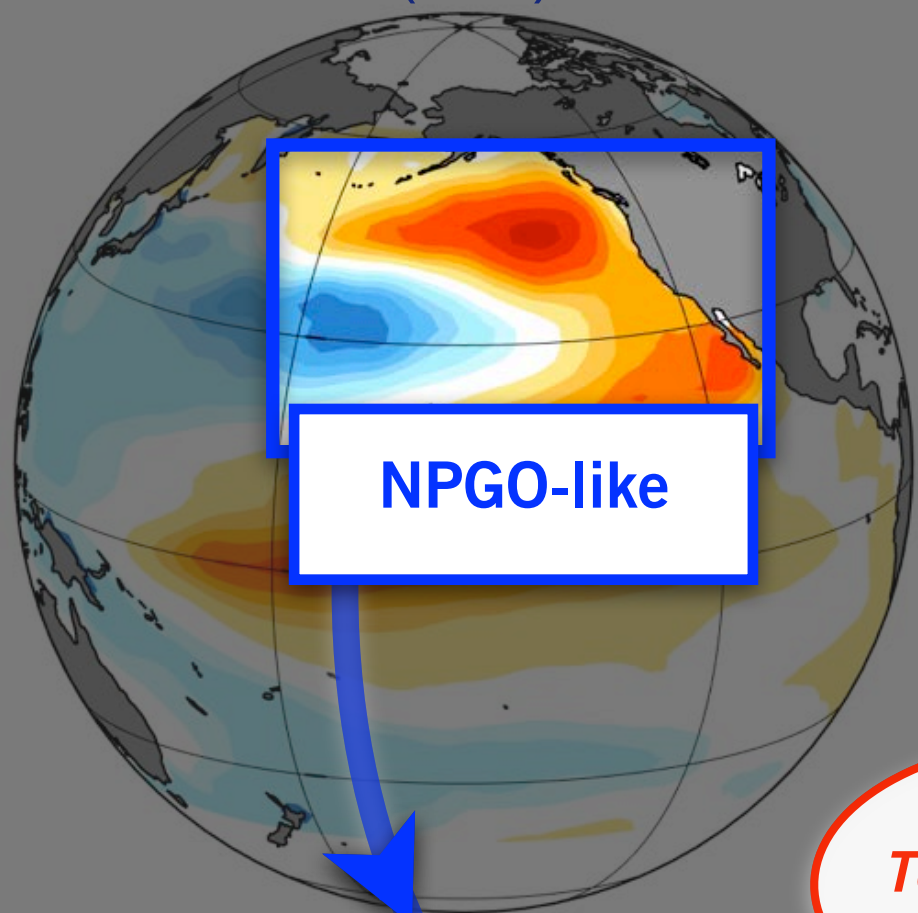
ENSO-like

SPRING (AMJ)



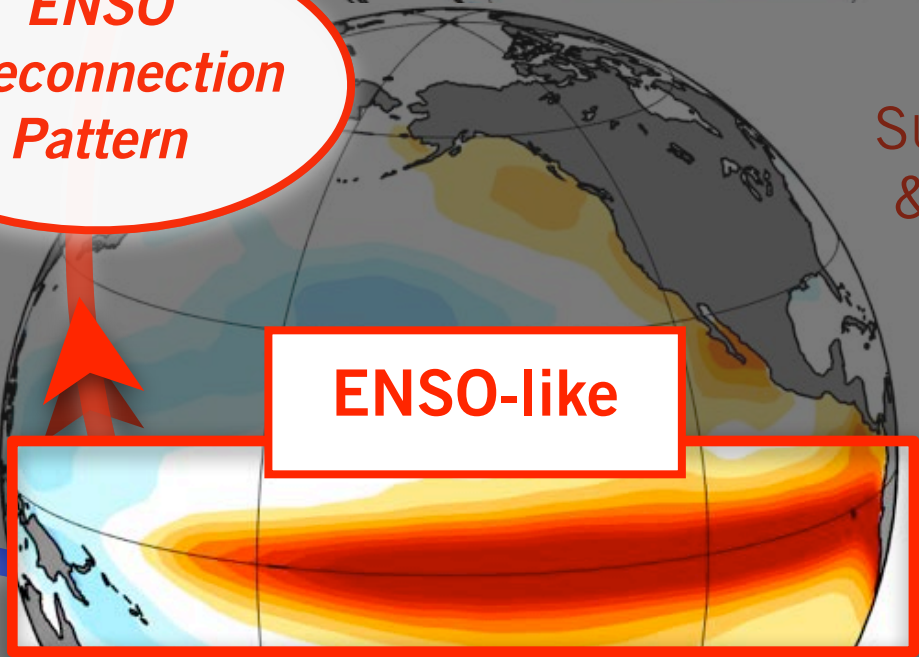
WINTER (JFM)

WINTER (JFM) NEXT YEAR



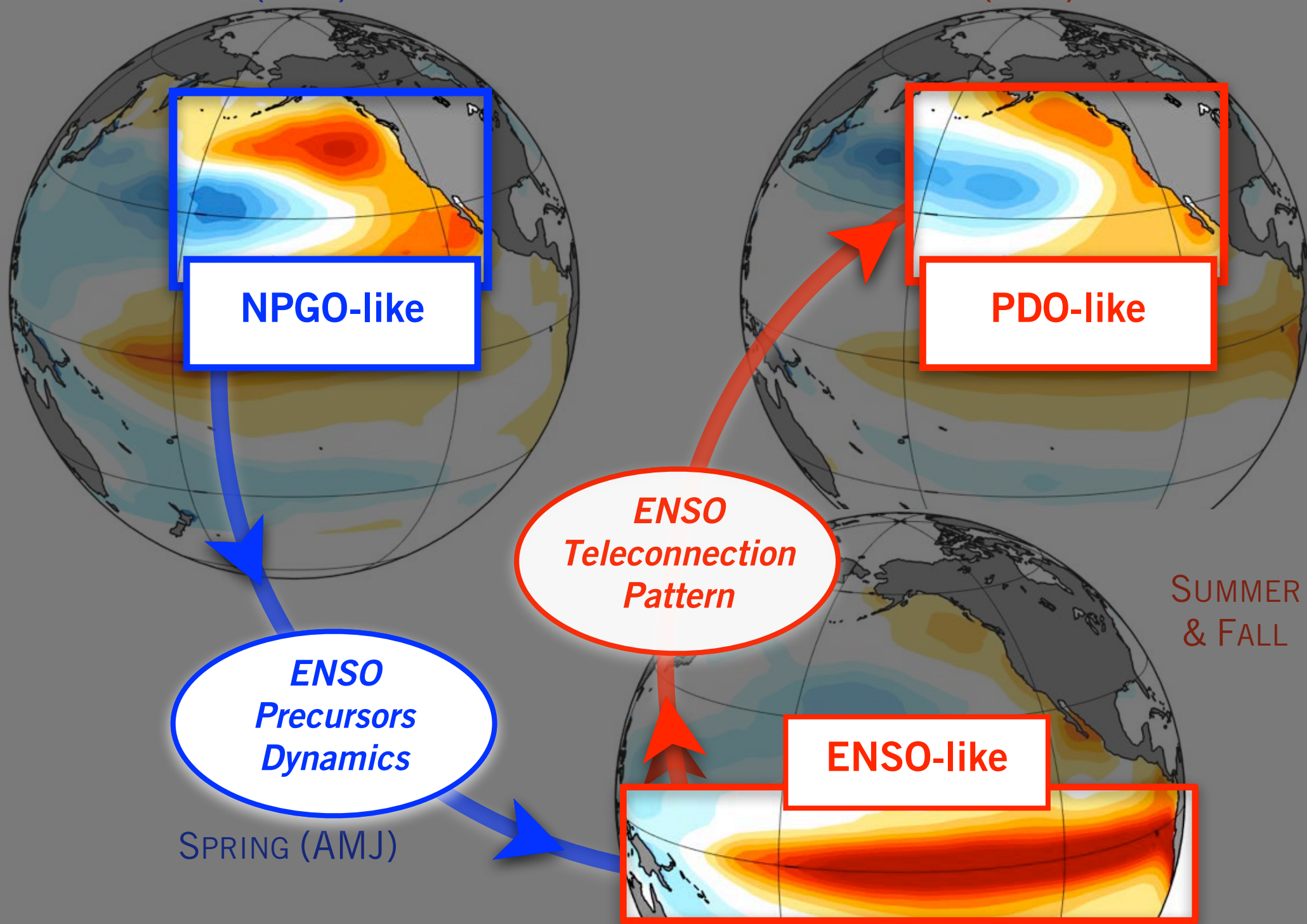
*ENSO
Teleconnection
Pattern*

*ENSO
Precursors
Dynamics*



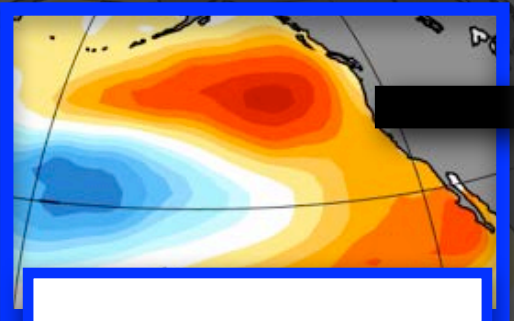
SUMMER
& FALL

SPRING (AMJ)



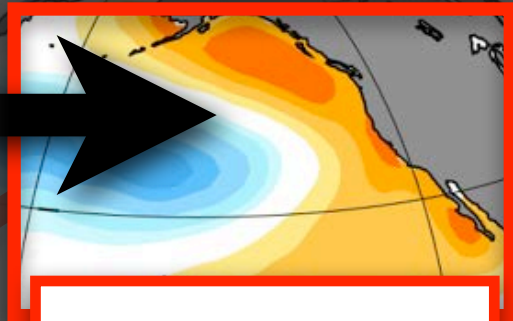
WINTER (JFM)

WINTER (JFM) NEXT YEAR



NPGO-like

**1-YEAR LAG
CORRELATION**
NPGO --> PDO

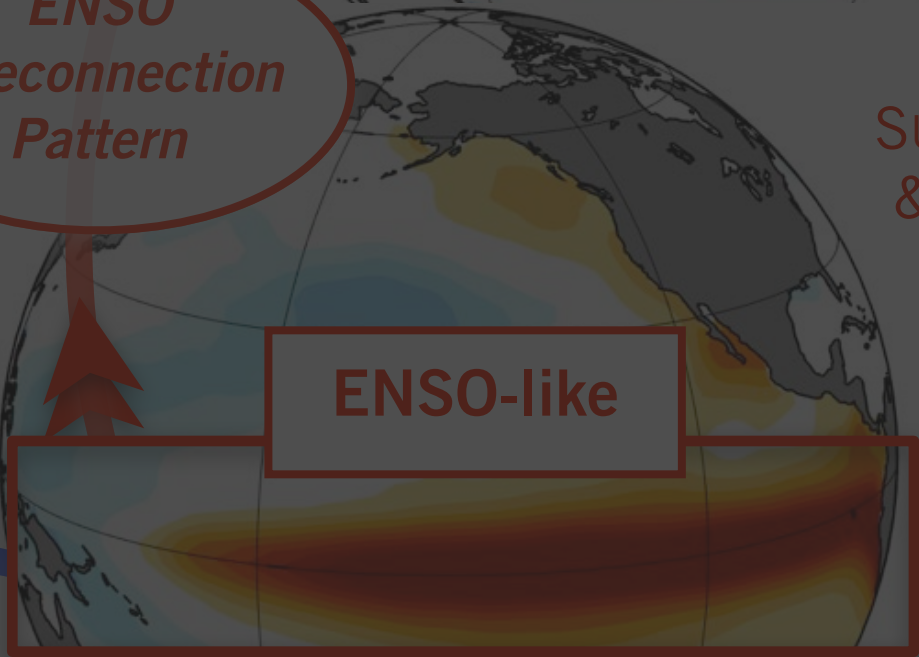


PDO-like

*Meridional
Modes*

SPRING (AMJ)

*ENSO
Teleconnection
Pattern*

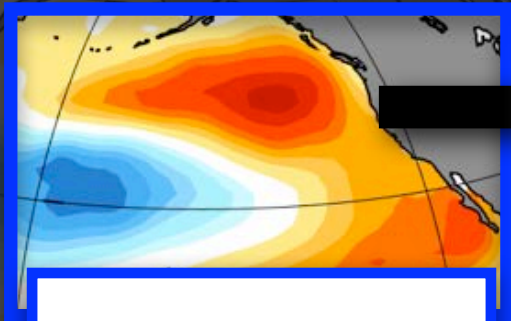


ENSO-like

SUMMER
& FALL

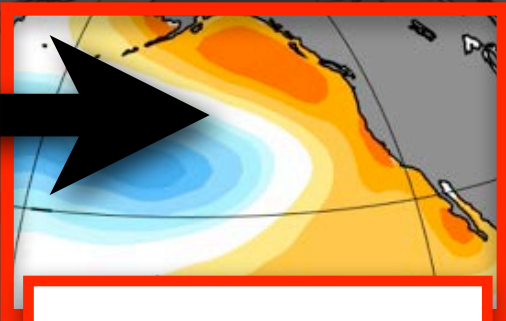
WINTER (JFM)

WINTER (JFM) NEXT YEAR



NPGO-like

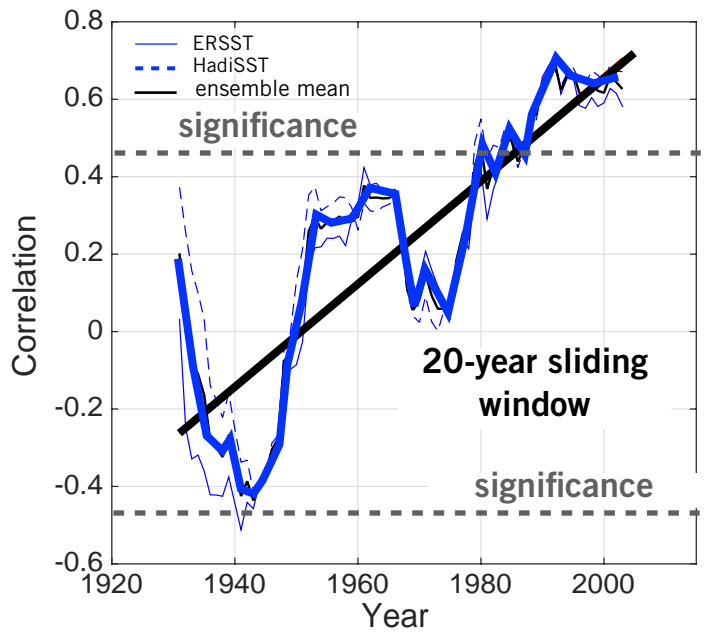
**1-YEAR LAG
CORRELATION
NPGO --> PDO**



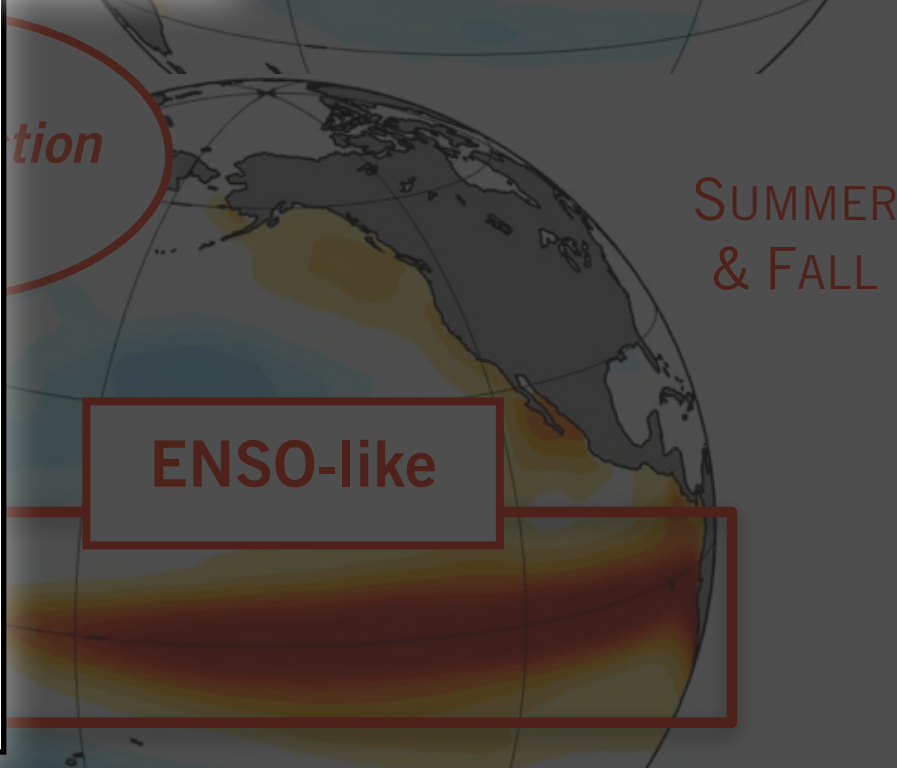
PDO-like

Joh and Di Lorenzo, GRL, 2017

REANALYSES



**Trend in Persistence
60%**

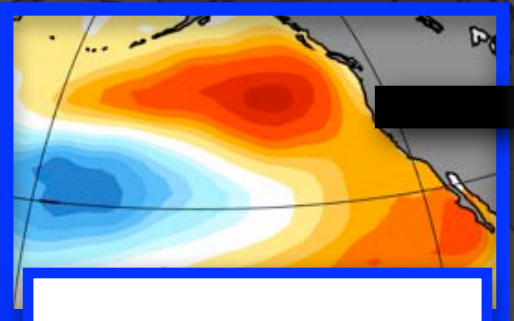


ENSO-like

SUMMER & FALL

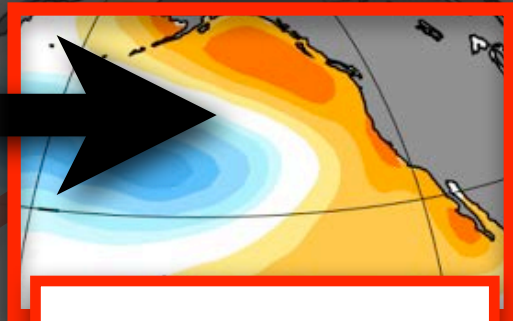
WINTER (JFM)

WINTER (JFM) NEXT YEAR



NPGO-like

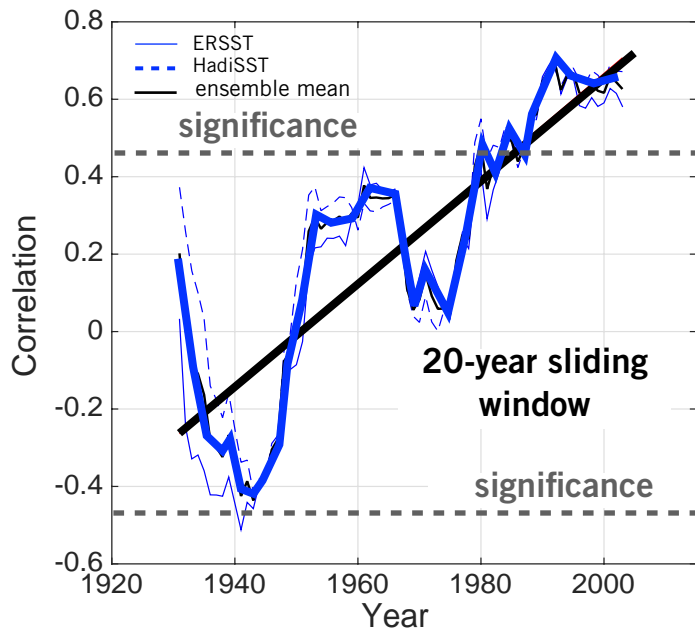
**1-YEAR LAG
CORRELATION**
NPGO --> PDO



PDO-like

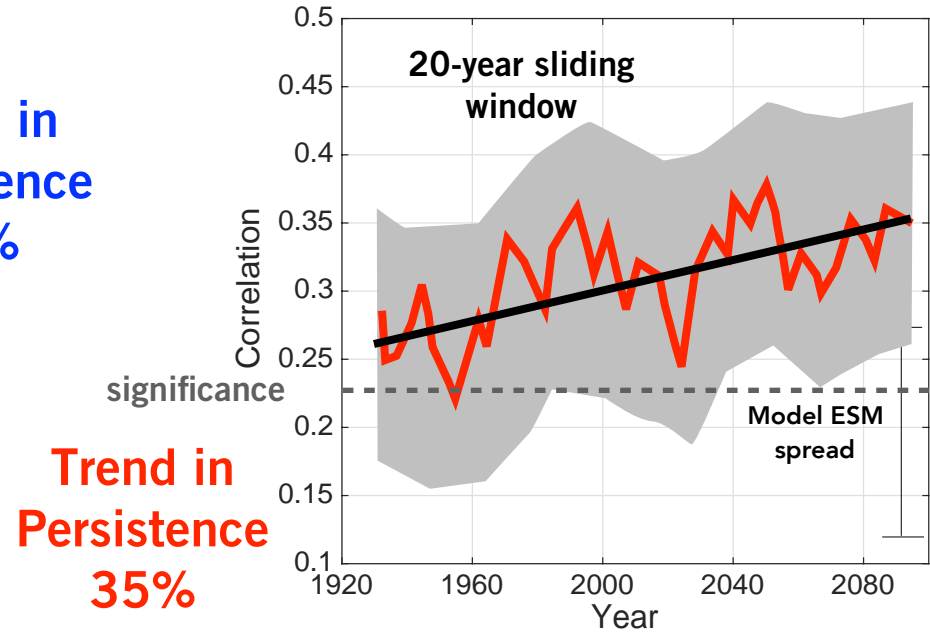
Joh and Di Lorenzo, GRL, 2017

REANALYSES



Trend in Persistence 60%

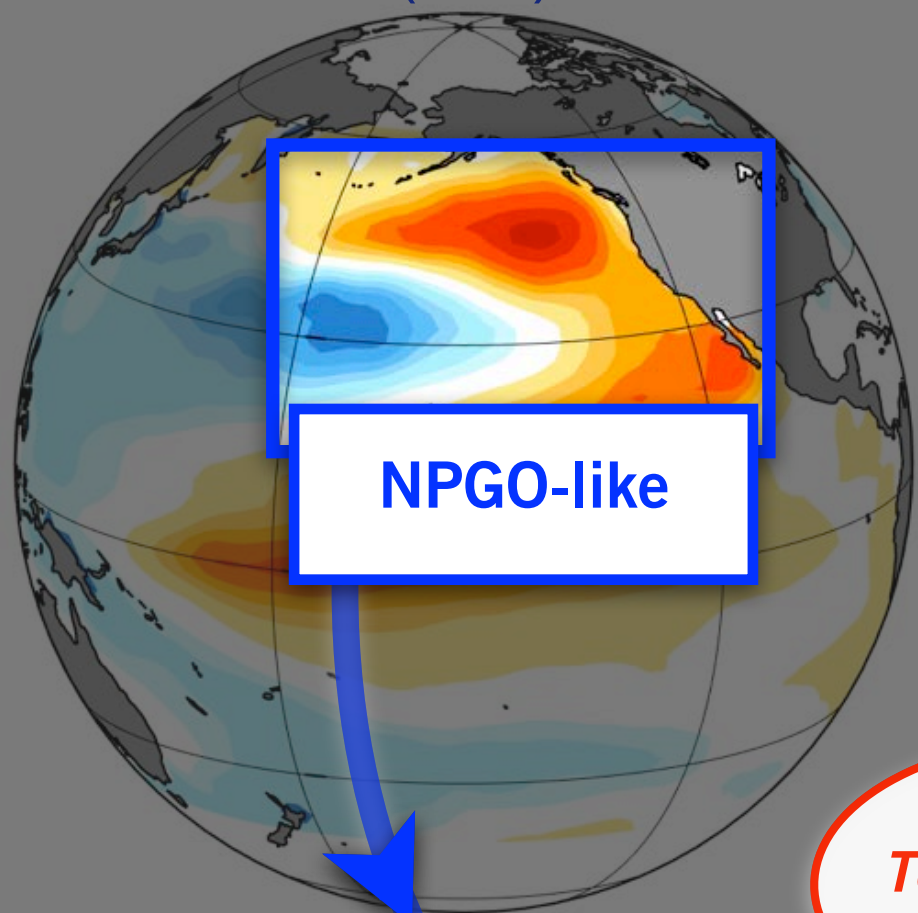
CESM LARGE ENSEMBLE RCP8.5



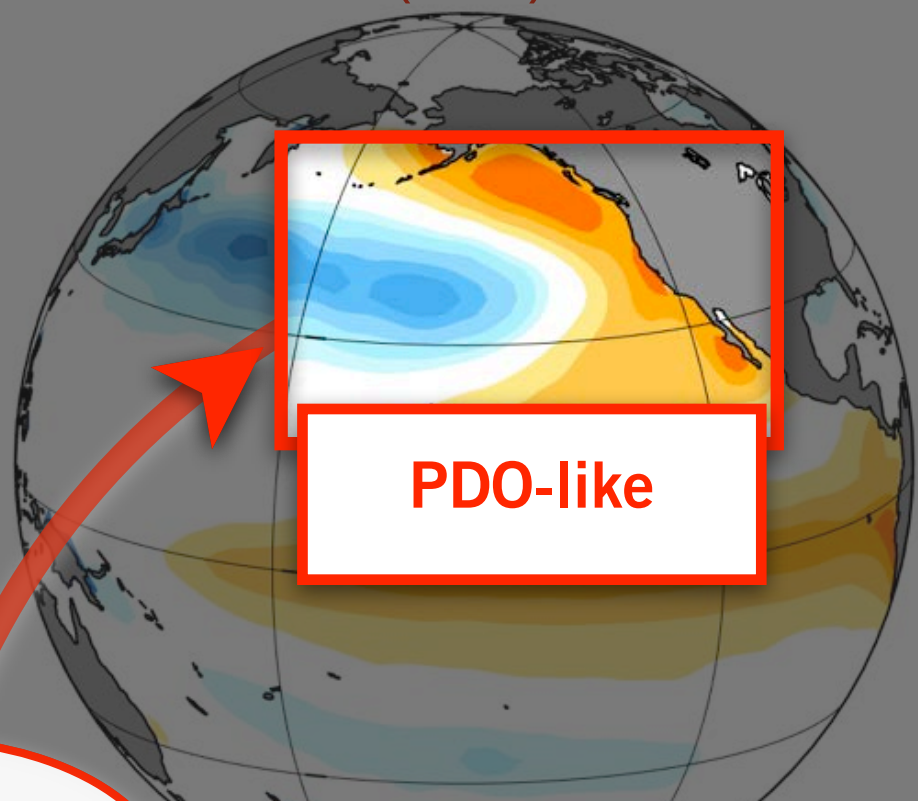
Trend in Persistence 35%

WINTER (JFM)

WINTER (JFM) NEXT YEAR



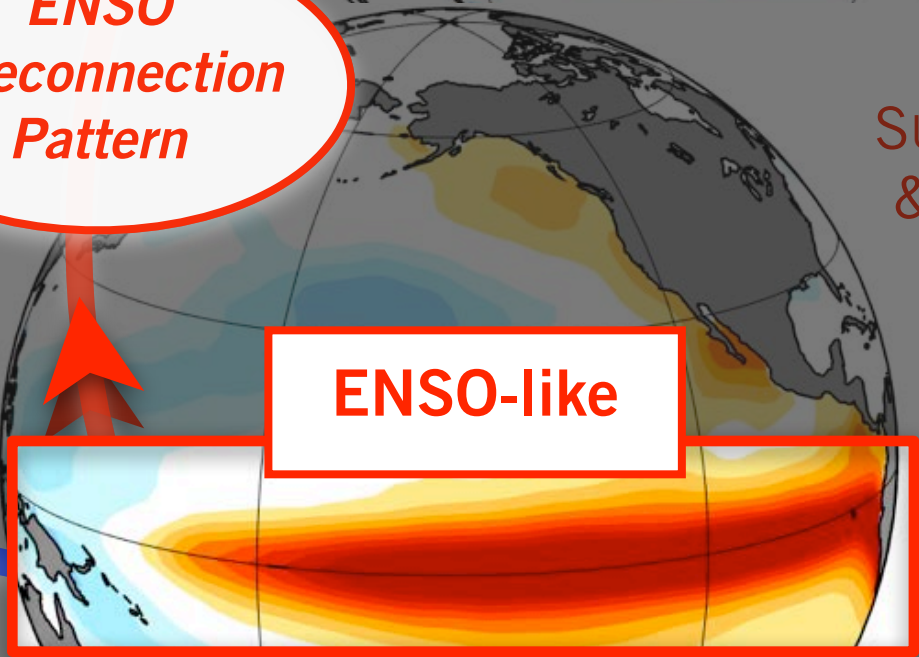
NPGO-like



PDO-like

**ENSO
Teleconnection
Pattern**

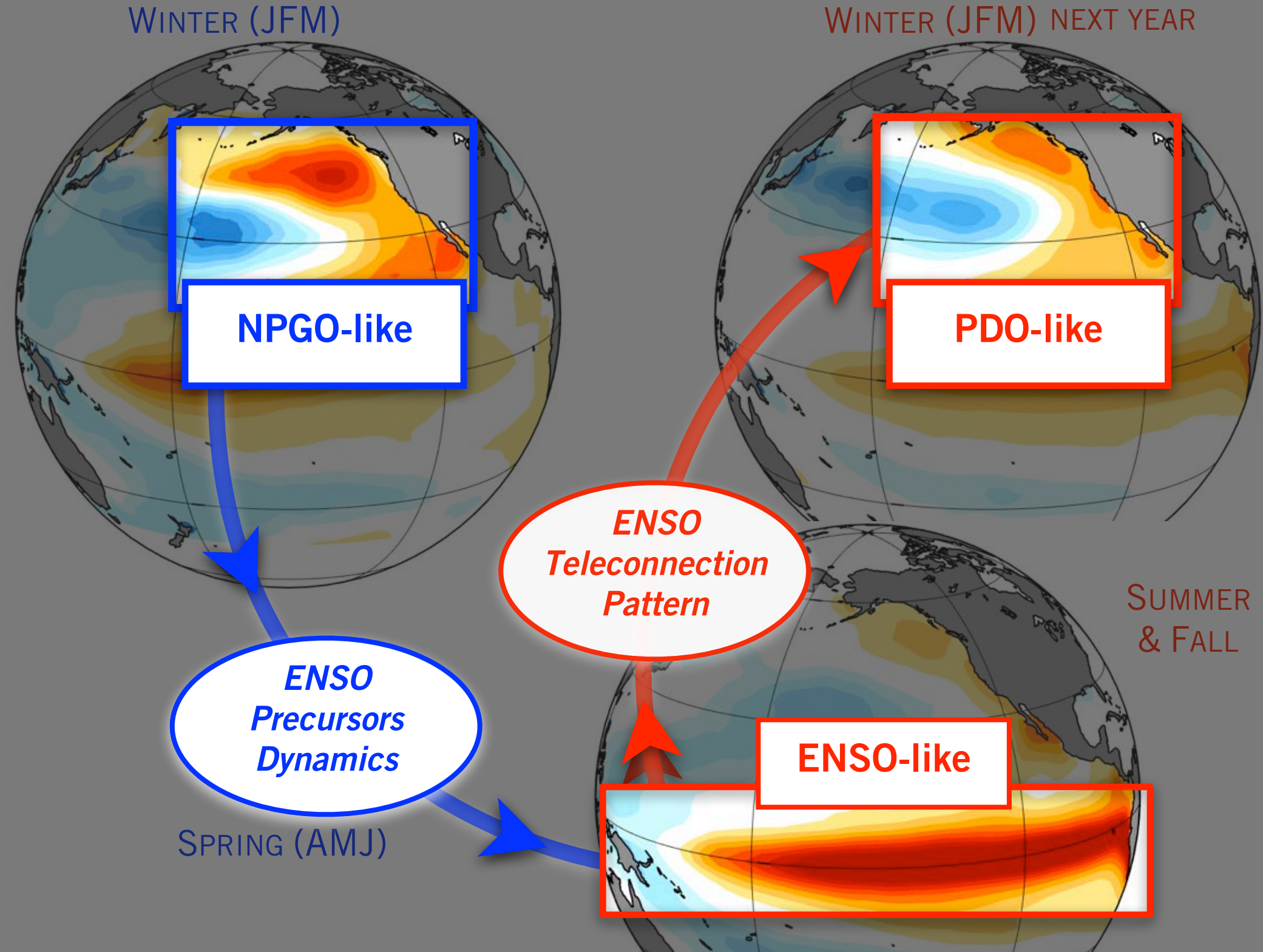
**ENSO
Precursors
Dynamics**



ENSO-like

SUMMER
& FALL

SPRING (AMJ)



WINTER (JFM)

WINTER (JFM) NEXT YEAR

EVIDENCE FOR ANTHROPOGENIC FORCING
of PTAs from CESM Large-Ensemble

NPGO-like

PDO-like

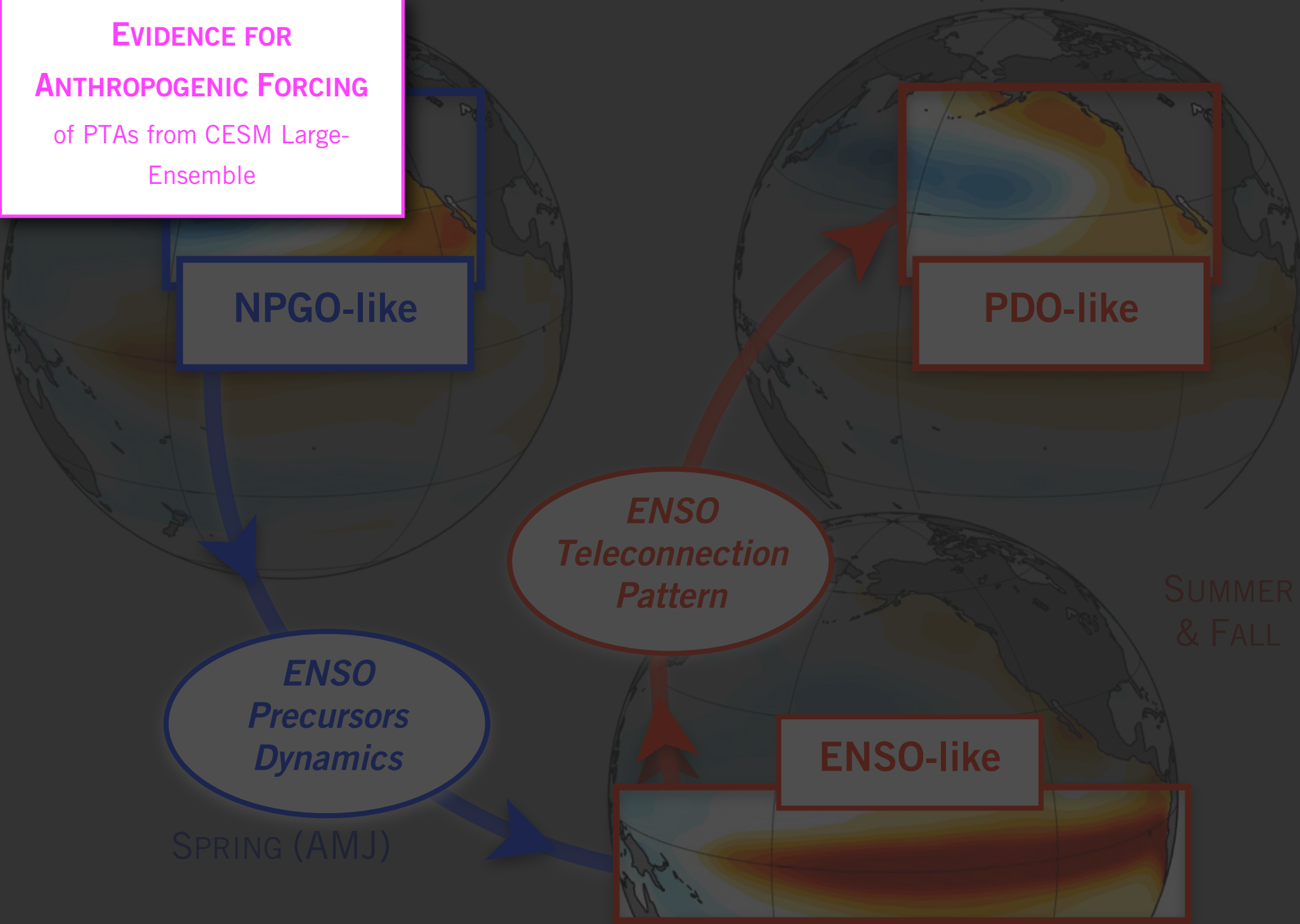
ENSO Teleconnection Pattern

ENSO Precursors Dynamics

ENSO-like

SPRING (AMJ)

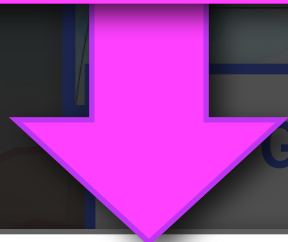
SUMMER & FALL



CLIMATE HYPOTHESIS for the DECADAL VARIABILITY

EVIDENCE FOR ANTHROPOGENIC FORCING

of PTAs from CESM Large-Ensemble



INTENSIFICATION OF ARCTIC CIRCULATION

GO-like

Meridional Modes

SPRING (AMJ)

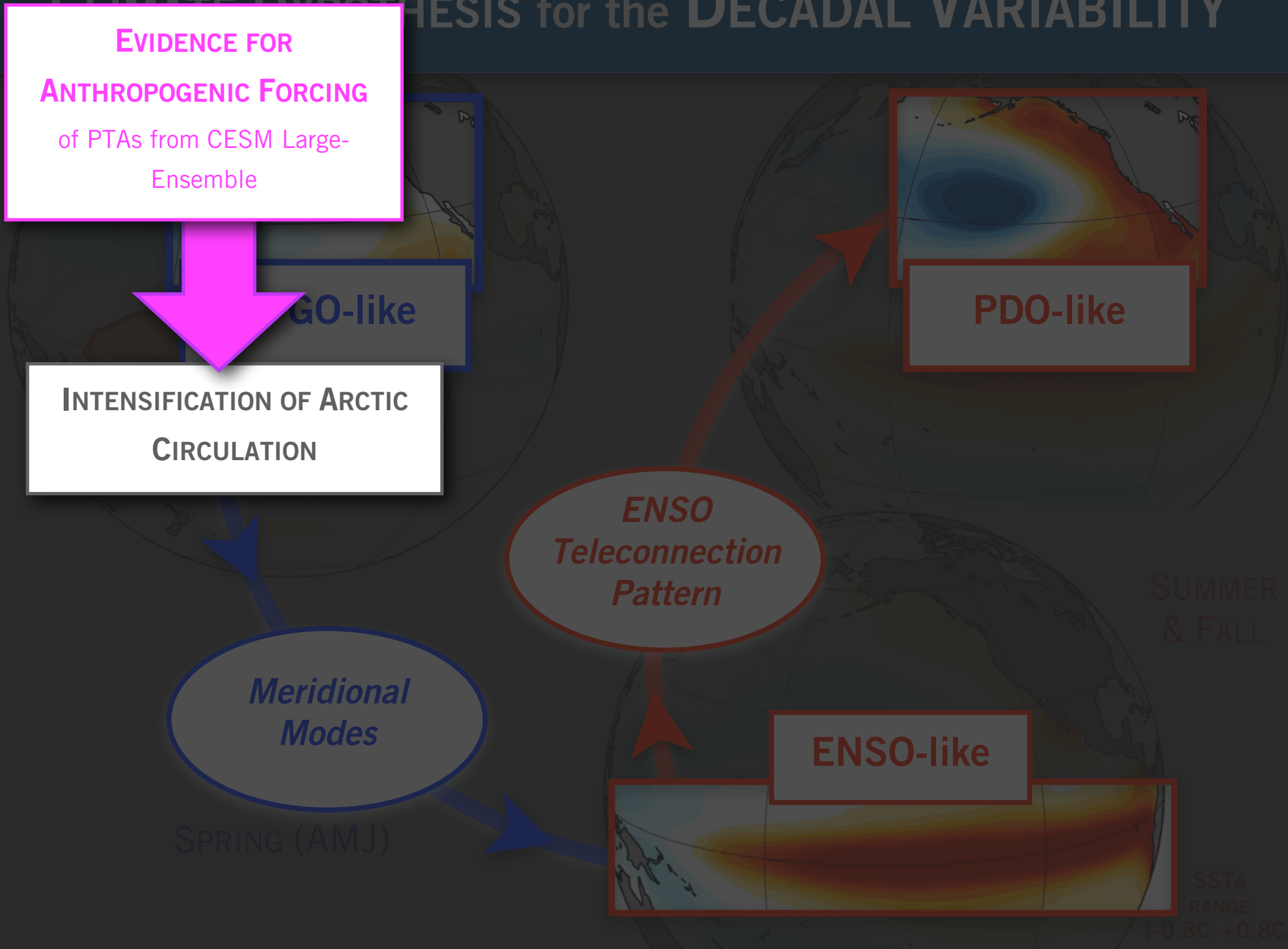
ENSO Teleconnection Pattern

ENSO-like

PDO-like

SUMMER & FALL

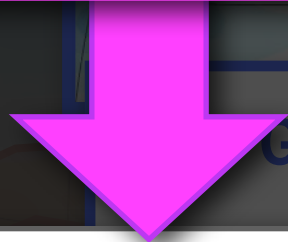
SSTA RANGE
[-0.8C +0.8C]



CLIMATE HYPOTHESIS for the DECADAL VARIABILITY

EVIDENCE FOR ANTHROPOGENIC FORCING

of PTAs from CESM Large-Ensemble



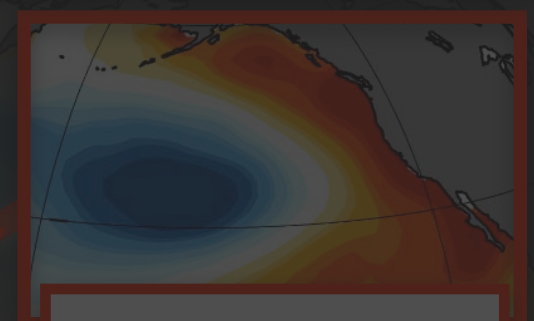
INTENSIFICATION OF ARCTIC CIRCULATION



NPTZ

POLEWARD SHIFT AND INTENSIFICATION

GO-like



PDO-like

ENSO Teleconnection Pattern

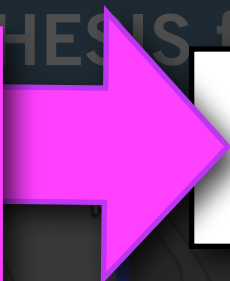


ENSO-like

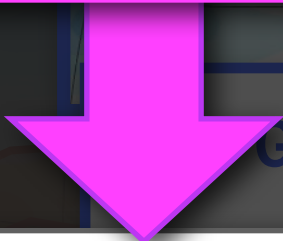
SUMMER & FALL

SSTA RANGE [-0.8C +0.8C]

EVIDENCE FOR ANTHROPOGENIC FORCING
of PTAs from CESM Large-Ensemble



Significant **INCREASE IN THE PDV VARIANCE**
via stronger Meridional Modes and ENSO

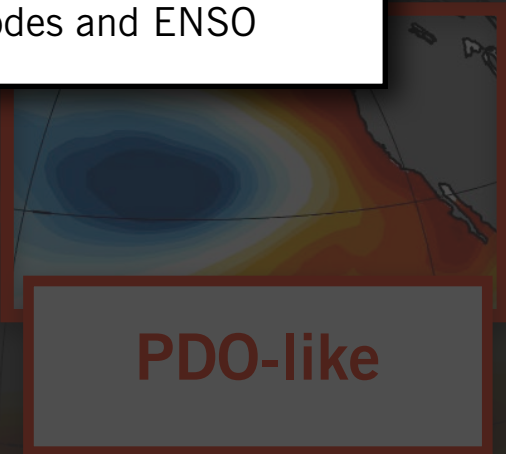


GO-like

INTENSIFICATION OF ARCTIC CIRCULATION



NPTZ
POLEWARD SHIFT AND INTENSIFICATION



PDO-like

ENSO Teleconnection Pattern



ENSO-like

SUMMER & FALL

SSTA RANGE [-0.8C +0.8C]

EVIDENCE FOR ANTHROPOGENIC FORCING
of PTAs from CESM Large-Ensemble

Significant **INCREASE IN THE PDV VARIANCE**
via stronger Meridional Modes and ENSO

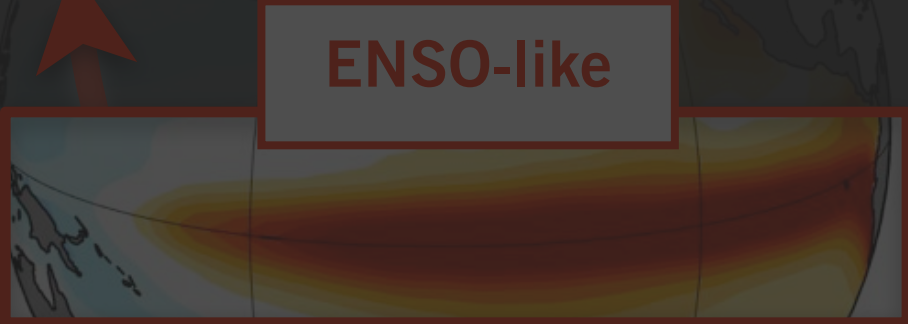
INCREASE VARIANCE IN PDO AND NPGO

INCREASE COUPLING BETWEEN PDO/NPGO

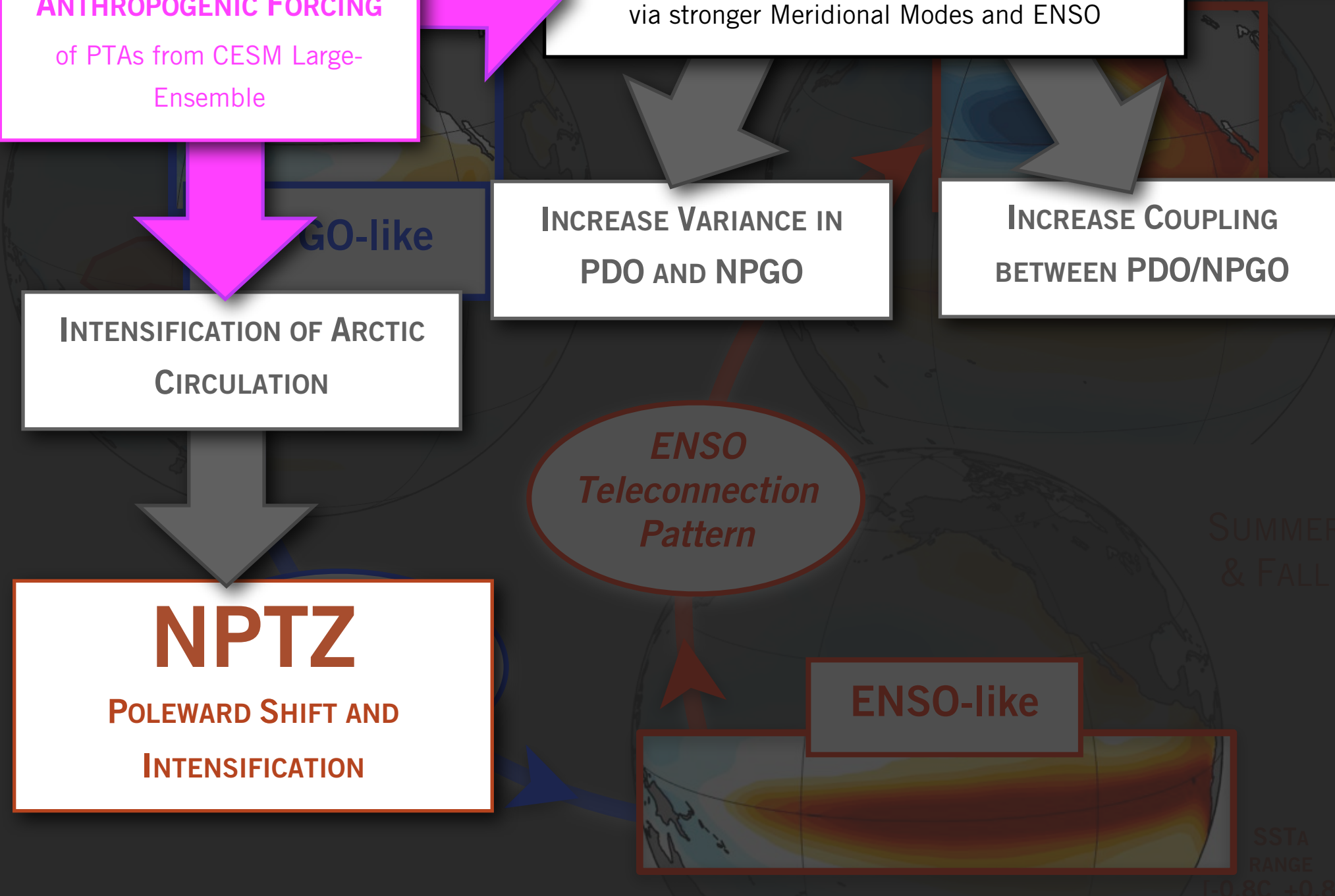
INTENSIFICATION OF ARCTIC CIRCULATION

ENSO Teleconnection Pattern

NPTZ
POLEWARD SHIFT AND INTENSIFICATION



SUMMER & FALL



EVIDENCE FOR ANTHROPOGENIC FORCING
of PTAs from CESM Large-Ensemble

Significant **INCREASE IN THE PDV VARIANCE**
via stronger Meridional Modes and ENSO

INTENSIFICATION OF ARCTIC CIRCULATION

INCREASE VARIANCE IN PDO AND NPGO

INCREASE COUPLING BETWEEN PDO/NPGO

NPTZ
POLEWARD SHIFT AND INTENSIFICATION

NPTZ

INCREASE LARGE-SCALE VARIANCE (PDO)
stronger variance and seasonal migration of NPTZ

INCREASE EDDY-SCALE VARIANCE (NPGO)

EVIDENCE FOR
<http://oces.us>

of PTAs from CESM Large-
Ensemble

Significant INCREASE IN THE PDV VARIANCE
via stronger Meridional modes

THANK YOU!

ARTICLES

PUBLISHED ONLINE: 11 JULY 2016 | DOI: 10.1038/NCLIMATE3082

Multi-year persistence of the 2014/15 North Pacific marine heatwave

Emanuele Di Lorenzo^{1*} and Nathan Mantua²

Between the winters of 2013/14 and 2014/15 during the strong North American drought, the largest marine heatwave ever recorded. Here we combine observations with an ensemble to show that teleconnections between the North Pacific and the weak 2014/2015 El Niño patterns of this event. These teleconnection dynamics from the extratropics to the tropics back to the extratropics during winter 2014/15, are a key source of multi-year persistence. The corresponding ocean anomalies map onto known patterns of North Pacific decadal Pacific Gyre Oscillation (NPGO) in 2014 and the Pacific Decadal Oscillation (PDO) in 2015. A model simulations predicts that the winter variance of the NPGO- and PDO-like patterns consistent with other studies suggesting an increase in the atmospheric extremes that

During the fall of 2013 a large developed in the upper ocean Pacific Current. As the anomaly of the Gulf of Alaska (GOA) during reached a record-breaking amplitude anomalies (SSTa) exceeding three (Fig. 1a and Supplementary Fig. 1) of the datasets and definition of and growth of this unusual water forcing associated with a persistent northeast Pacific¹ (Fig. 1b) that i Oscillation (NPO), a leading pa Extreme amplitude and persists implicated in the record drought in the winter of 2013/14²⁻⁵ and in El Niño conditions^{6,7}. By the anomalies reached the Pacific and although the amplitude in the Current System (CCS) were re in the regions of southern and of 2014/15, the SSTa over the exceeding again the 3 °C threshold (Fig. 1). The record-breaking persistence of this warm a heatwave⁸, have had unpre levels of the marine ecosys fisheries. Associated ecos productivity⁹, 11 new war California Current shelf/ starving Cassin's auklets from October through a mortality event in the

AGU PUBLICATIONS 2017

Geophysical Research Letters

RESEARCH LETTER

10.1002/2017GL075930

Special Section:

Midlatitude Marine Heatwaves: Forcing and Impacts

Key Points:

- Multiyear SST warm events in the Northeast Pacific typically emerge as a winter NPGO-like warm pattern and transition to a PDO-like pattern in the following winter
- The coupling between winter NPGO and the following winter PDO is a robust climate teleconnection in both observations and the CESM-LENS over the period 1920–2100
- A stronger NPGO-PDO coupling is predicted under anthropogenic forcing in the CESM-LENS and leads to more prolonged and larger area multiyear marine heatwaves

Supporting Information:
• Supporting Information S1

Increasing Coupling Between NPGO and PDO Leads to Prolonged Marine Heatwaves in the Northeast Pacific

Yongji Joh¹ and Emanuele Di Lorenzo¹

¹School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA, USA

Abstract The marine heatwave of 2014/2015 in the Northeast Pacific caused significant impacts on marine ecosystems and fisheries. While several studies suggest that land and marine heatwaves may intensify under climate change, less is known about the prolonged multiyear nature (~2 years) of the Northeast Pacific events. Examination of reanalysis products and a 30-member climate model ensemble confirms that prolonged multiyear marine heatwaves are linked to the dynamics of the two dominant modes of winter sea surface temperature variability in the North Pacific, the Pacific Decadal Oscillation (PDO), and the North Pacific Gyre Oscillation (NPGO). Specifically, we find a significant correlation between winter warm NPGO anomalies and the following winter PDO arising from extratropical/tropical teleconnections. In the model projections for 2100 under the RCP8.5 scenario, this NPGO/PDO 1 year lag correlation exhibits a significant positive trend (~35%) that favors more prolonged multiyear warm events (>1°C) with larger spatial coverage (~18%) and higher maximum amplitude (~0.5°C for events >2°C) over the Northeast Pacific.

Plain Language Summary Between the winters of 2014 and 2015 the Northeast Pacific experienced the largest and longest marine heatwave ever recorded in the instrumental record. A

AGU PUBLICATIONS 2018

Geophysical Research Letters

RESEARCH LETTER

10.1002/2017GL076548

Key Points:

- The low-frequency variance of the main Pacific climate modes might increase under anthropogenic forcing
- The coupling between ENSO and the Pacific Meridional mode increases under anthropogenic forcing

Supporting Information:
• Supporting Information S1

Meridional Modes and Increasing Pacific Decadal Variability Under Anthropogenic Forcing

Giovanni Liguori¹ and Emanuele Di Lorenzo¹

¹School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA, USA

Abstract Pacific decadal variability (PDV) shows trends in droughts, hurricanes,

the statistics of weather, atmosphere extremes, ns. Sea surface temperature (SST) observations as increased by ~30% (1920–2015) with a though we cannot attribute these trends to community Earth System Model Large p (1920–2100) suggests that significant 20 in response to a more energetic North y. In the LENS, the increase in PMM n-SST thermodynamic feedback that

weather, droughts, hurricanes, and gical impacts. Understanding how assess because of the limited nate projection models. We del ensemble, to show that the of stronger thermodynamic ing is also increasing in other e amplification of climate

f great interest because of nd atmosphere extremes a et al., 1997; Roemer ty (PNA)