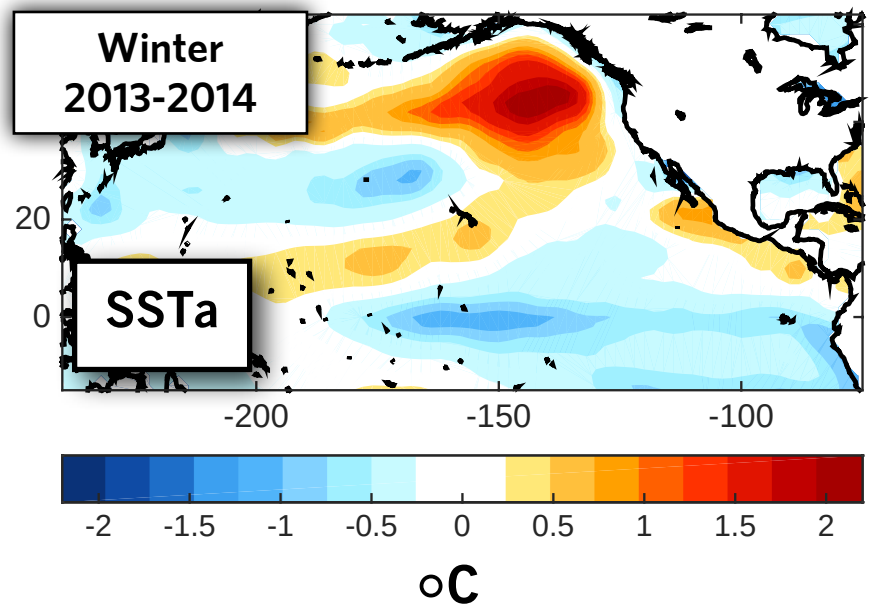
GENERATION, PROPAGATION & PERSISTENCE

WARM BLOB IN 2014/15

by **Emanuele Di Lorenzo**

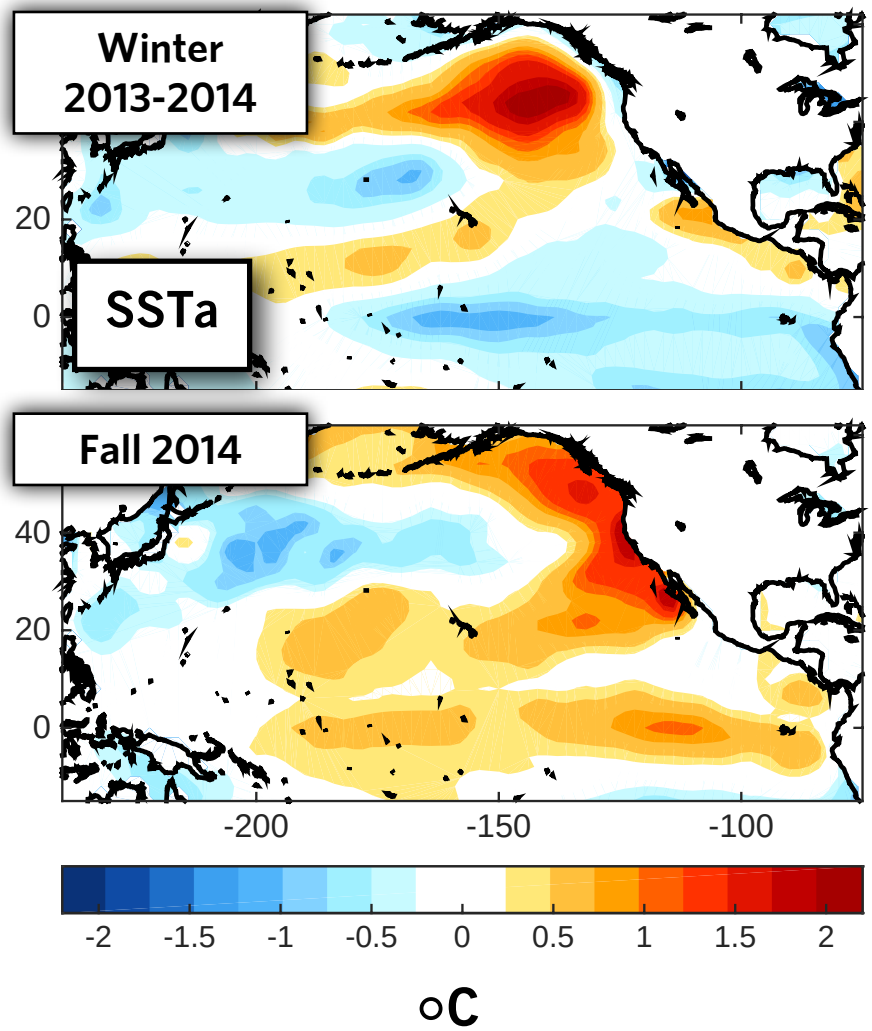
& Nate Mantua

Georgia Institute of Technology



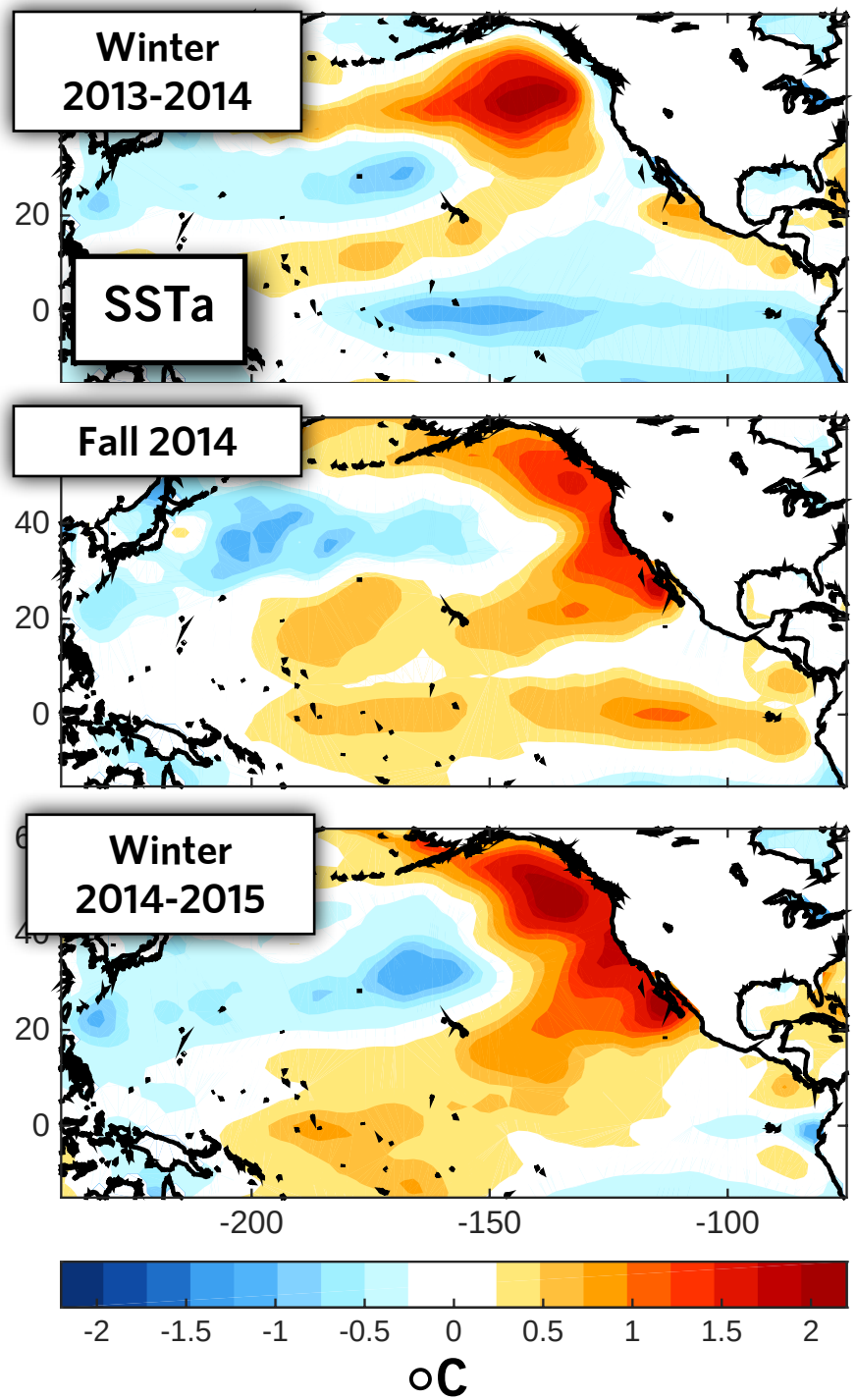
WARM BLOB

Evolution and persistence



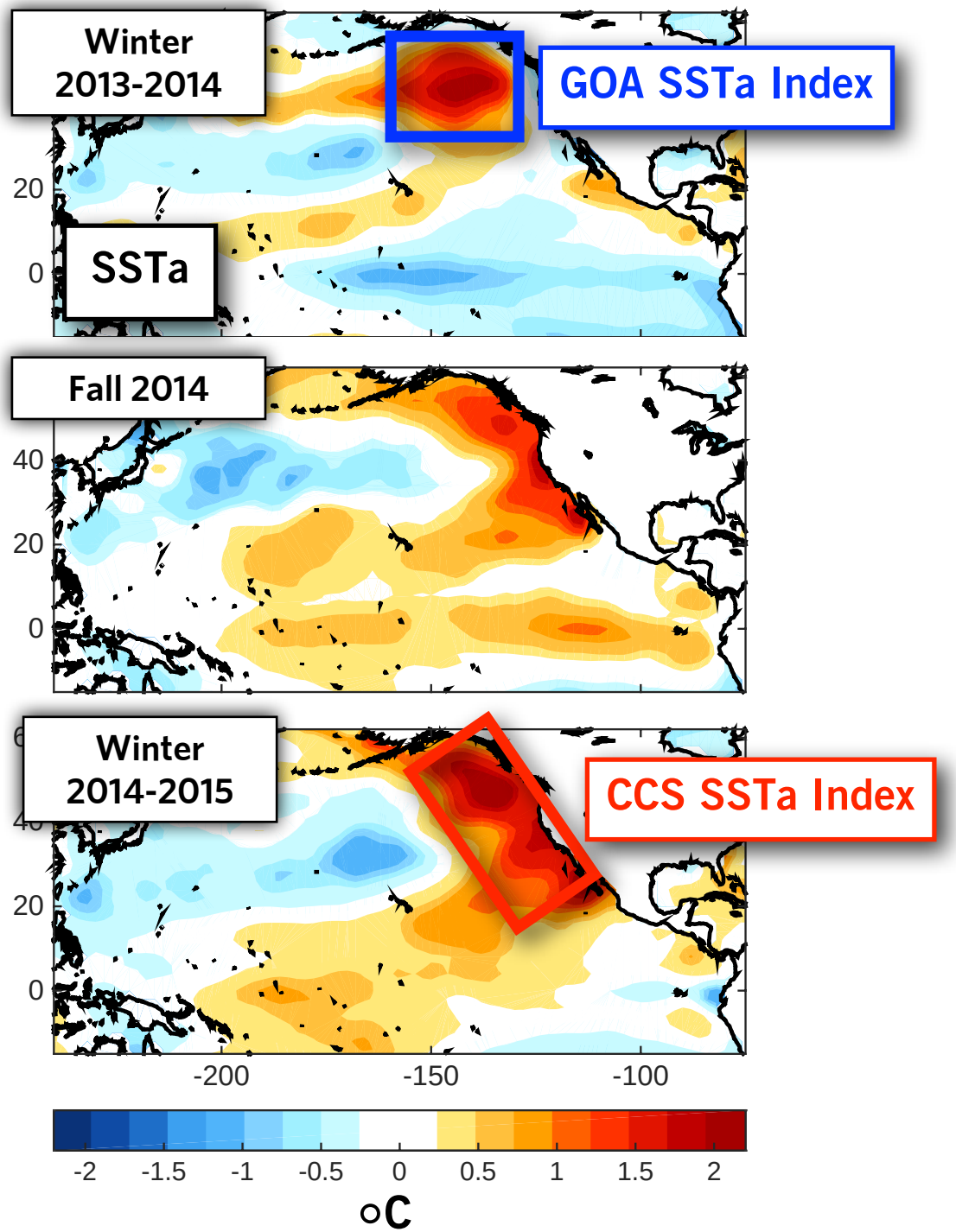
WARM BLOB

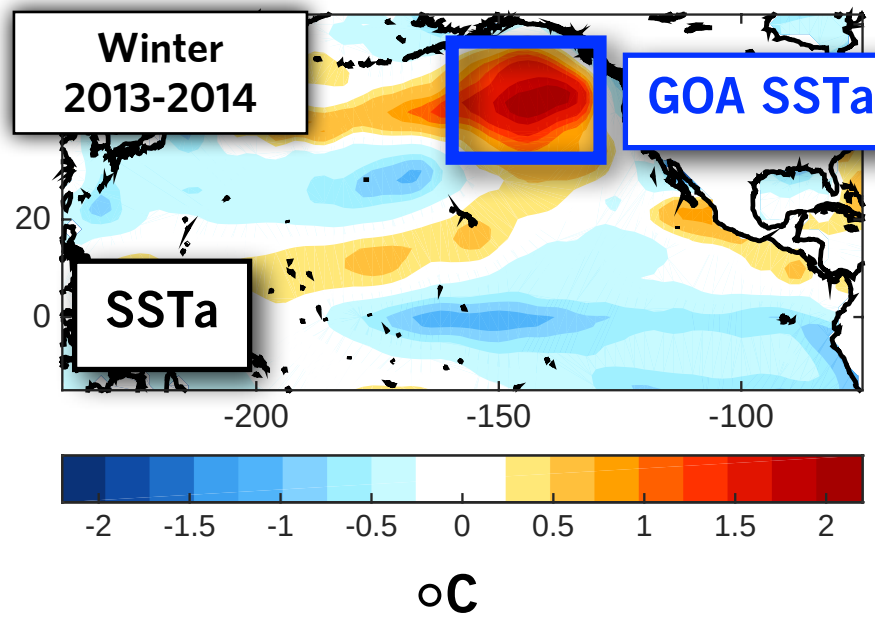
Evolution and persistence

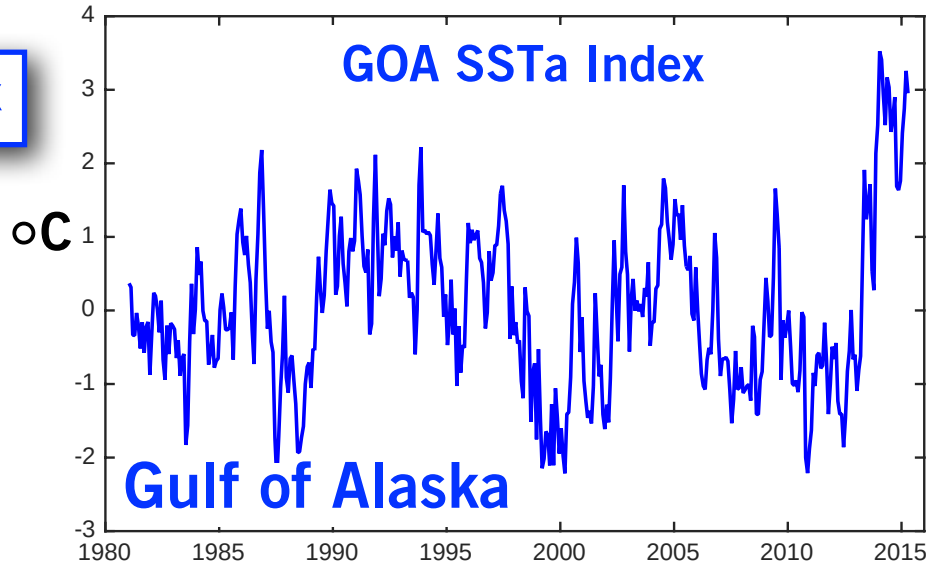


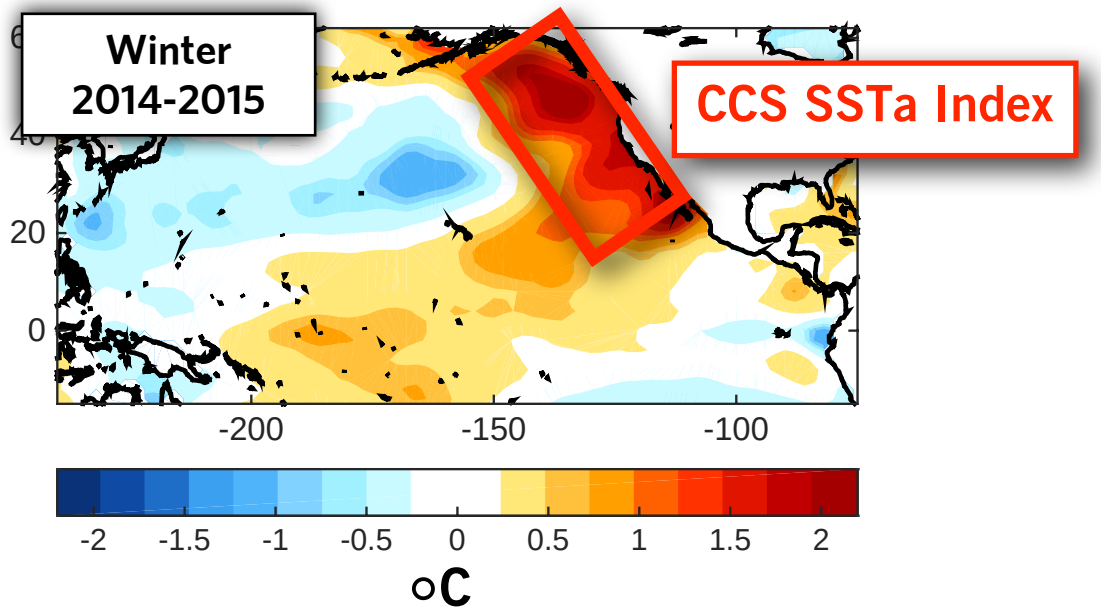
WARM BLOB

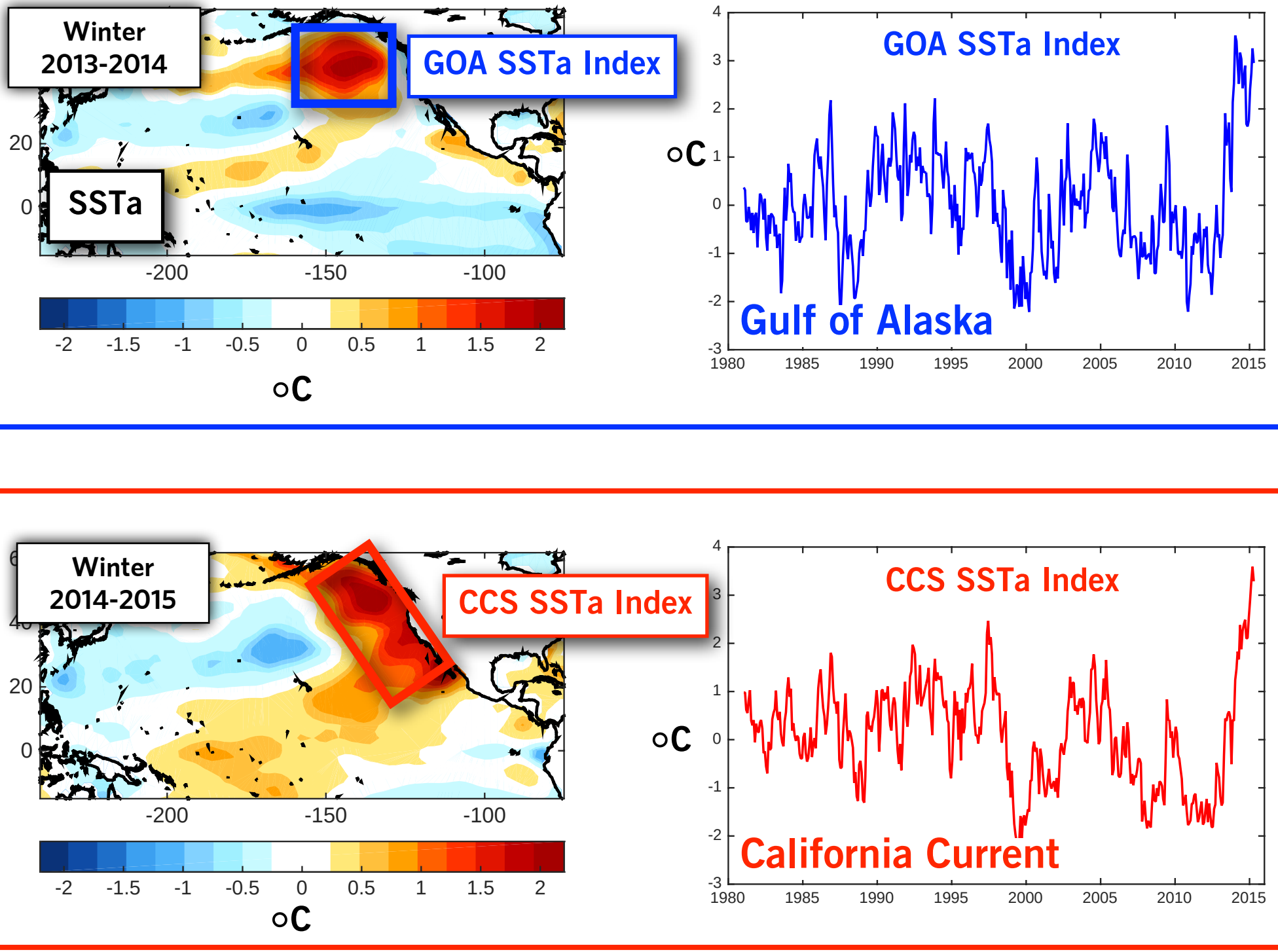
Evolution and persistence


Winter
2013-2014
GOA SSTa Index
SSTa
Fall 2014
Winter
2014-2015
CCS SSTa Index
20
0
40
20
0
20
0
-200
-150
-100
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
°C


Winter
2013-2014
GOA SSTa Index
SSTa
20
0
-200
-150
-100
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
°C


GOA SSTa Index
°C
4
3
2
1
0
-1
-2
-3
1980
1985
1990
1995
2000
2005
2010
2015
Gulf of Alaska


Winter
2014-2015
CCS SSTa Index
20
0
-200
-150
-100
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
°C


Winter
2013-2014
GOA SSTa Index
SSTa
20
0
-200
-150
-100
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
°C
GOA SSTa Index
°C
4
3
2
1
0
-1
-2
-3
1980
1985
1990
1995
2000
2005
2010
2015
Gulf of Alaska
Winter
2014-2015
CCS SSTa Index
20
0
-200
-150
-100
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
°C
CCS SSTa Index
°C
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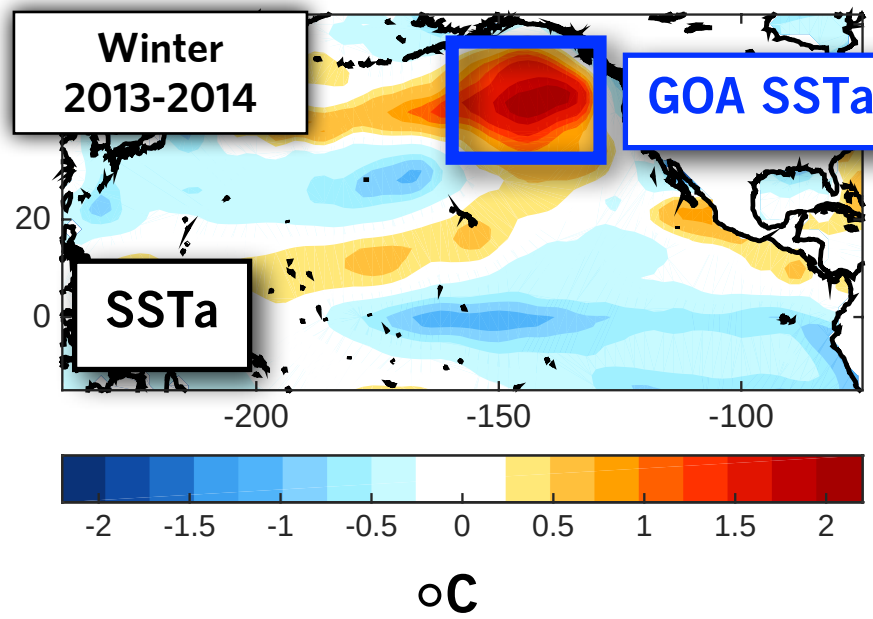
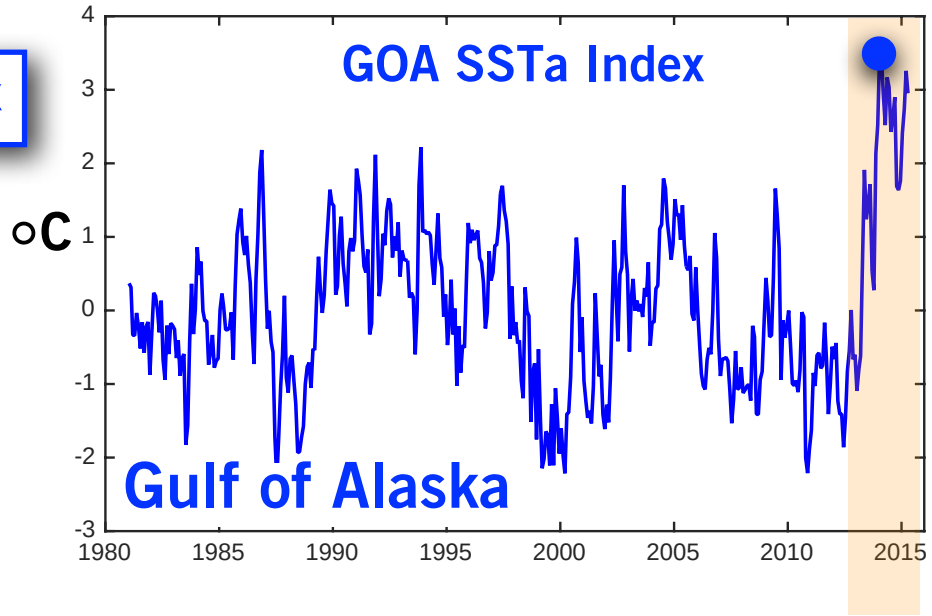
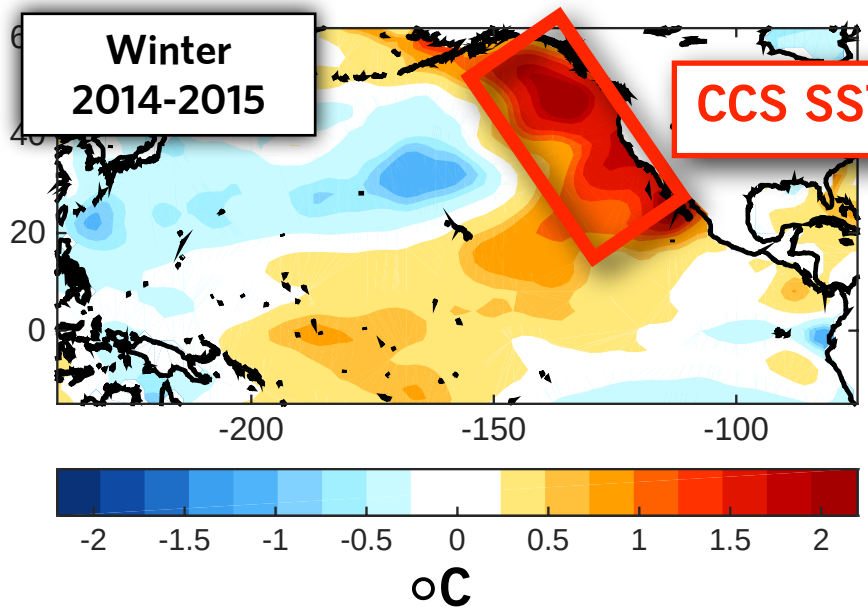
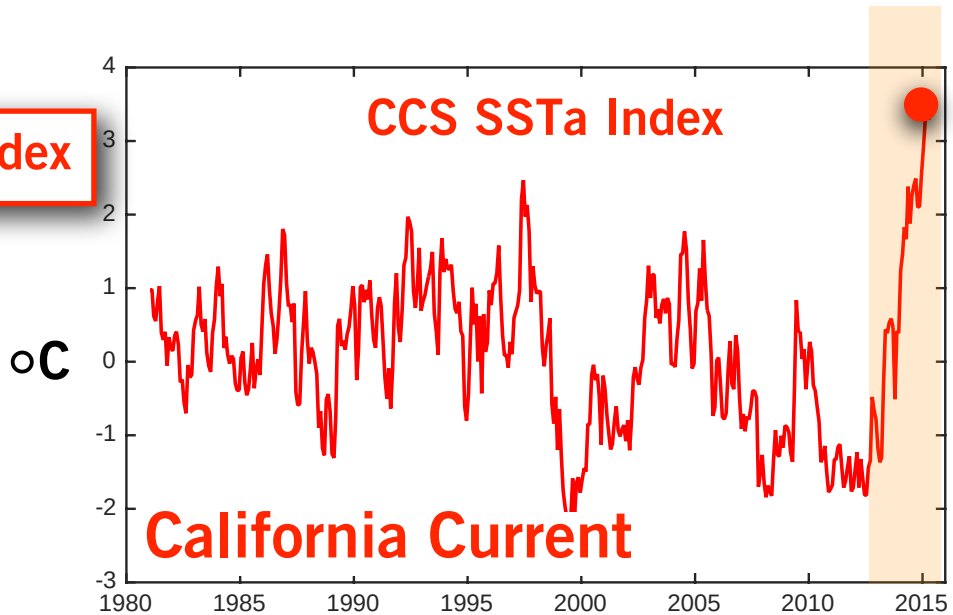
-3
1980
1985
1990
1995
2000
2005
2010
2015
California Current

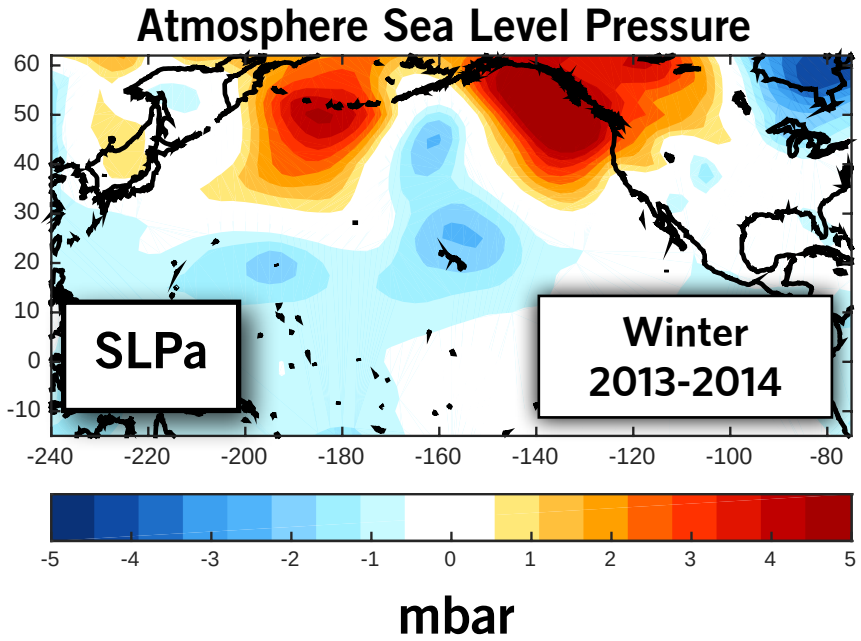


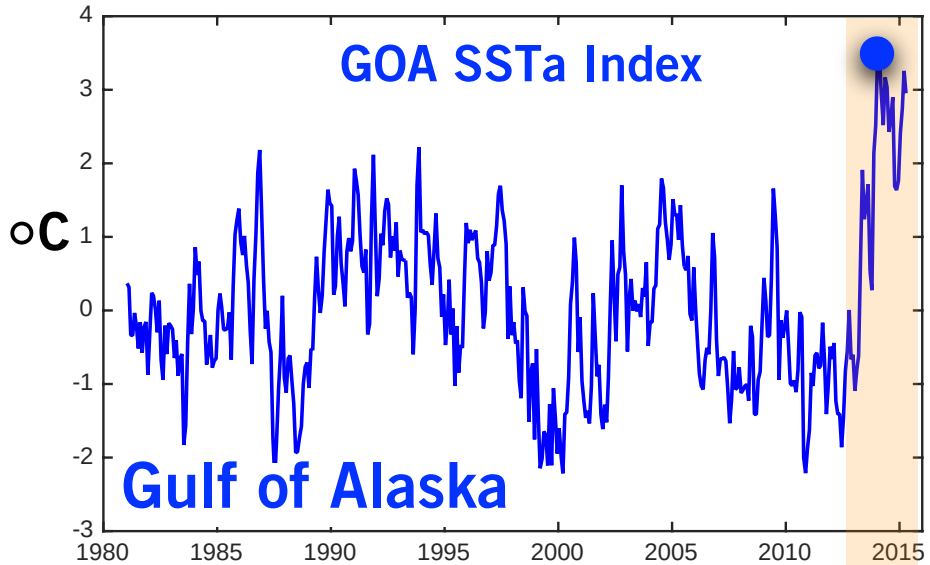


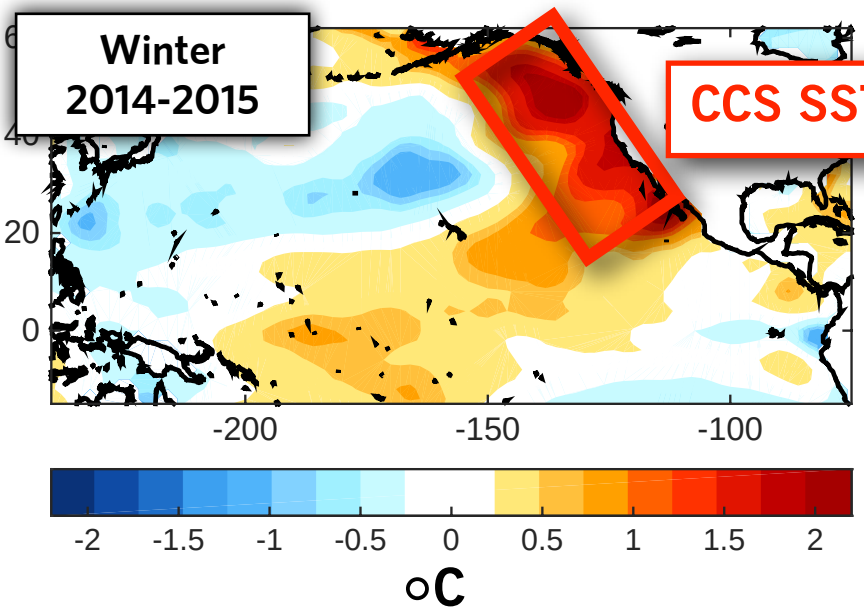
evolution of 2014/15

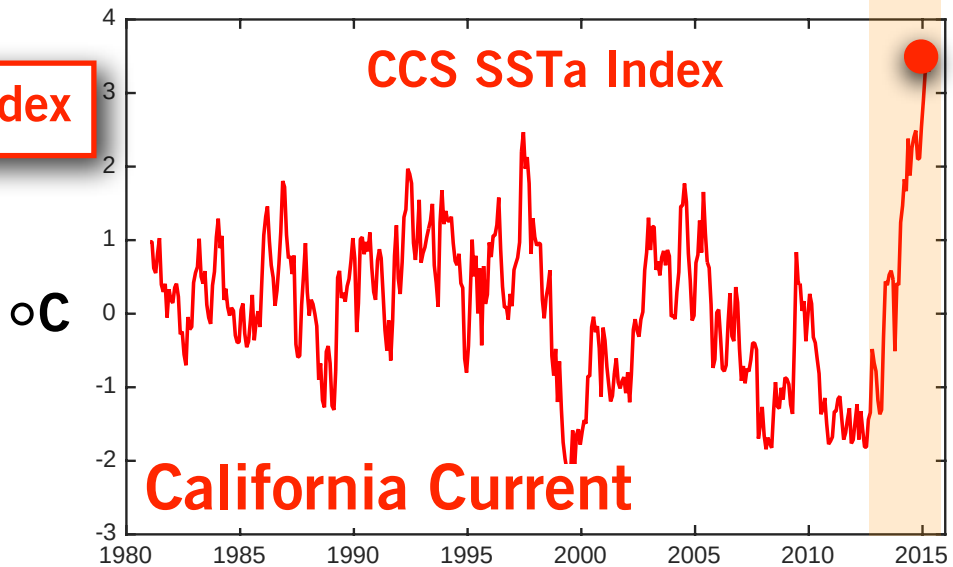


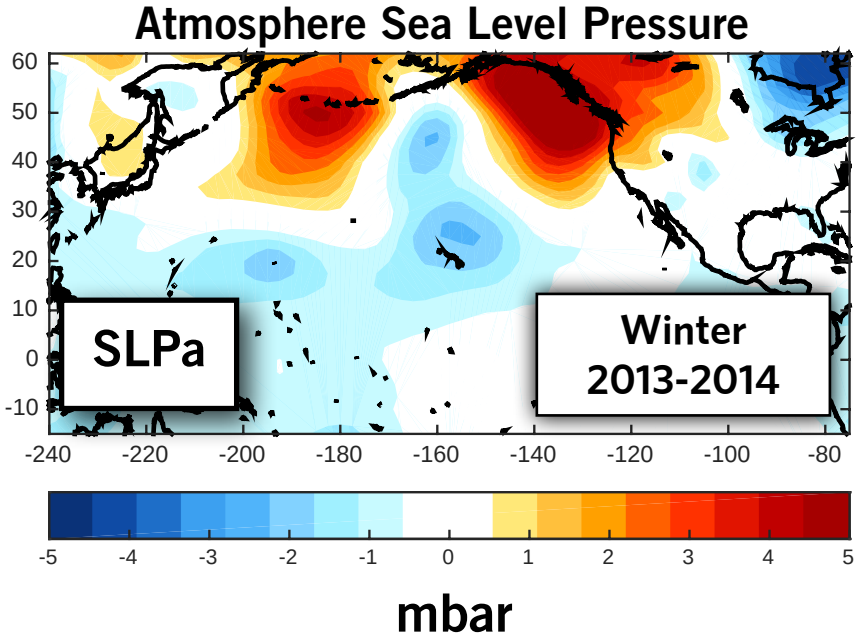


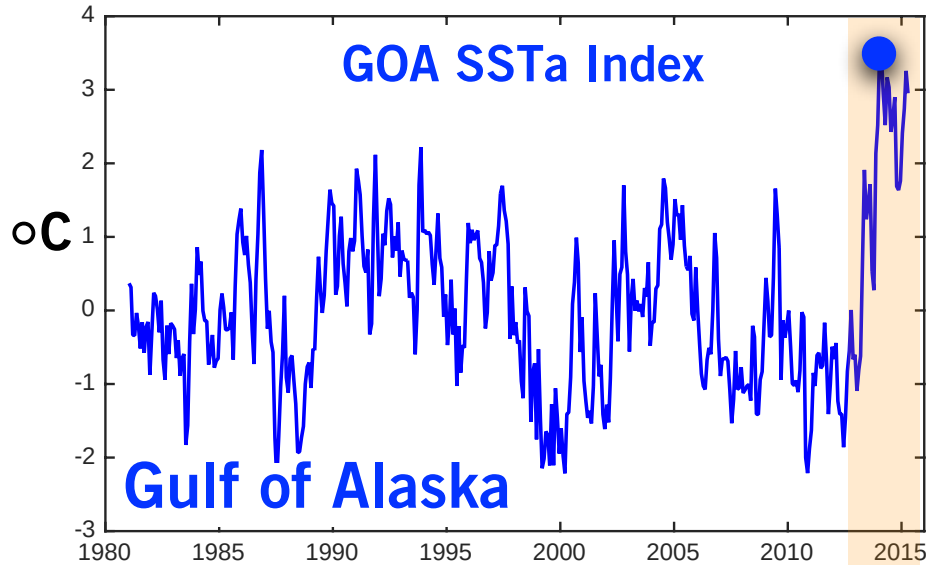

Atmosphere Sea Level Pressure
SLPa
Winter
2013-2014
mbar

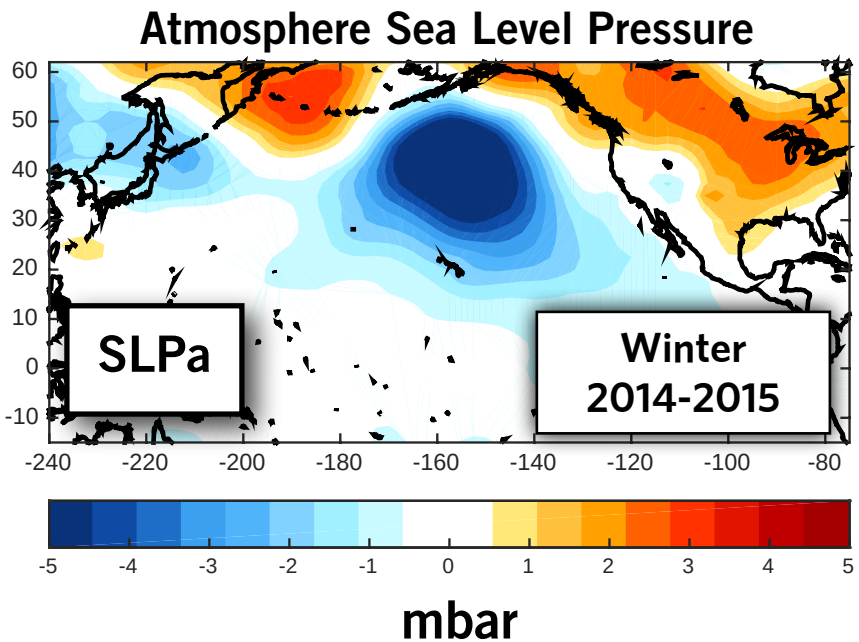

GOA SSTa Index
°C
Gulf of Alaska

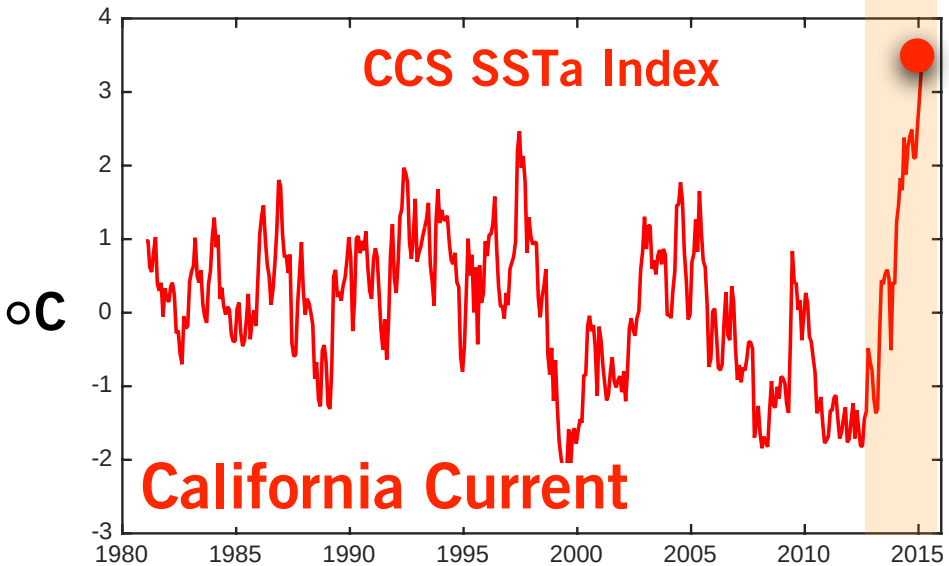

Winter
2014-2015
CCS SSTa Index
°C

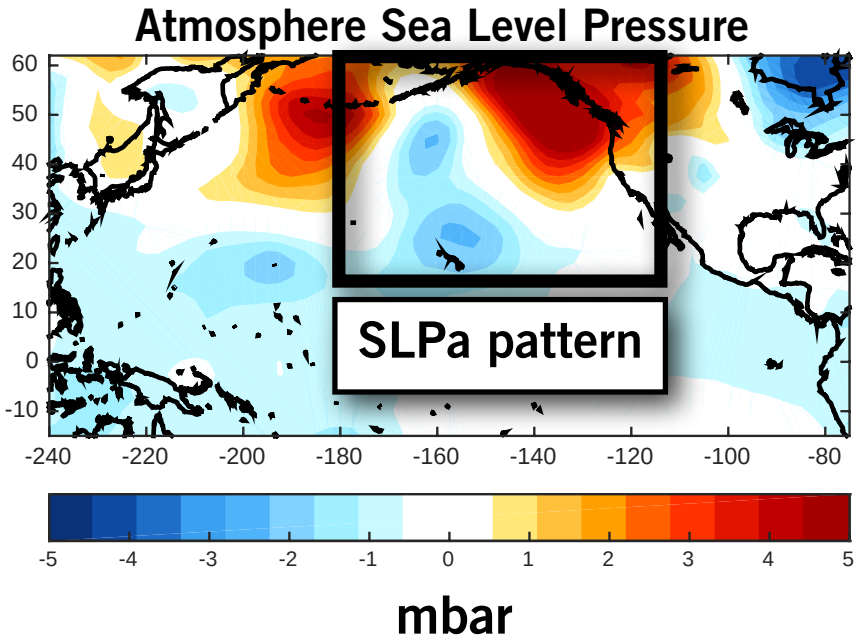

CCS SSTa Index
°C
California Current

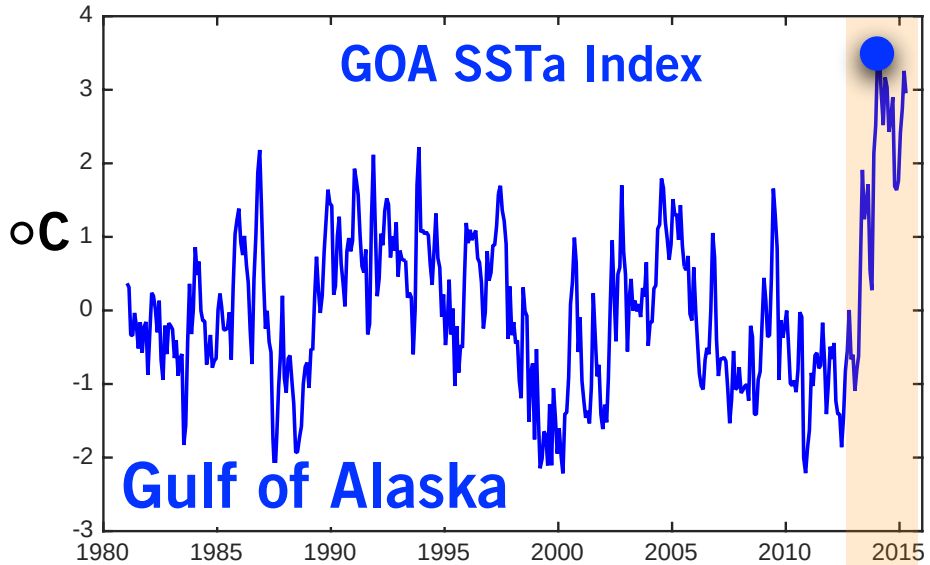

Atmosphere Sea Level Pressure
SLPa
Winter
2013-2014
mbar

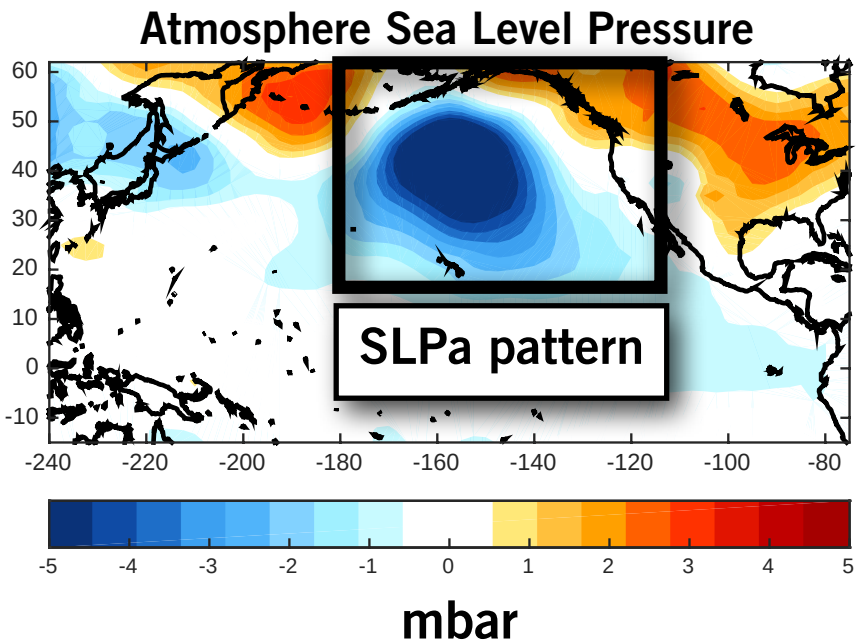

GOA SSTa Index
°C
Gulf of Alaska

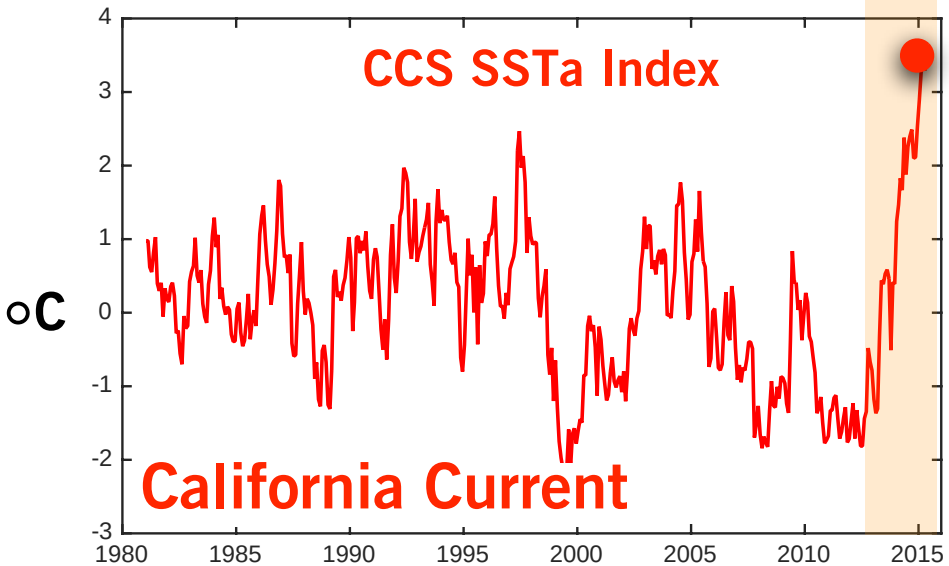

Atmosphere Sea Level Pressure
SLPa
Winter
2014-2015
mbar

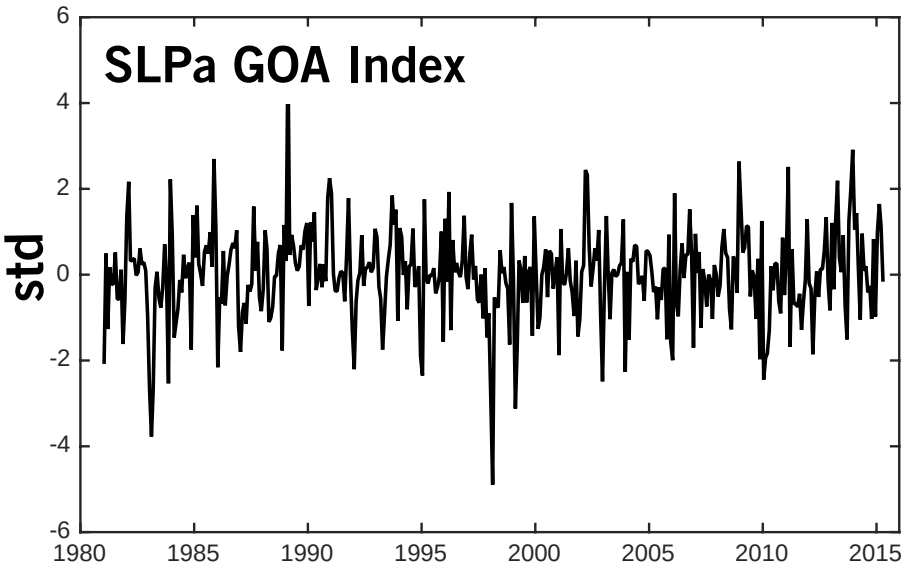

CCS SSTa Index
°C
California Current

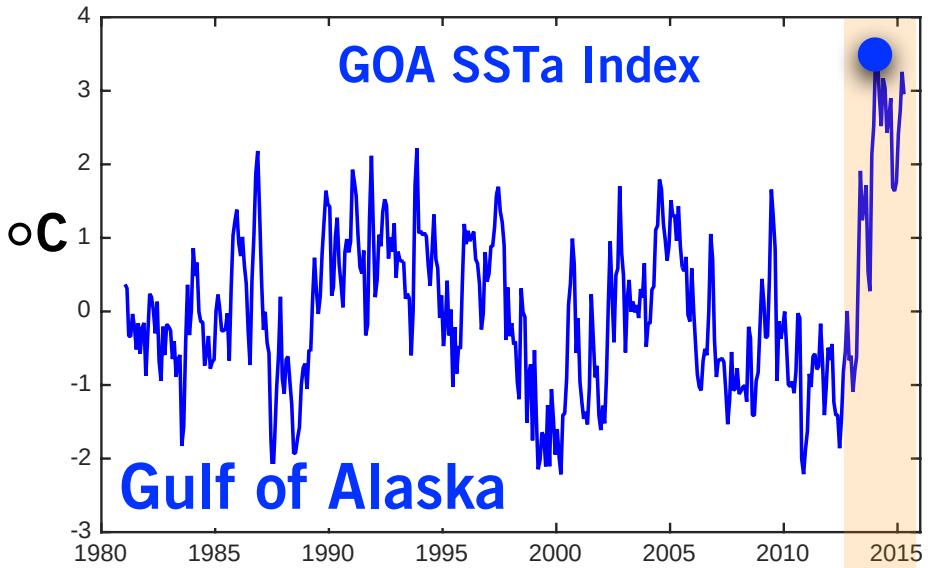

Atmosphere Sea Level Pressure
SLPa pattern
mbar


GOA SSTa Index
Gulf of Alaska
°C


Atmosphere Sea Level Pressure
SLPa pattern
mbar


CCS SSTa Index
California Current
°C


SLPa GOA Index
std
6
4
2
0
-2
-4
-6
1980
1985
1990
1995
2000
2005
2010
2015


GOA SSTa Index
°C
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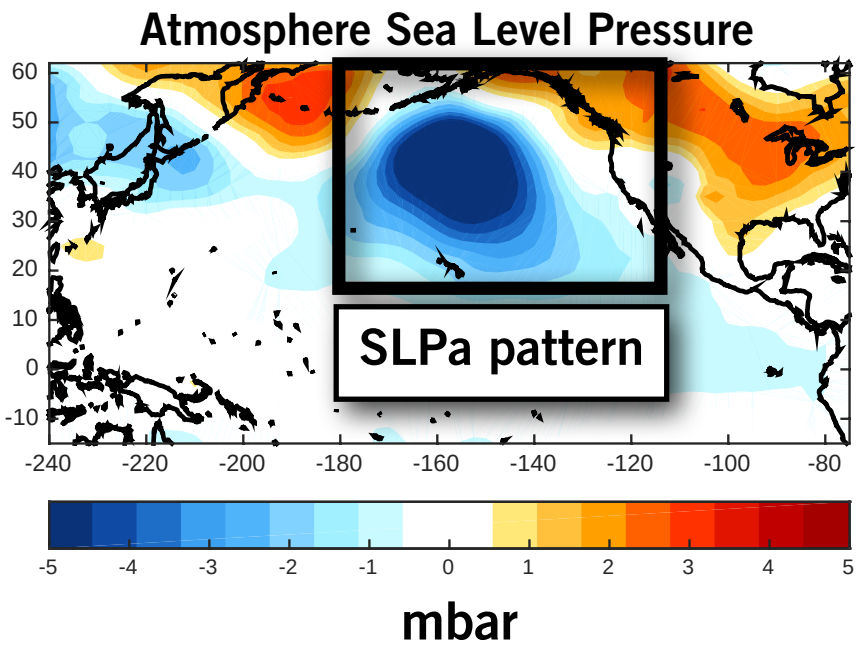
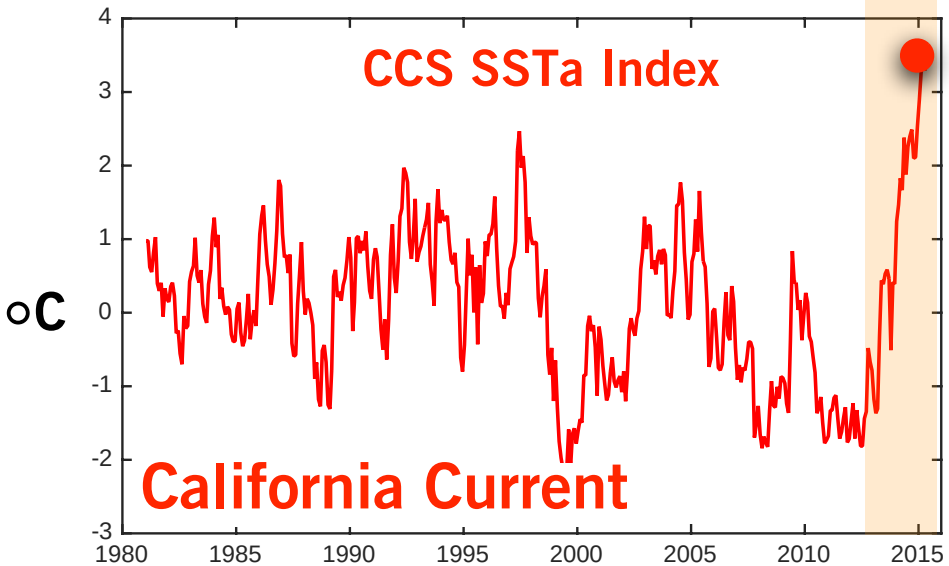
2015


Atmosphere Sea Level Pressure
60
50
40
30
20
10
0
-10
SLPa pattern
-240
-220
-200
-180
-160
-140
-120
-100
-80
-5
-4
-3
-2
-1
0
1
2
3
4
5
mbar


CCS SSTa Index
°C
4
3
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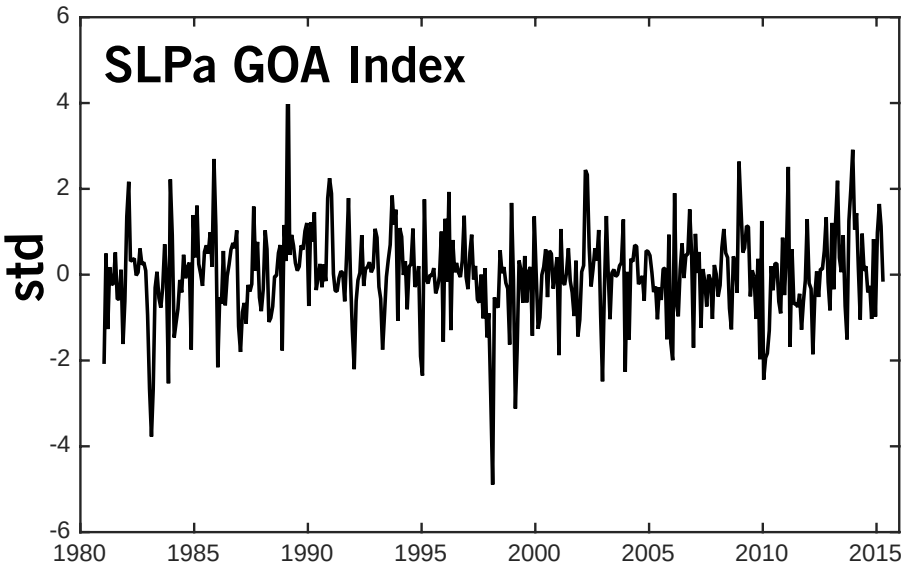
-3
California Current
1980
1985
1990
1995
2000
2005
2010
2015


SLPa GOA Index
std
6
4
2
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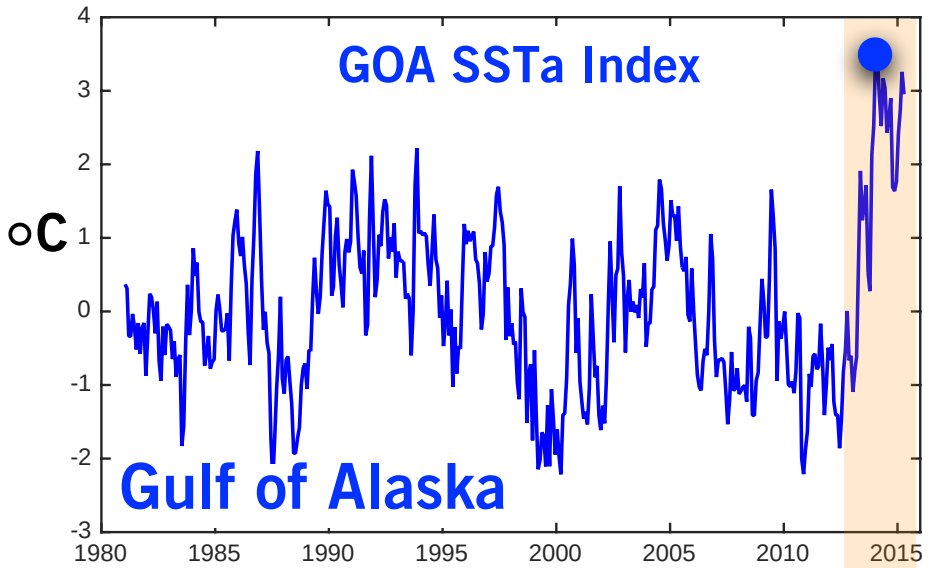
-2
-4
-6
1980
1985
1990
1995
2000
2005
2010
2015


GOA SSTa Index
°C
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Gulf of Alaska
1980
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2005
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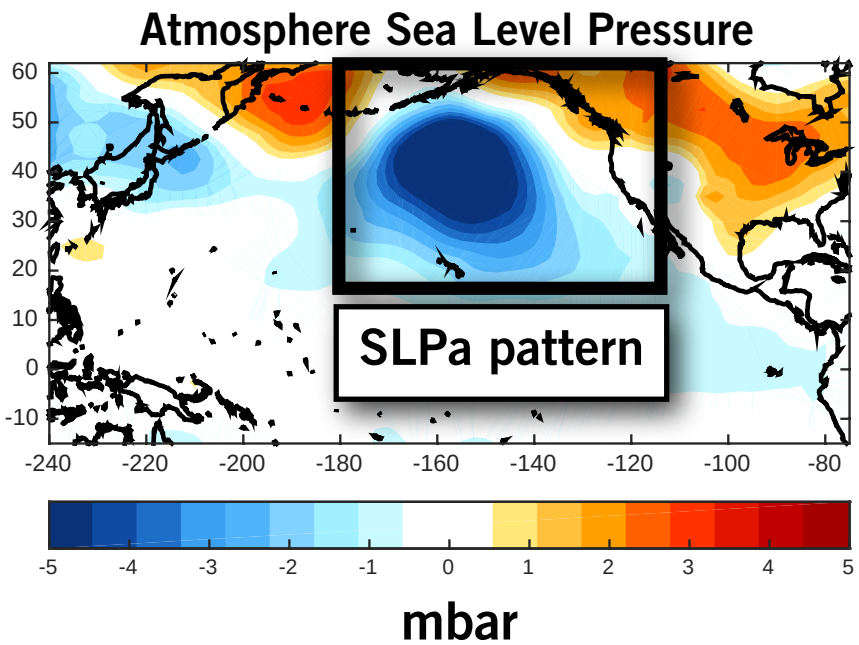
2015


Atmosphere Sea Level Pressure
60
50
40
30
20
10
0
-10
SLPa pattern
-240
-220
-200
-180
-160
-140
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-80
-5
-4
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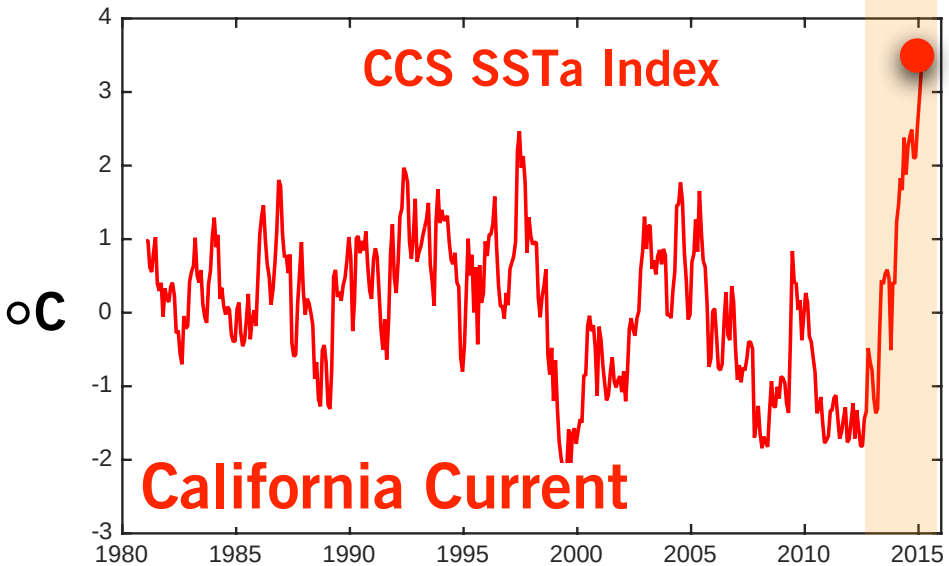
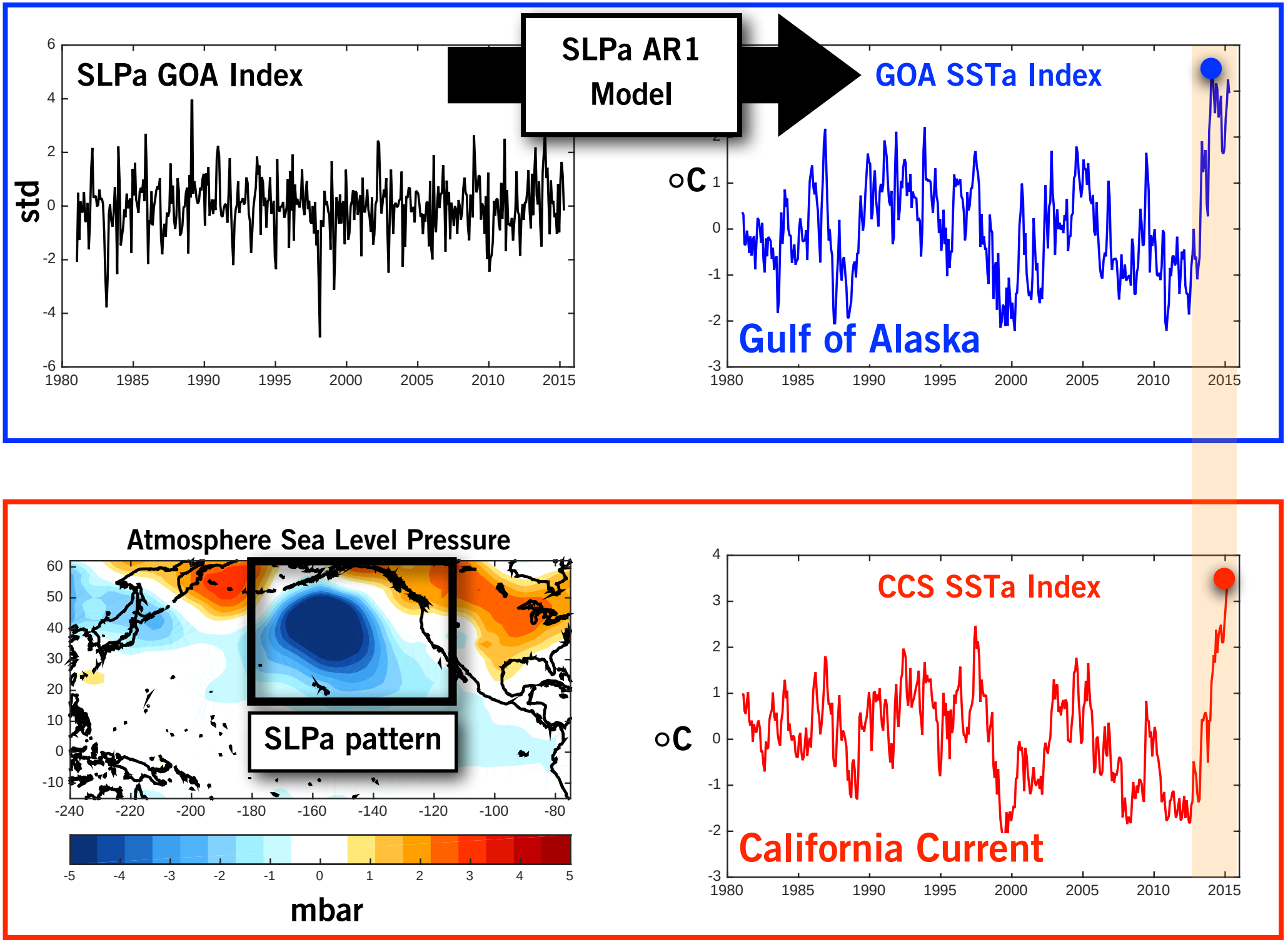
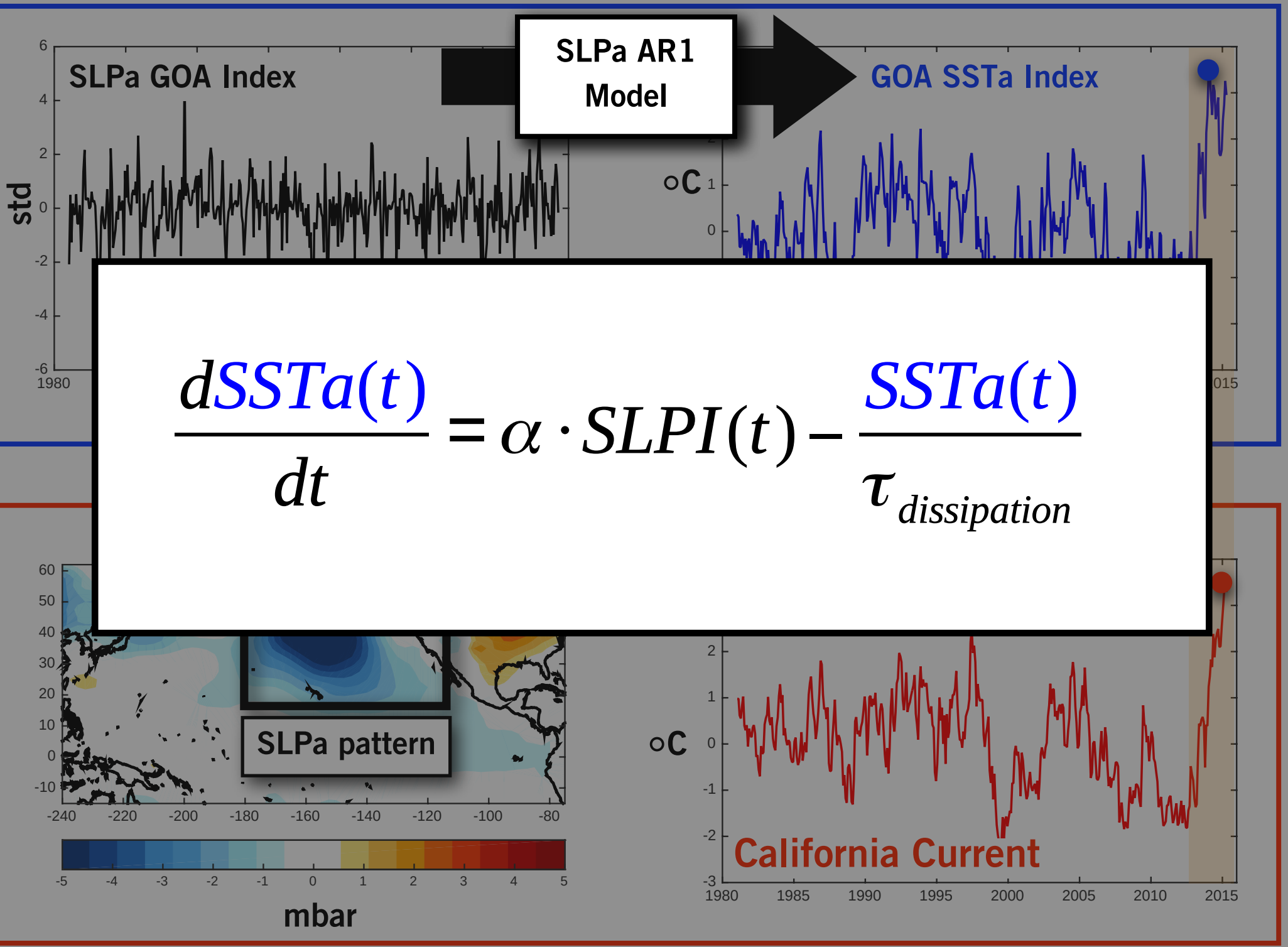
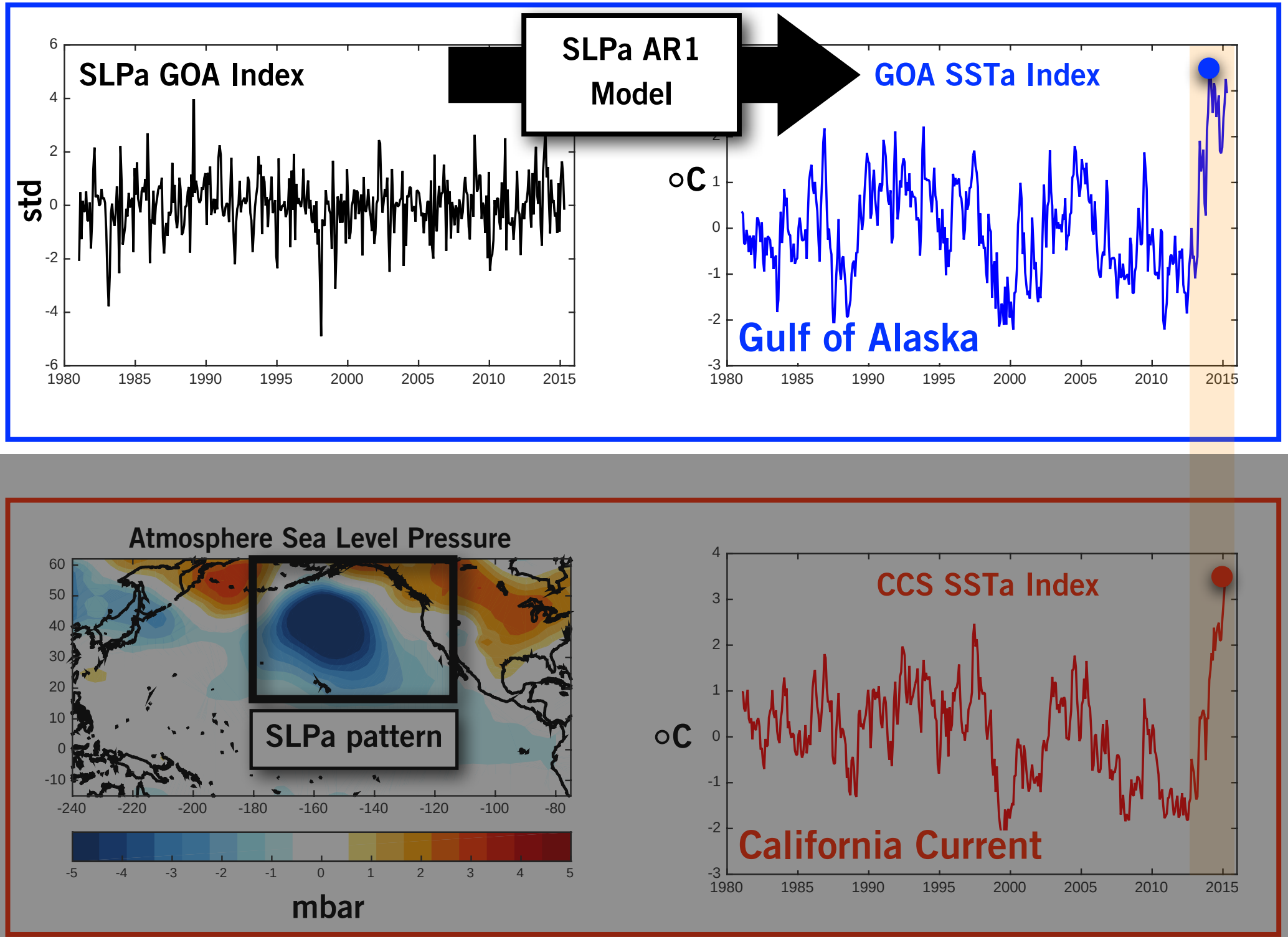
-2
-1
0
1
2
3
4
5
mbar

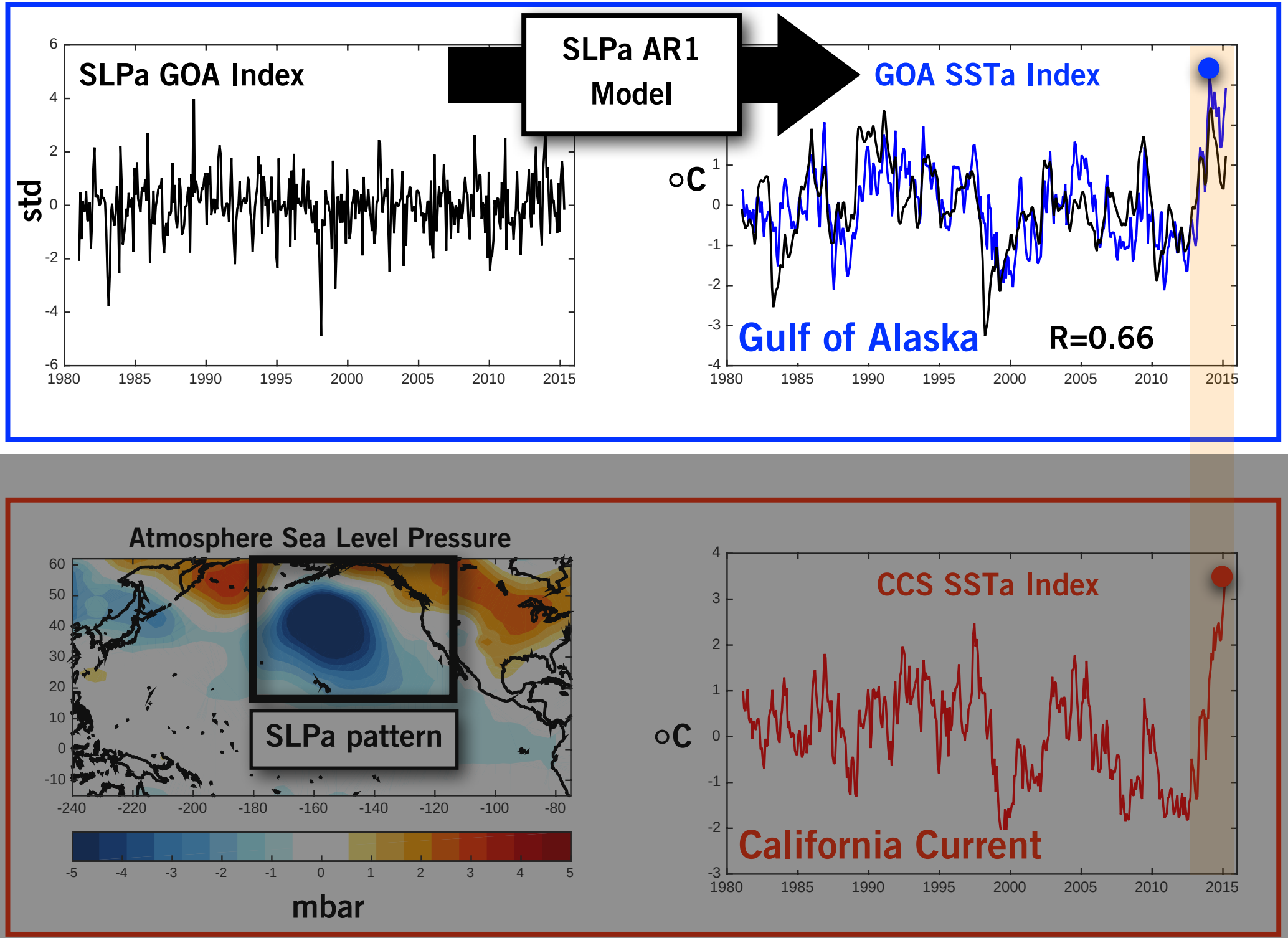

CCS SSTa Index
°C
4
3
2
1
0
-1
-2
-3
California Current
1980
1985
1990
1995
2000
2005
2010
2015

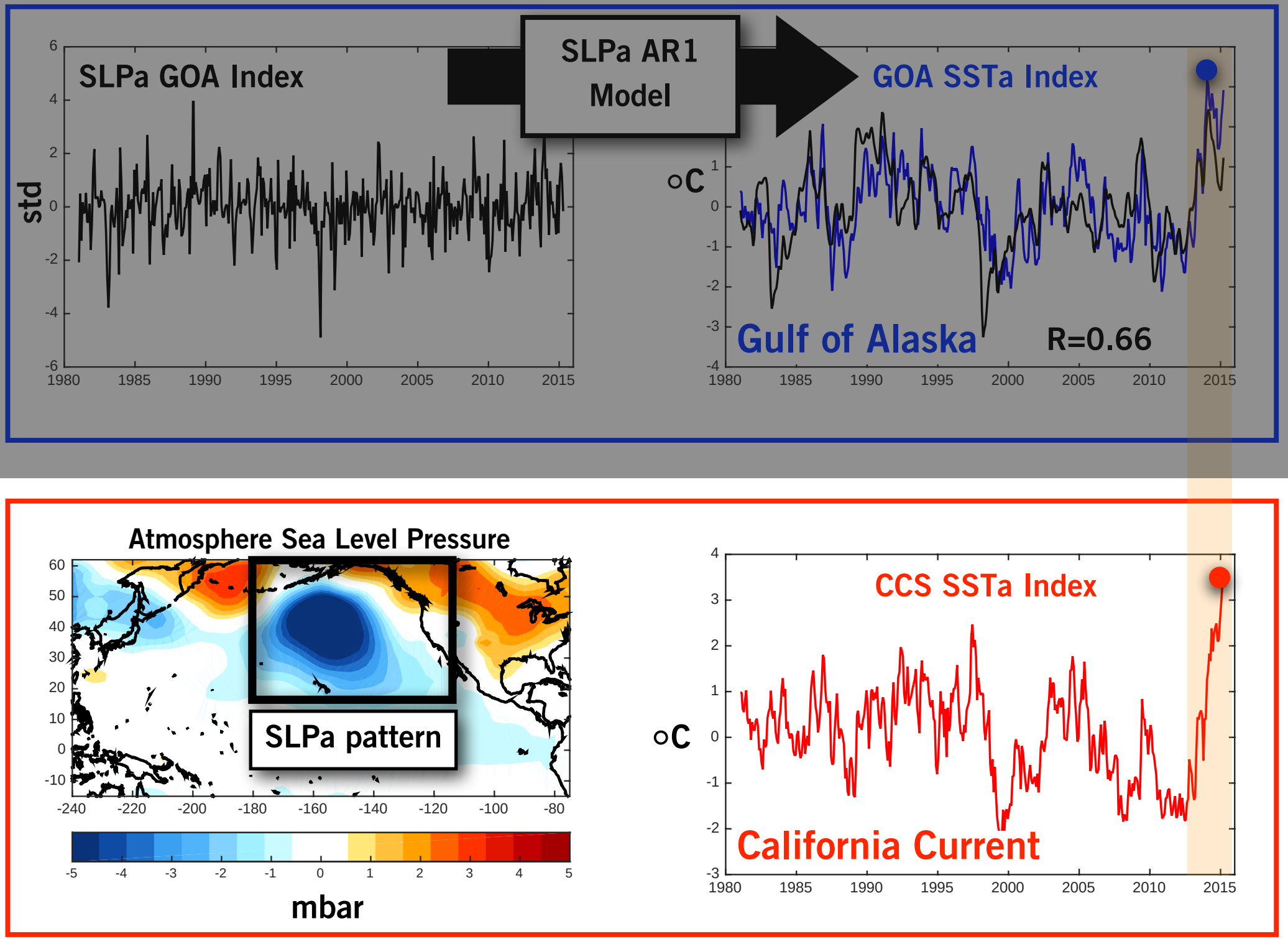
$$\frac{dSSTa(t)}{dt} = \alpha \cdot SLPI(t) - \frac{SSTa(t)}{\tau_{dissipation}}$$

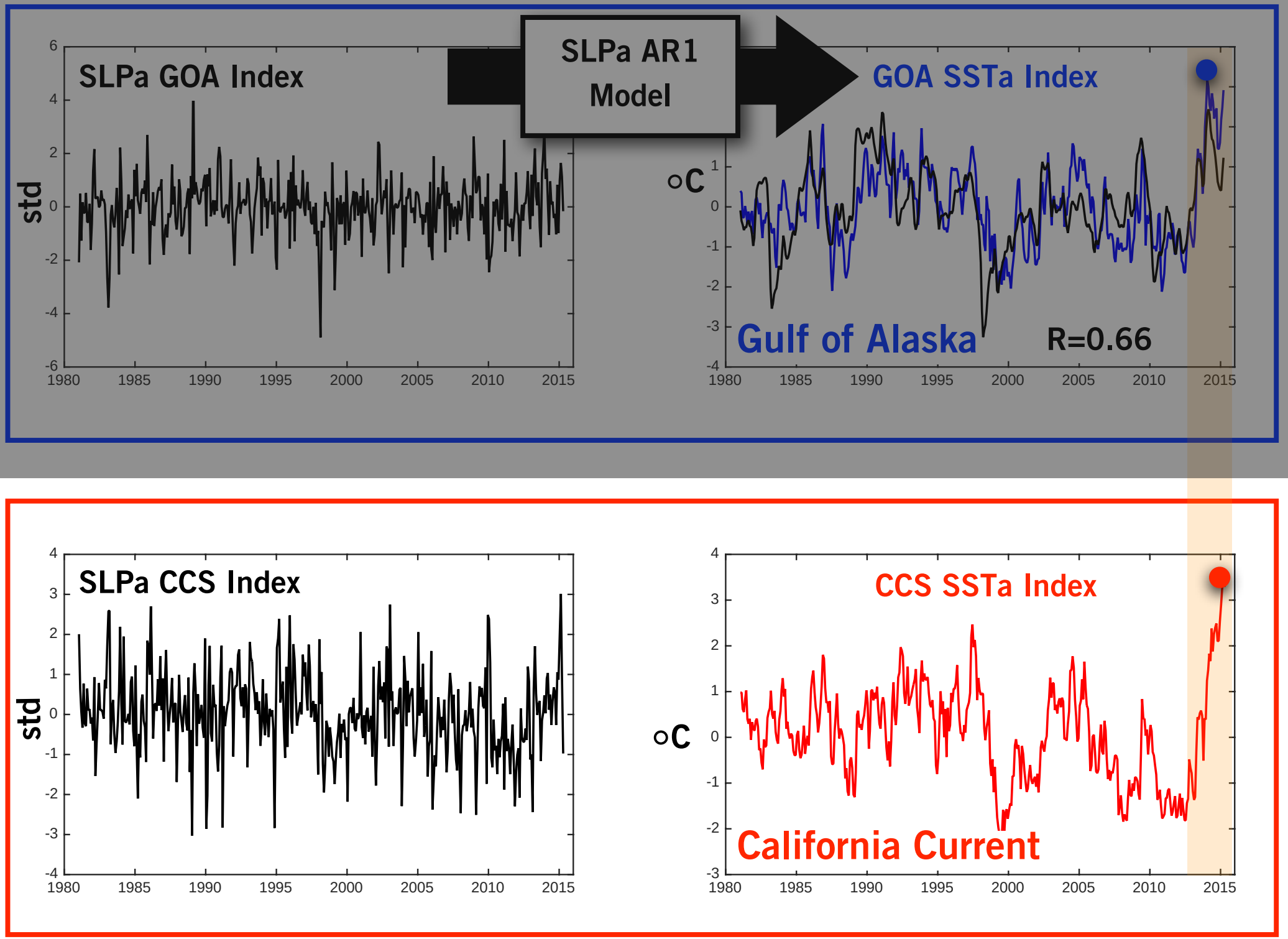

SLPa GOA Index
std
SLPa AR1 Model
GOA SSTa Index
°C
Gulf of Alaska
Atmosphere Sea Level Pressure
SLPa pattern
mbar
CCS SSTa Index
°C
California Current

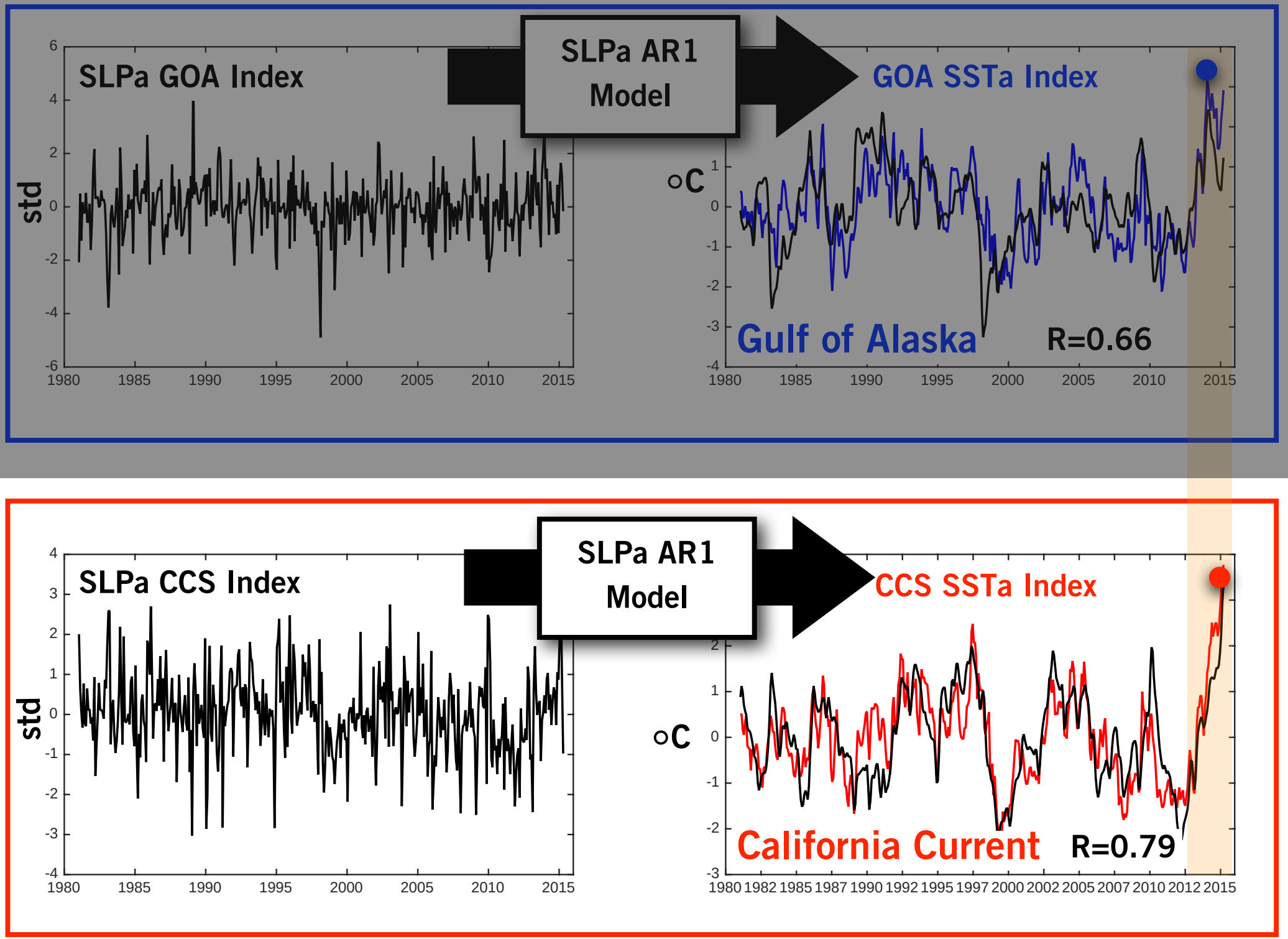

SLPa GOA Index
std
SLPa AR1 Model
GOA SSTa Index
°C
$\frac{dSSTa(t)}{dt} = \alpha \cdot SLPI(t) - \frac{SSTa(t)}{\tau_{dissipation}}$
SLPa pattern
mbar
California Current
°C

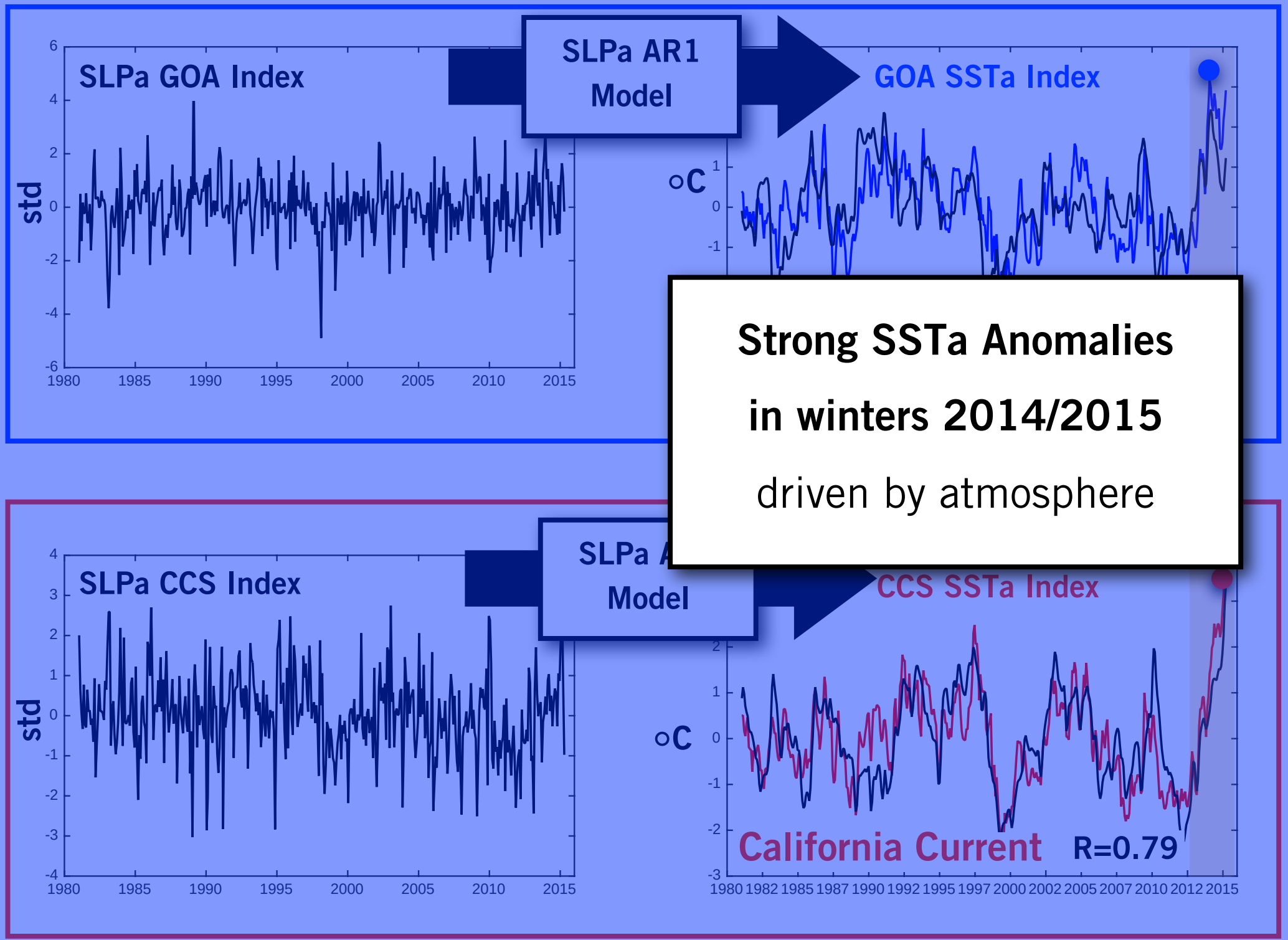

SLPa GOA Index
std
SLPa AR1 Model
GOA SSTa Index
°C
Gulf of Alaska
Atmosphere Sea Level Pressure
SLPa pattern
mbar
CCS SSTa Index
°C
California Current

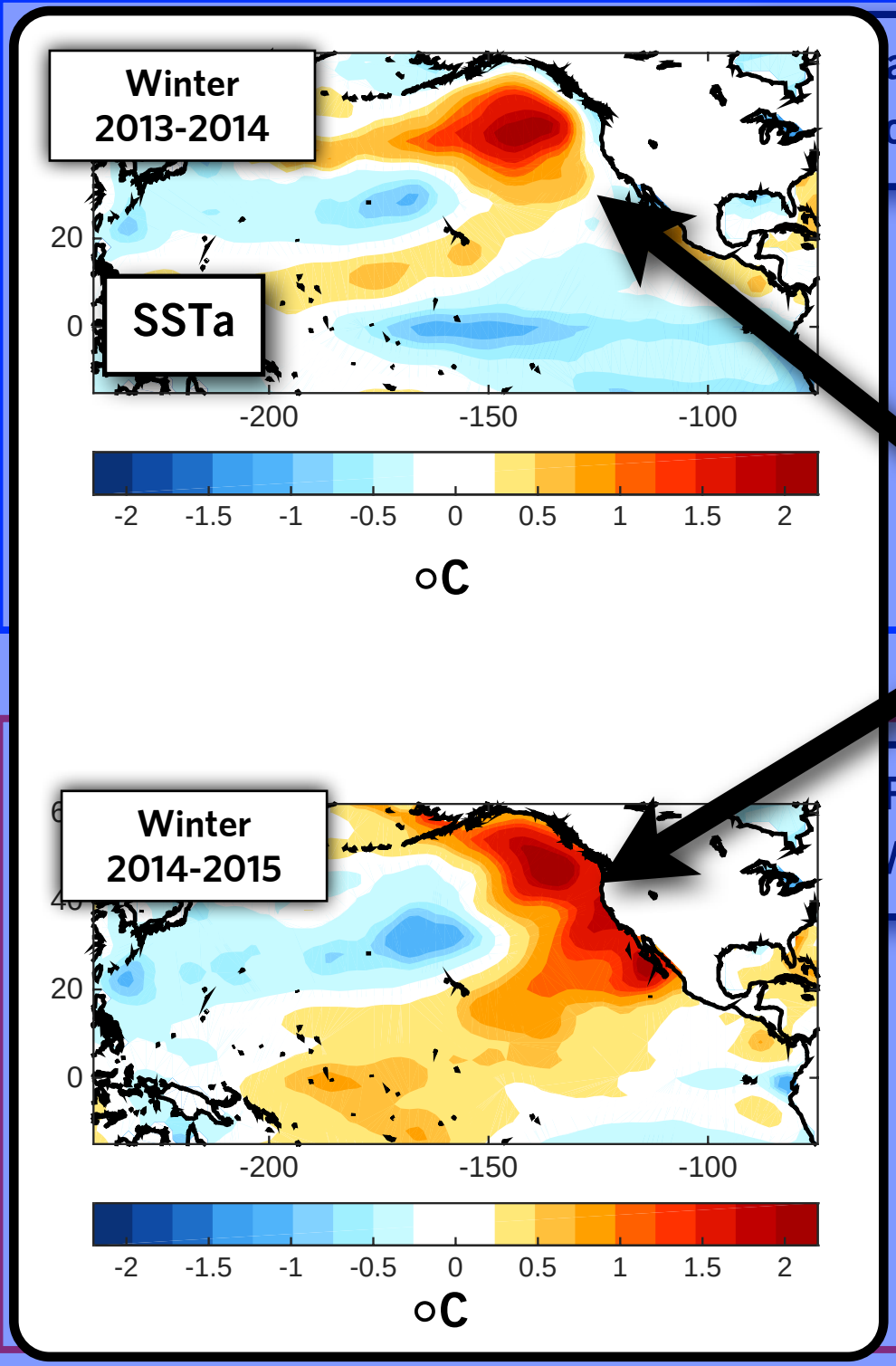

SLPa GOA Index
std
SLPa AR1 Model
GOA SSTa Index
°C
Gulf of Alaska
R=0.66
Atmosphere Sea Level Pressure
SLPa pattern
mbar
CCS SSTa Index
°C
California Current


SLPa GOA Index
std
SLPa AR1 Model
GOA SSTa Index
°C
Gulf of Alaska
R=0.66
Atmosphere Sea Level Pressure
SLPa pattern
mbar
CCS SSTa Index
°C
California Current


SLPa GOA Index
std
SLPa AR1 Model
GOA SSTa Index
°C
Gulf of Alaska
R=0.66
SLPa CCS Index
std
CCS SSTa Index
°C
California Current
1980
1985
1990
1995
2000
2005
2010
2015


SLPa GOA Index
std
SLPa AR1 Model
GOA SSTa Index
°C
Gulf of Alaska
R=0.66
SLPa CCS Index
std
SLPa AR1 Model
CCS SSTa Index
°C
California Current
R=0.79


SLPa GOA Index
std
SLPa AR1 Model
GOA SSTa Index
°C
Strong SSTa Anomalies
in winters 2014/2015
driven by atmosphere
SLPa CCS Index
std
SLPa A
Model
CCS SSTa Index
°C
California Current
R=0.79



a AR1
odel

GOA SSTa Index

°C

1
0
-1

Strong SSTa Anomalies
in winters 2014/2015
driven by atmosphere

Pa A
Model

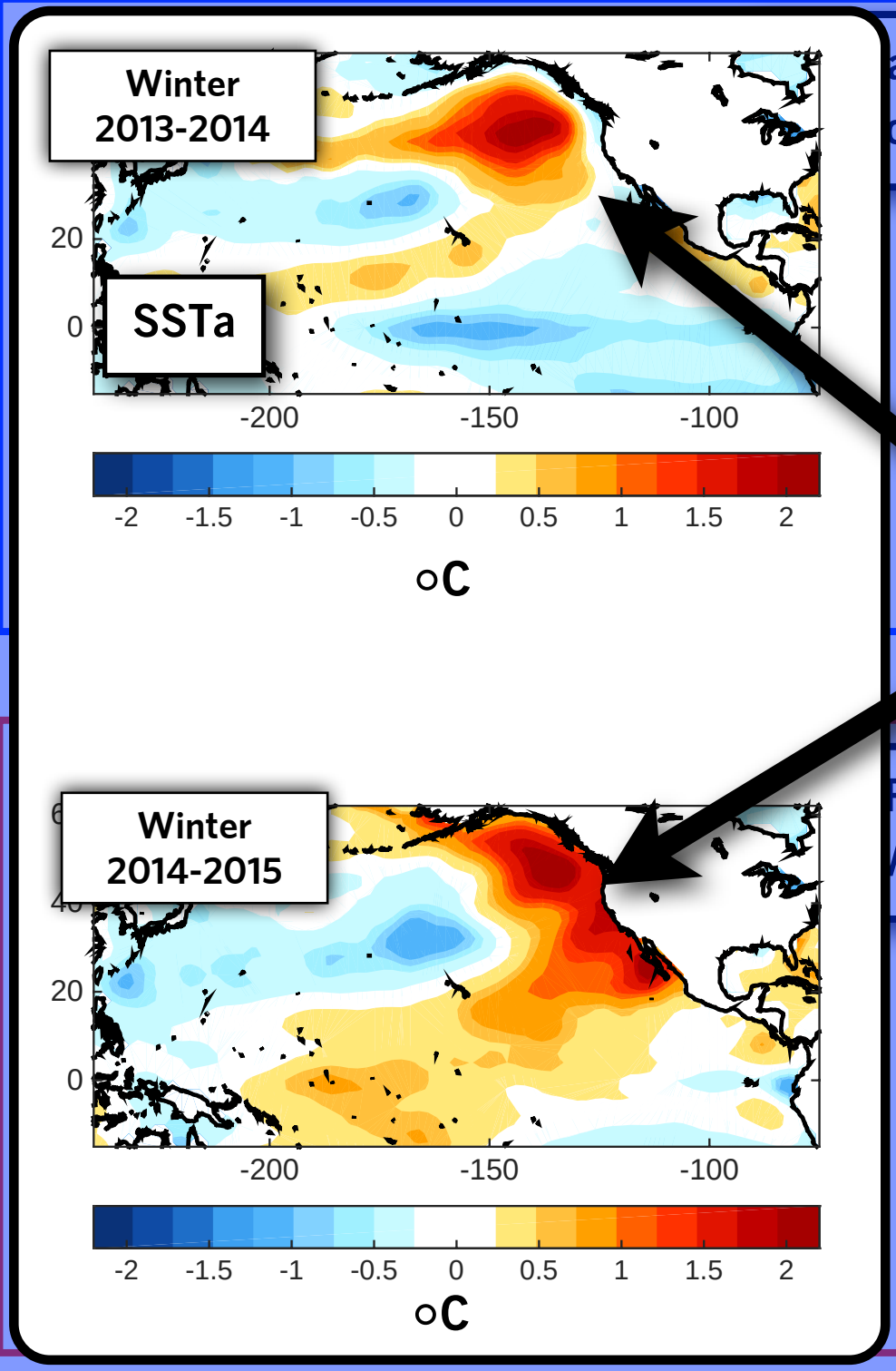
CCS SSTa Index

°C

2
1
0
-1
-2
-3

California Current R=0.79

1980 1982 1985 1987 1990 1992 1995 1997 2000 2002 2005 2007 2010 2012 2015



a AR1
odel

GOA SSTa Index

°C

1
0
-1

Pa A
Model

CCS SSTa Index

°C

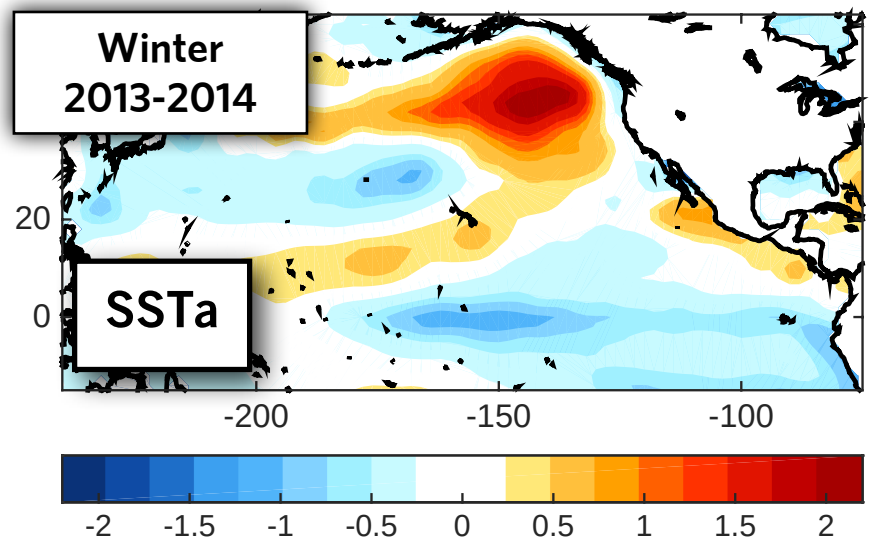
2
1
0
-1
-2
-3

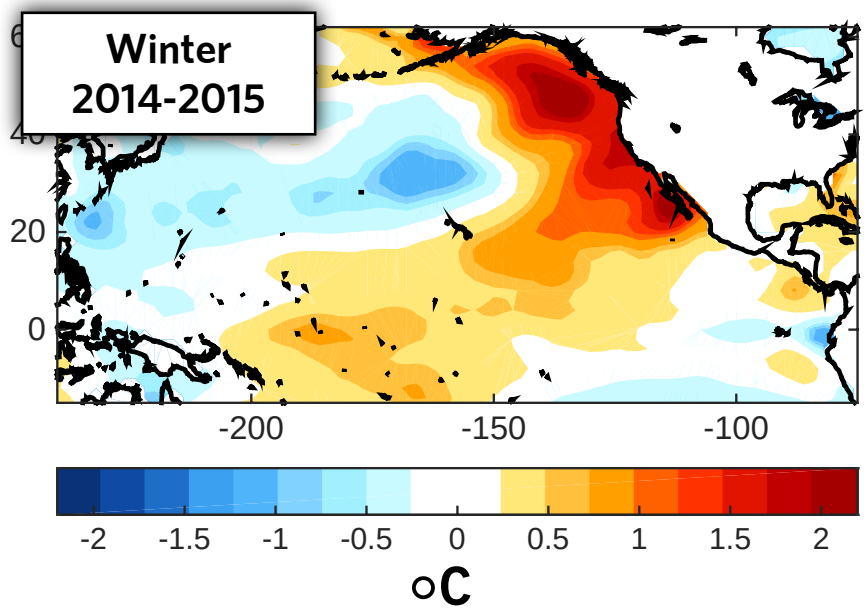
California Current R=0.79

1980 1982 1985 1987 1990 1992 1995 1997 2000 2002 2005 2007 2010 2012 2015

QUESTION:

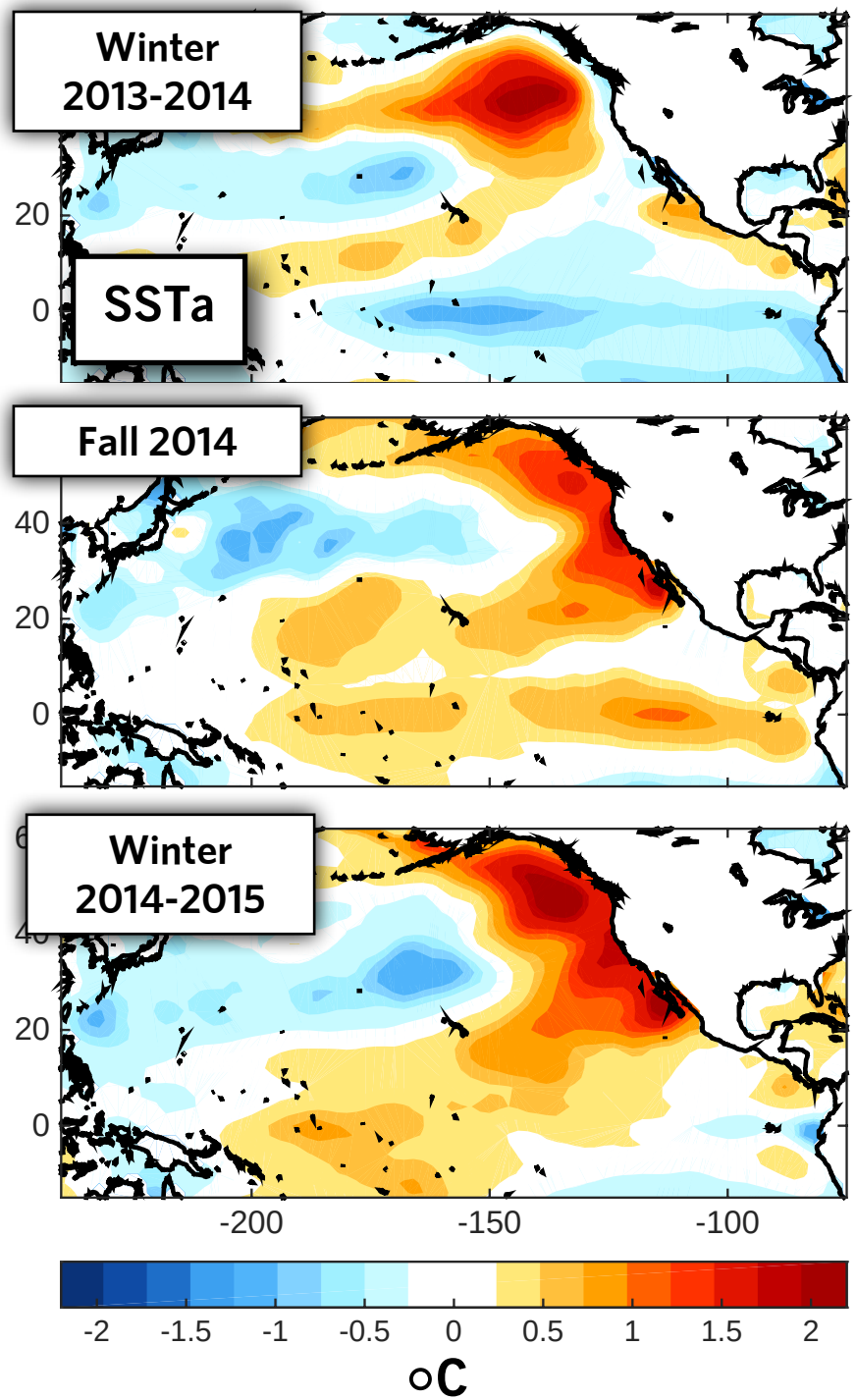
Are the 2014 and 2015 anomalies linked?





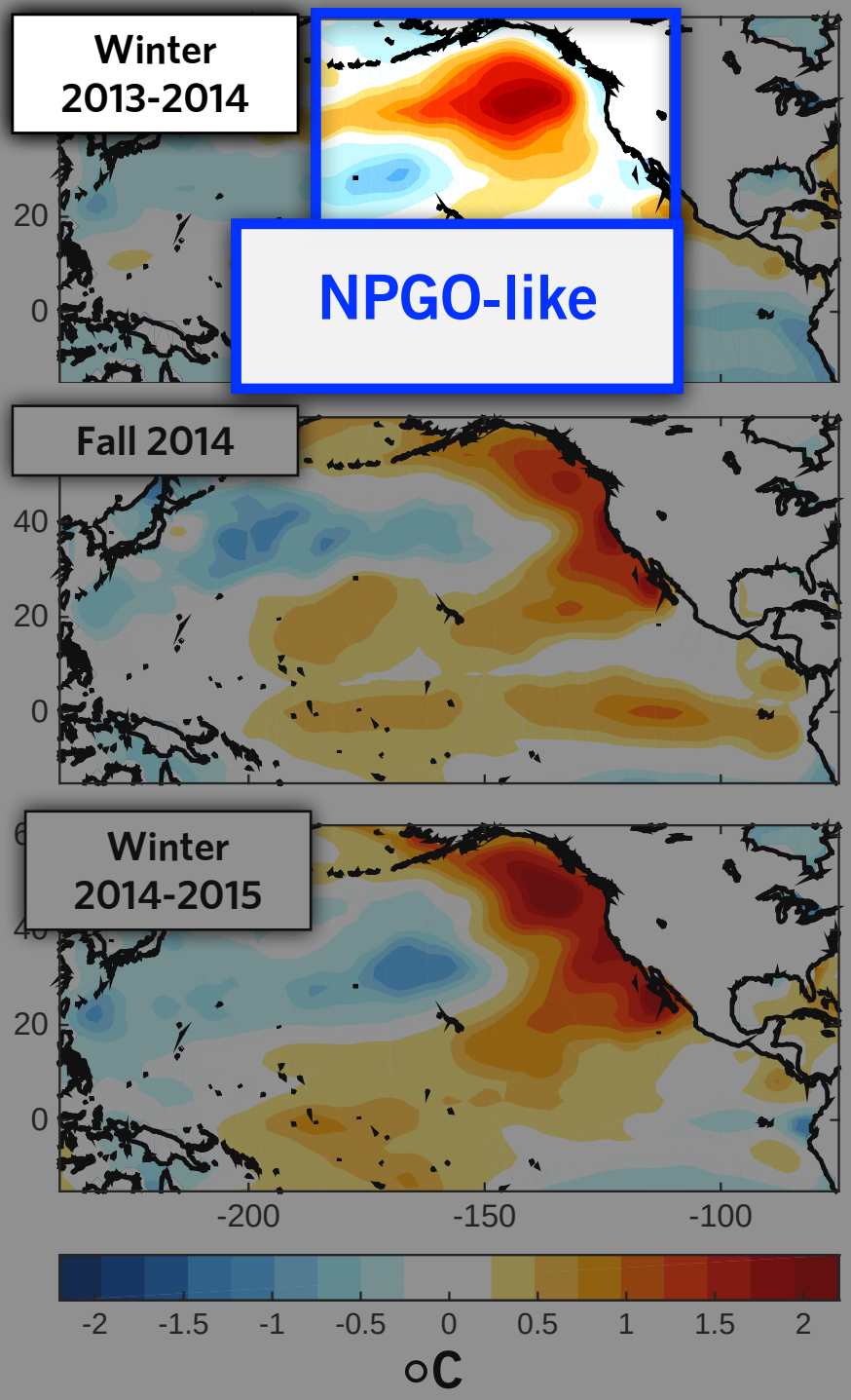
QUESTION:

Are the 2014 and 2015 anomalies linked?



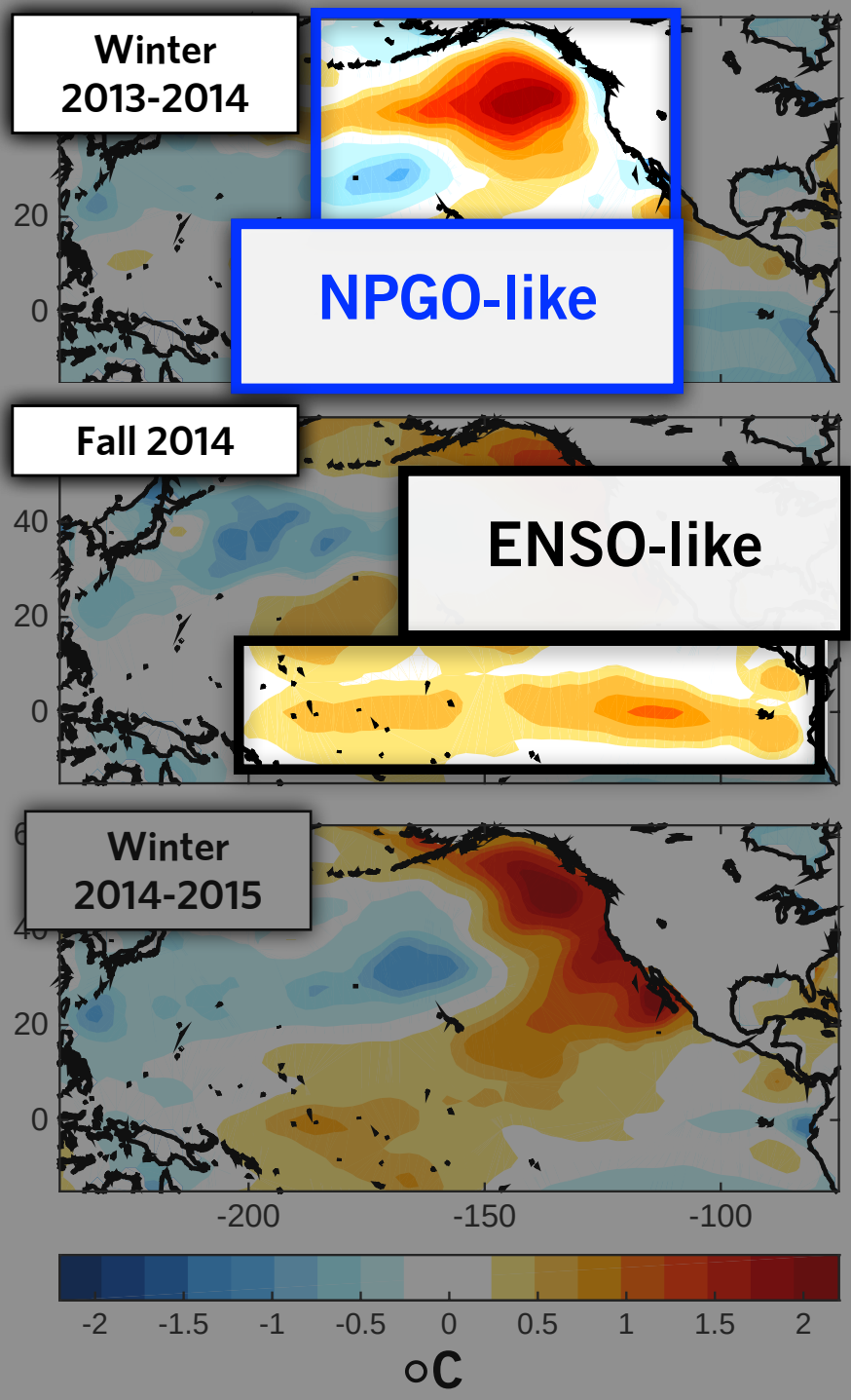
Warm Blob

Evolution and persistence



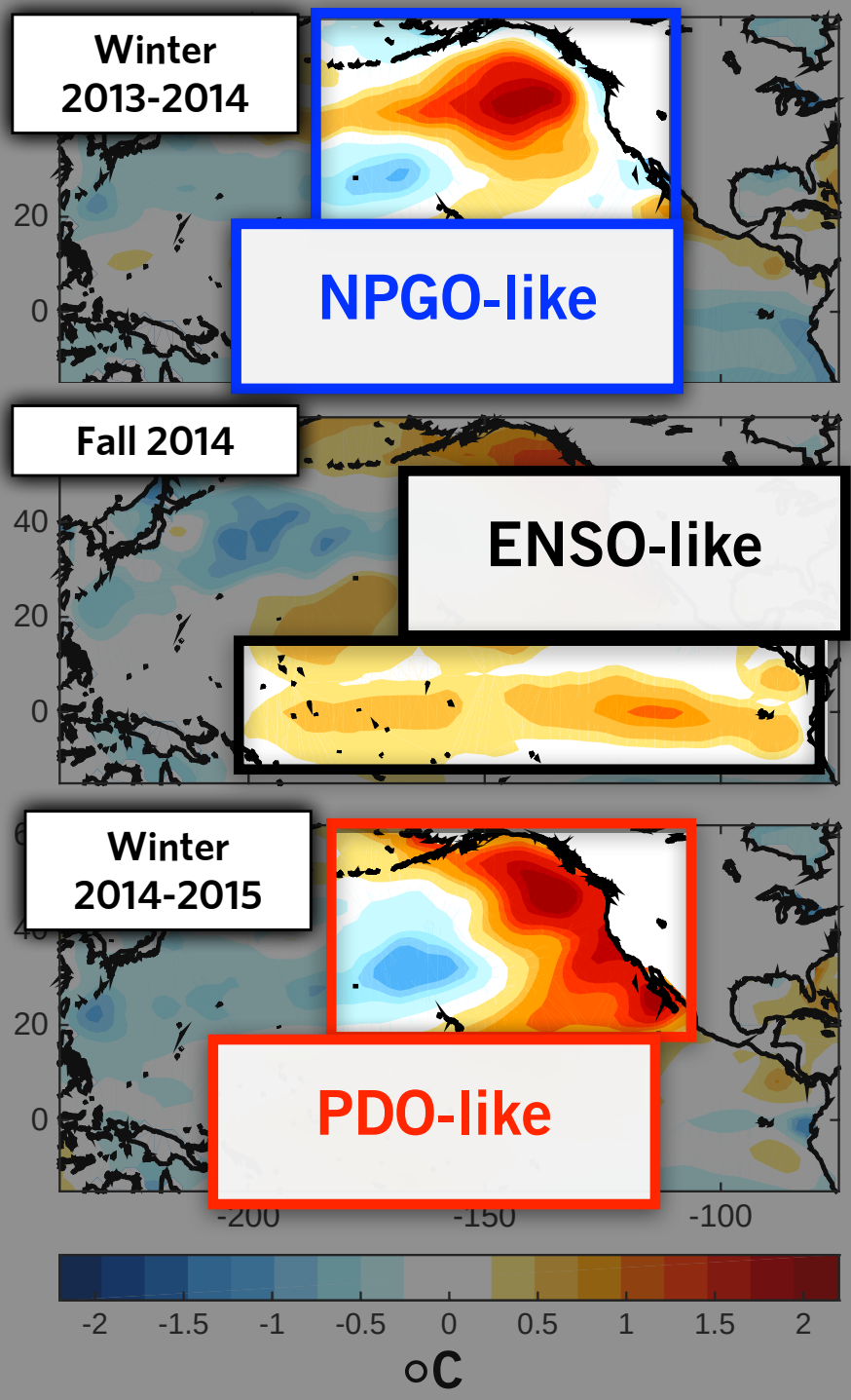
Warm Blob

Evolution and persistence



Warm Blob

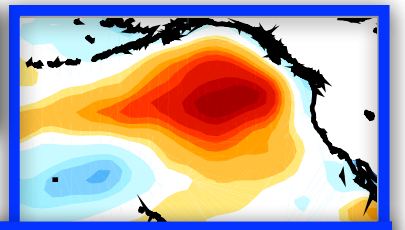
Evolution and persistence



Warm Blob

Evolution and persistence

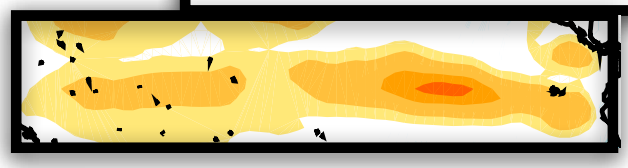
Winter
2013-2014



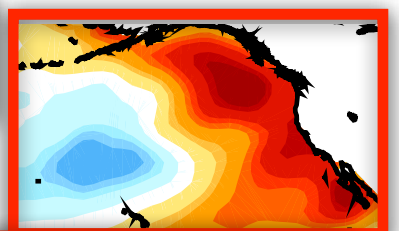
NPGO-like

Fall 2014

ENSO-like

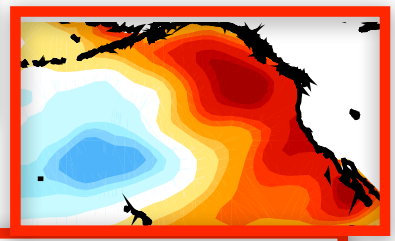


Winter
2014-2015



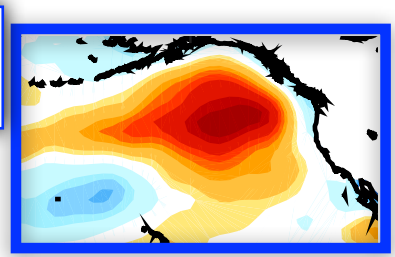
PDO-like

Winter
2014-2015



PDO-like

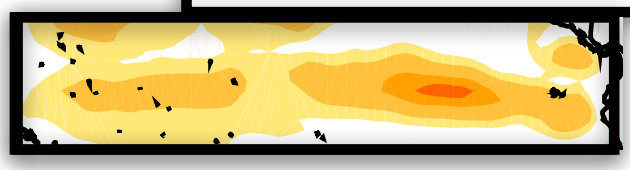
Winter
2013-2014



NPGO-like

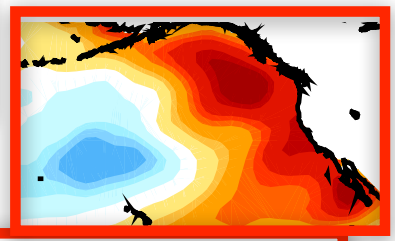
Fall 2014

ENSO-like



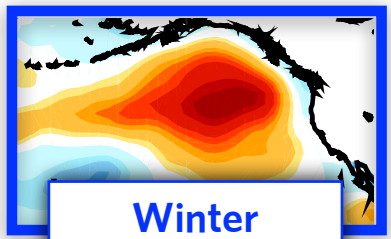
Strong in Winter 2013/2014

Winter
2014-2015



PDO-like

North Pacific
Oscillation
ATMOSPHERE

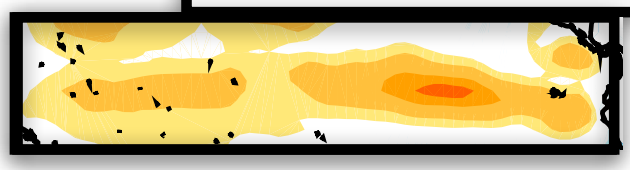


Winter
2013-2014

North Pacific
Gyre Oscillation
OCEAN

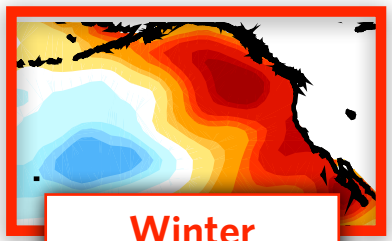
Fall 2014

ENSO-like



Strong in Winter 2013/2014

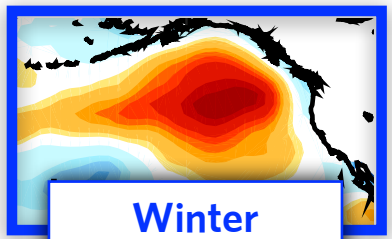
Aleutian Low
ATMOSPHERE



Winter
2014-2015

Pacific Decadal Oscillation
OCEAN

North Pacific Oscillation
ATMOSPHERE

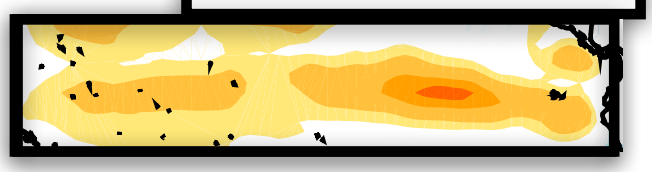


Winter
2013-2014

North Pacific Gyre Oscillation
OCEAN

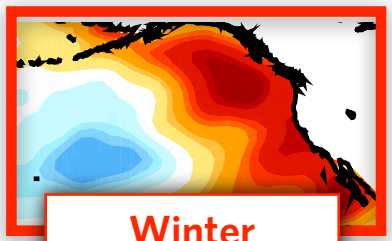
Fall 2014

ENSO-like



Strong in Winter 2013/2014

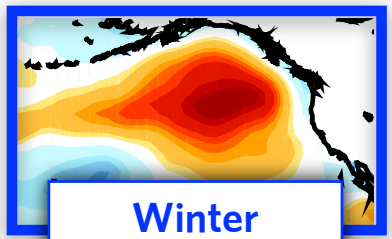
Aleutian Low
ATMOSPHERE



Winter
2014-2015

Pacific Decadal Oscillation
OCEAN

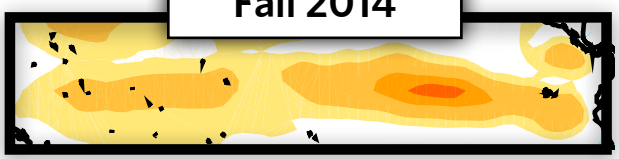
North Pacific Oscillation
ATMOSPHERE



Winter
2013-2014

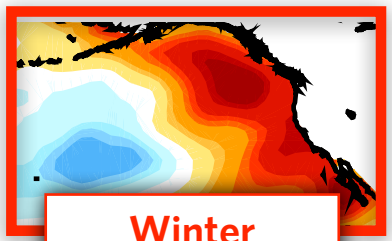
North Pacific Gyre Oscillation
OCEAN

ENSO



Fall 2014

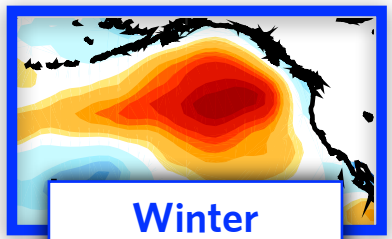
Aleutian Low
ATMOSPHERE



Winter
2014-2015

Pacific
Decadal Oscillation
OCEAN

North Pacific
Oscillation
ATMOSPHERE

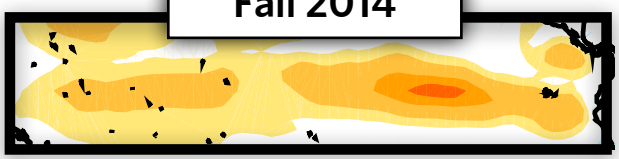


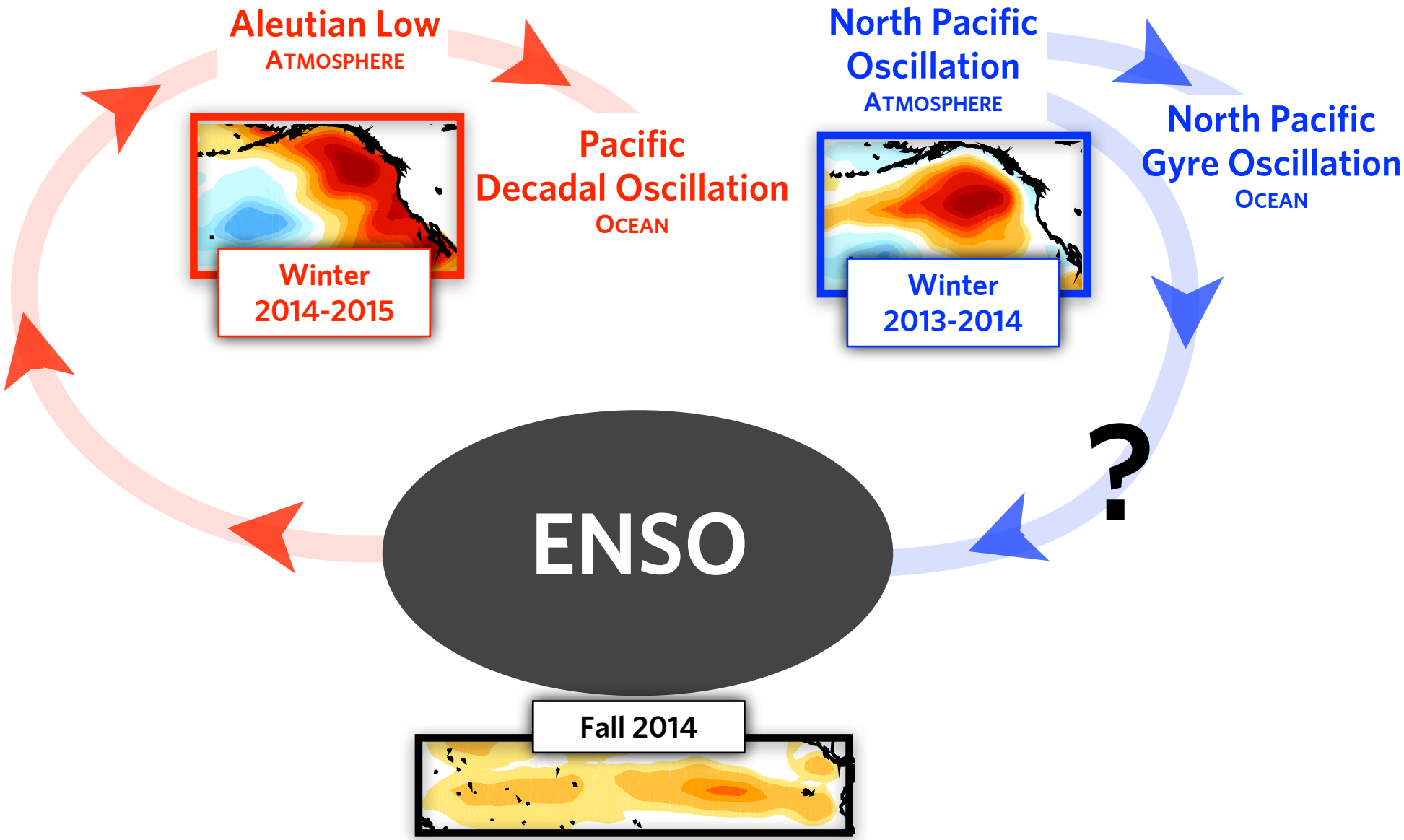
Winter
2013-2014

North Pacific
Gyre Oscillation
OCEAN

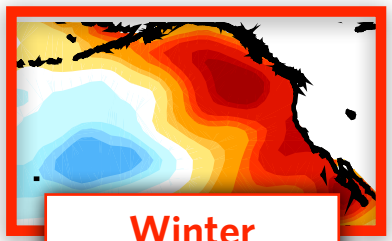
ENSO

Fall 2014




Aleutian Low
ATMOSPHERE
Winter
2014-2015
Pacific
Decadal Oscillation
OCEAN
North Pacific
Oscillation
ATMOSPHERE
Winter
2013-2014
North Pacific
Gyre Oscillation
OCEAN
?
ENSO
Fall 2014

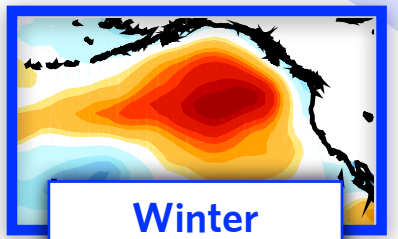
Aleutian Low
ATMOSPHERE



Winter
2014-2015

Pacific
Decadal Oscillation
OCEAN

North Pacific
Oscillation
ATMOSPHERE

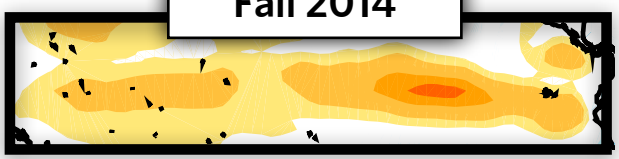


Winter
2013-2014

North Pacific
Gyre Oscillation
OCEAN

Meridional
Modes

ENSO

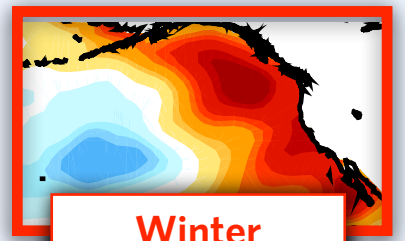


Fall 2014

Work by:
Vimont, Chiang, Chang,
Anderson, Alexander

EXTRA-TROPICS

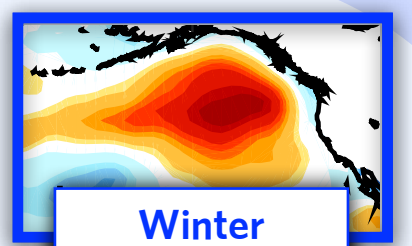
Aleutian Low
ATMOSPHERE



Winter
2014-2015

Pacific Decadal Oscillation
OCEAN

North Pacific Oscillation
ATMOSPHERE



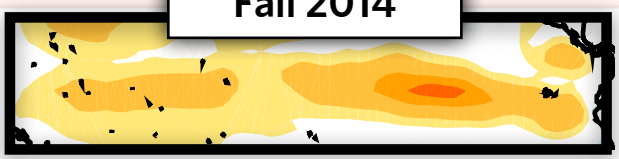
Winter
2013-2014

North Pacific Gyre Oscillation
OCEAN

ENSO

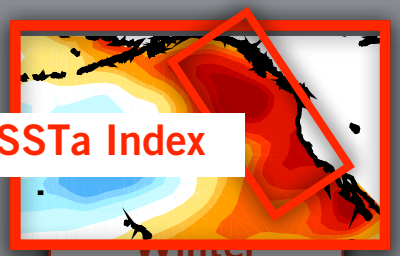
TROPICS

Fall 2014



EXTRA-TROPICS

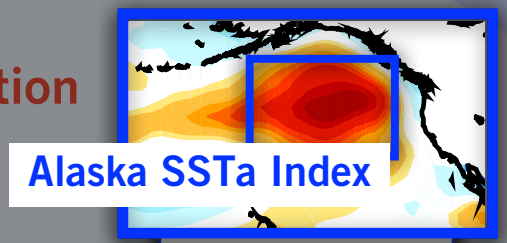
Aleutian Low
ATMOSPHERE



Winter
2014-2015

Pacific
Decadal Oscillation
OCEAN

North Pacific
Oscillation
ATMOSPHERE



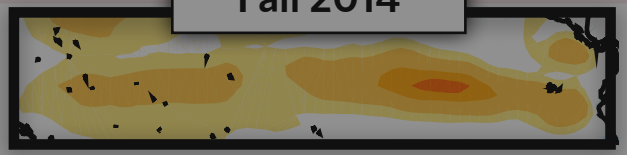
2013-2014

North Pacific
Gyre Oscillation
OCEAN

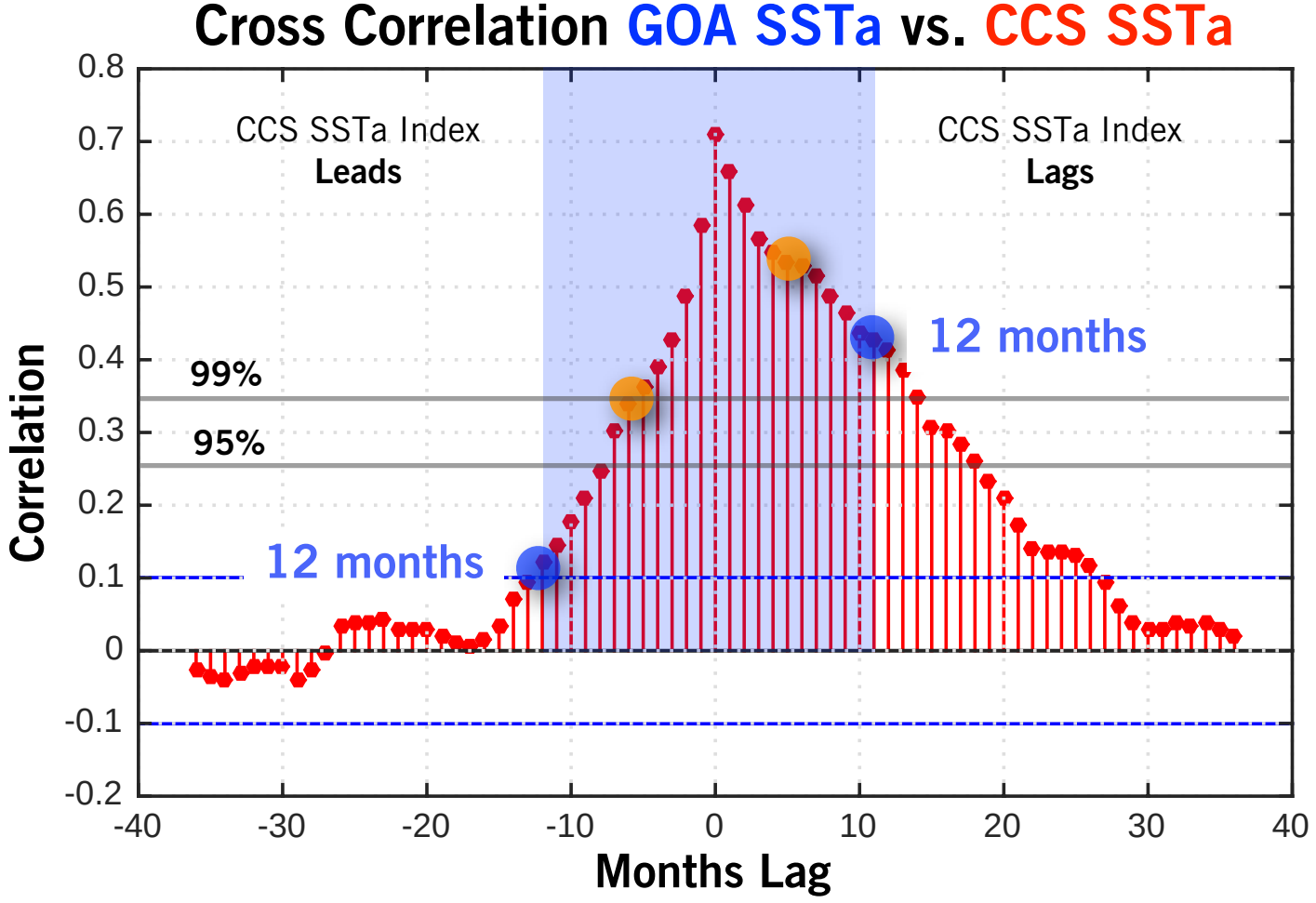
ENSO

TROPICS

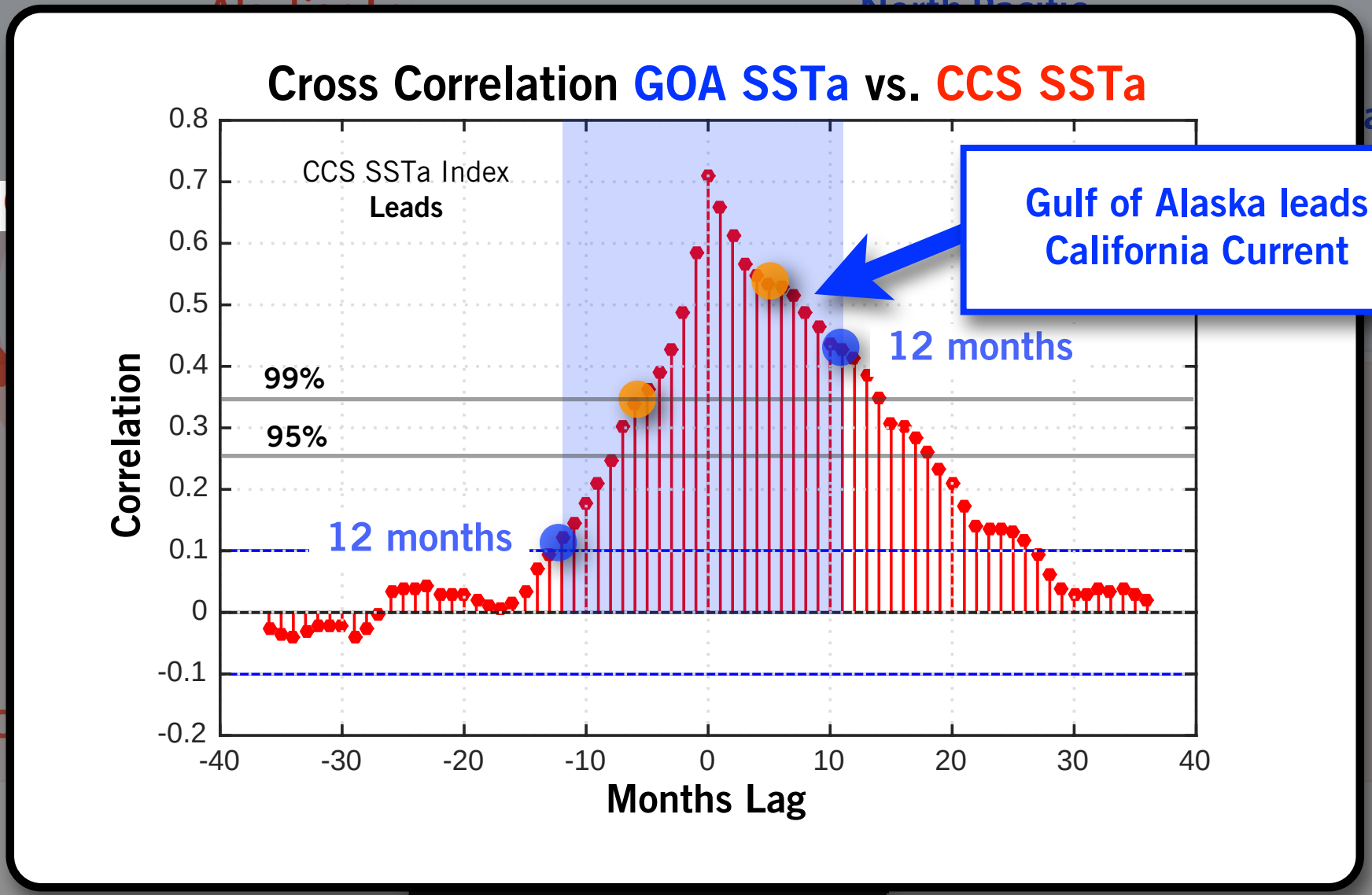
Fall 2014



Evolution of the warm blob



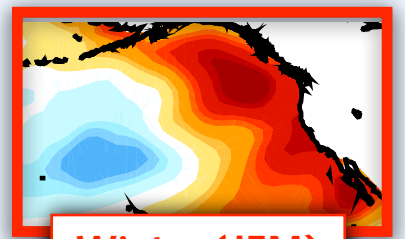
Evolution of the warm blob



Evolution of the warm blob

EXTRA-TROPICS

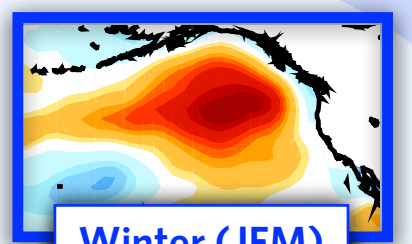
Aleutian Low
ATMOSPHERE



Winter (JFM)
2015

Pacific
Decadal Oscillation
OCEAN

North Pacific
Oscillation
ATMOSPHERE



Winter (JFM)
2014

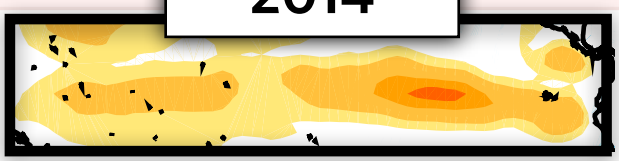
North Pacific
Gyre Oscillation
OCEAN

?

ENSO

TROPICS

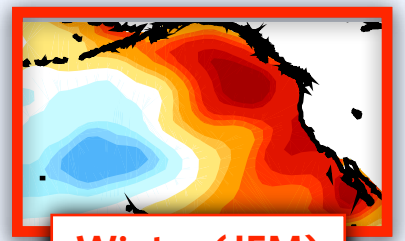
Fall (OND)
2014



Evolution of the warm blob

EXTRA-TROPICS

Aleutian Low
ATMOSPHERE



Winter (JFM)
2015

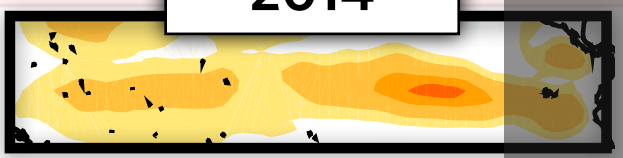
Pacific
Decadal Oscillation
OCEAN

?

ENSO

TROPICS

Fall (OND)
2014

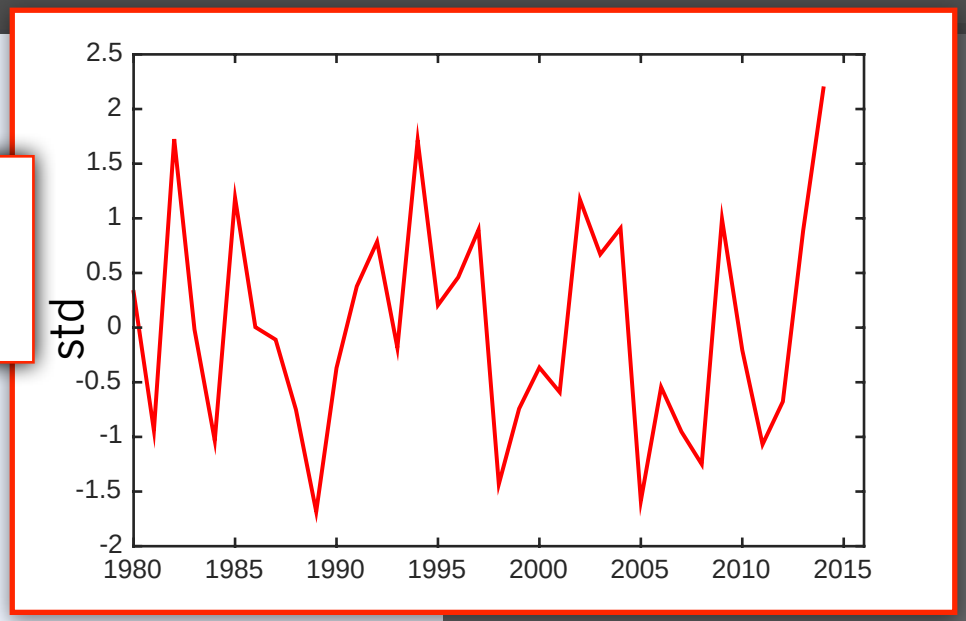


QUESTION

What was the role of ENSO teleconnection in the persistence?

Evolution of the warm blob

Evolution of the warm blob



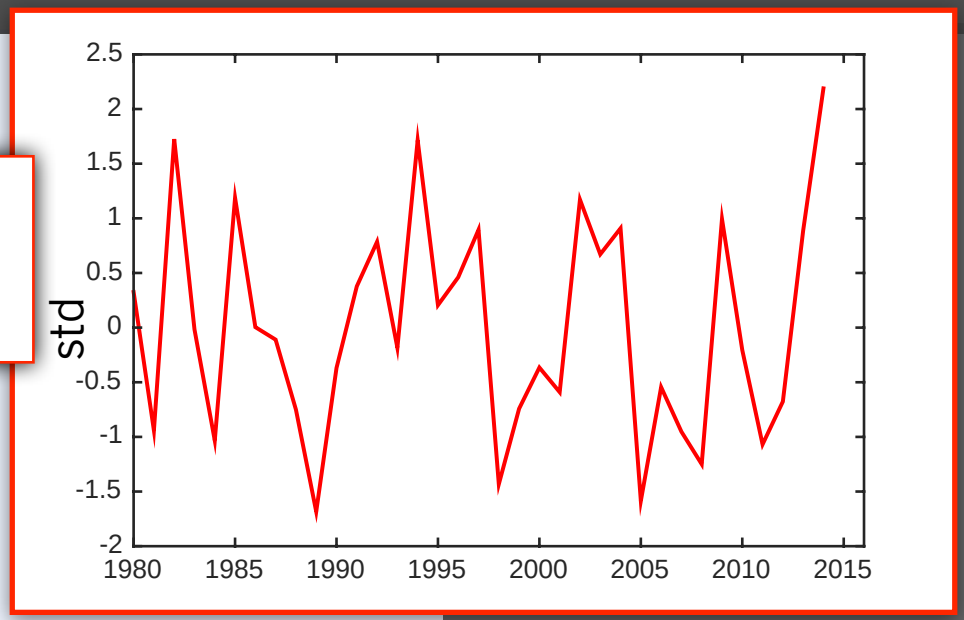
Winter SLPa (JFM)

Fall ENSO SLPa (OND)

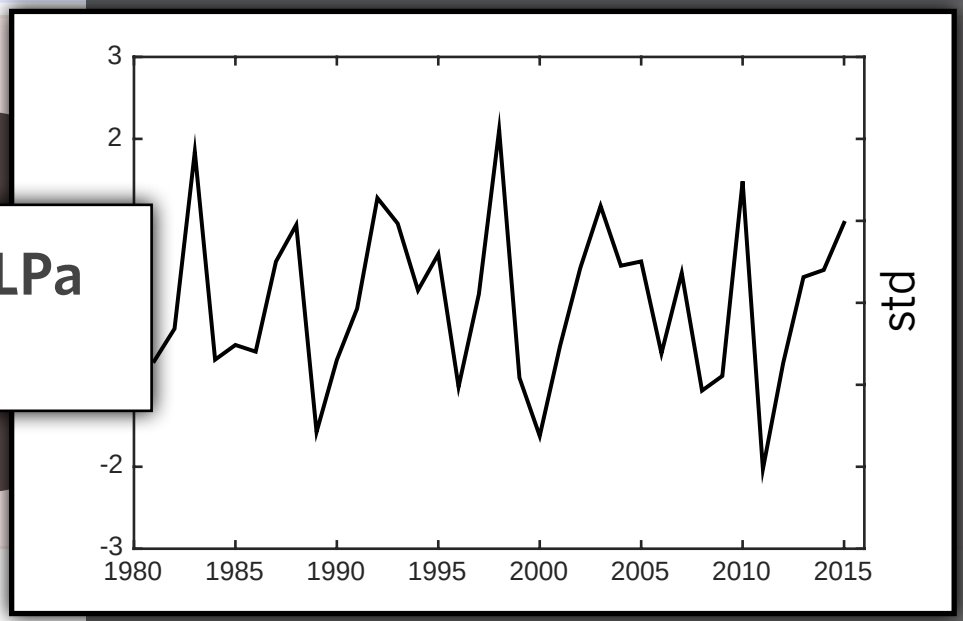
TROPICS

Evolution of the warm blob

Winter SLPa (JFM)



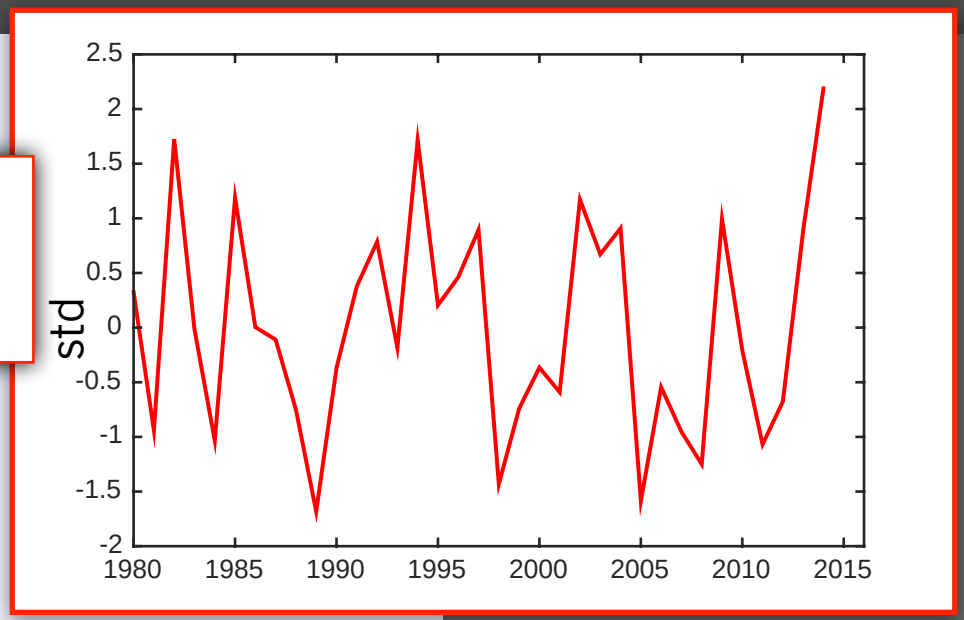
Fall ENSO SLPa (OND)



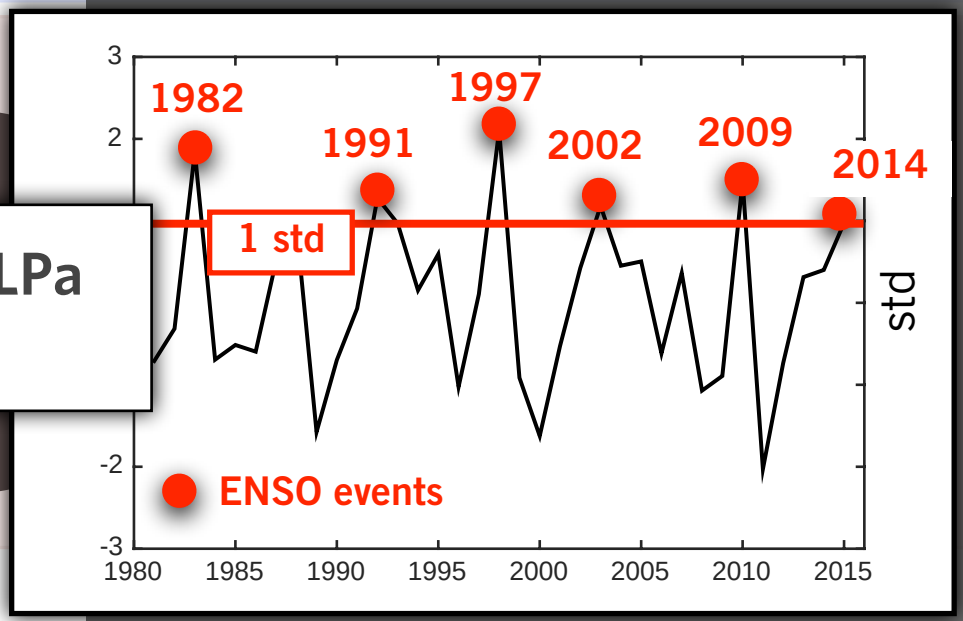
TROPICS

Evolution of the warm blob

Winter SLPa (JFM)

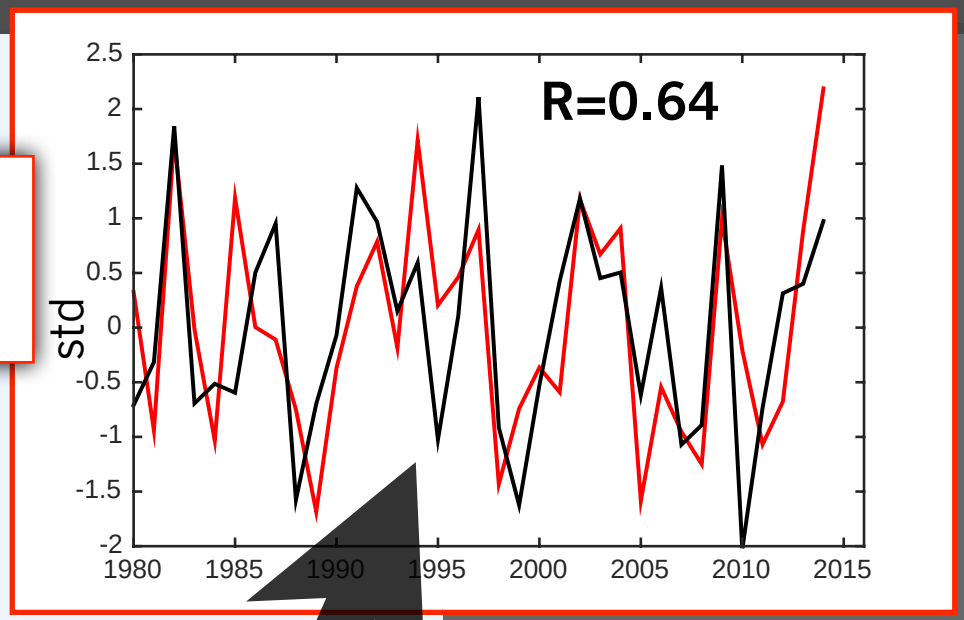


Fall ENSO SLPa (OND)



TROPICS

Evolution of the warm blob

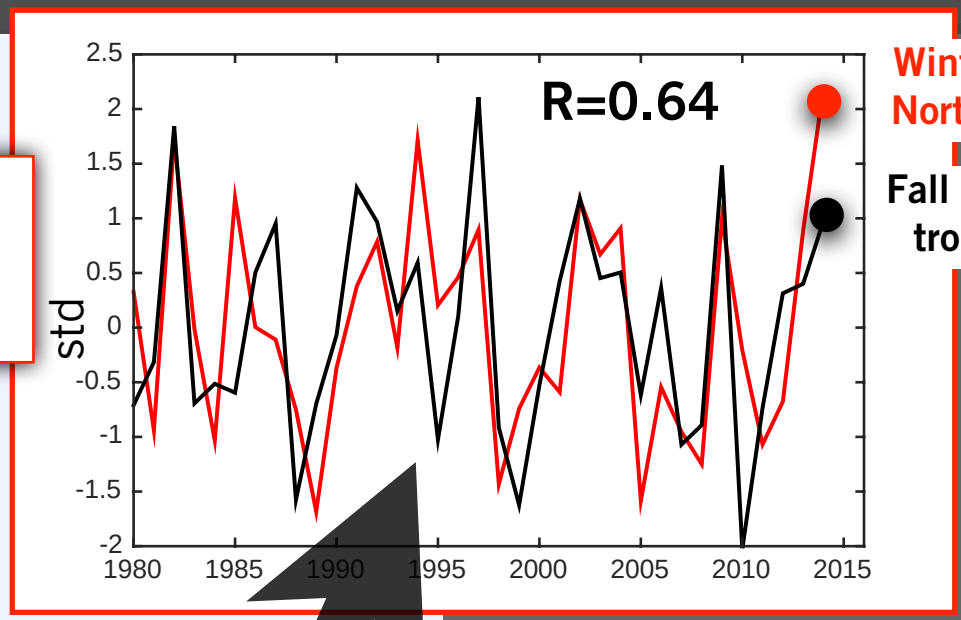


Winter SLPa (JFM)

Fall ENSO SLPa (OND)

TROPICS

Evolution of the warm blob



Winter SLPa (JFM)

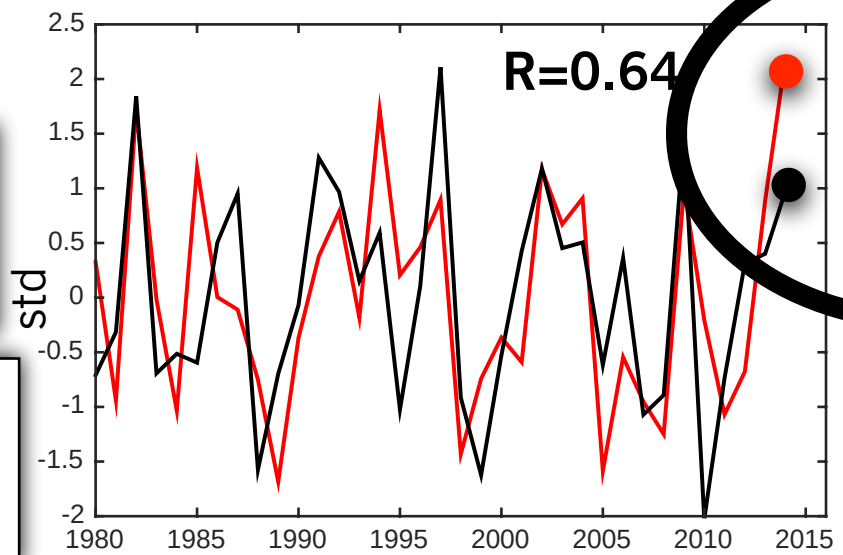
Fall ENSO SLPa (OND)

TROPICS

Evolution of the warm blob

Winter SLPa (JFM)

Fall ENSO SLPa (OND)

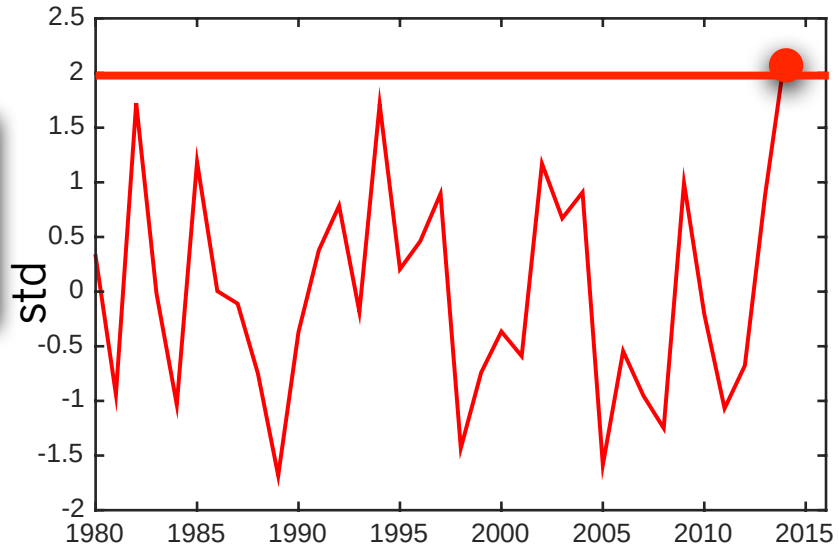


QUESTION:

What fraction of variance is accounted by ENSO teleconnection?

Evolution of the warm blob

Winter SLPa (JFM)



Winter 2015 North Pacific ~2.2

UNITS = std

GOAL:

Decompose SLPa into contributions

from **Tropics vs. North Pacific**

Evolution of the warm blob

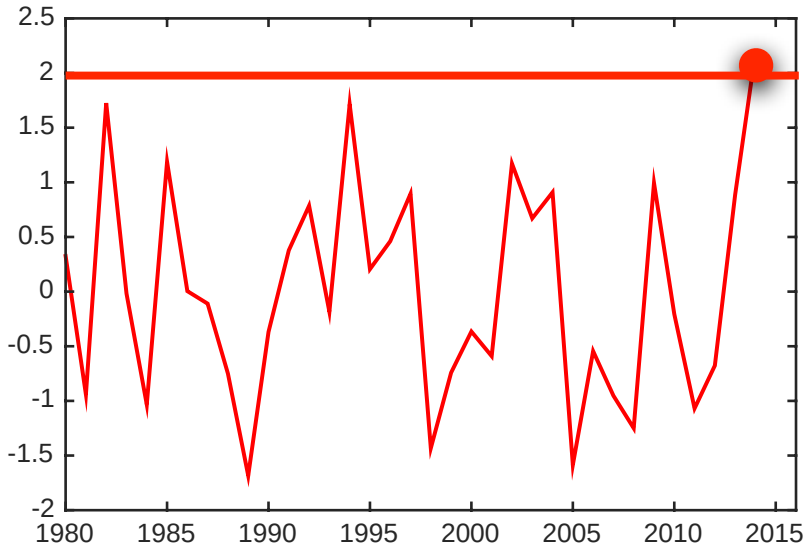
Winter SLPa (JFM)

=

Winter NP SLPa (JFM)

+

Fall ENSO SLPa (OND)



Winter 2015 North Pacific ~2.2

UNITS = std

GOAL:

Decompose SLPa into contributions

from **Tropics vs. North Pacific**

Evolution of the warm blob

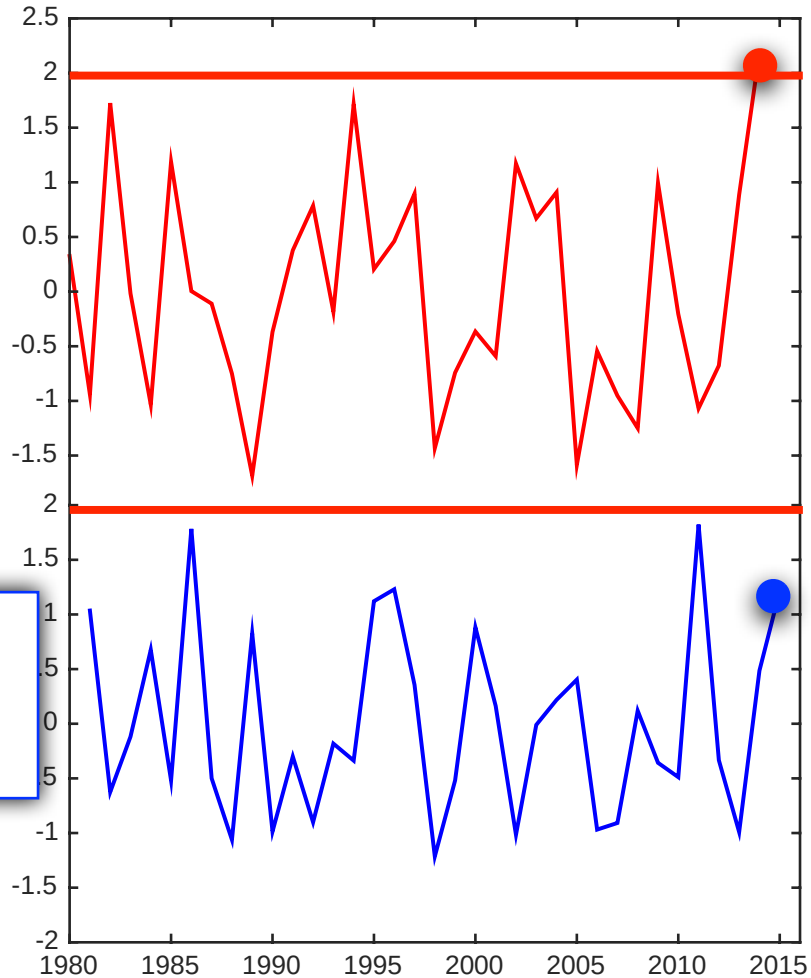
Winter SLPa (JFM)

=

Winter NP SLPa (JFM)

+

Fall ENSO SLPa (OND)



Winter 2015 North Pacific ~2.2

UNITS = std

NP contribution ~1.2

Evolution of the warm blob

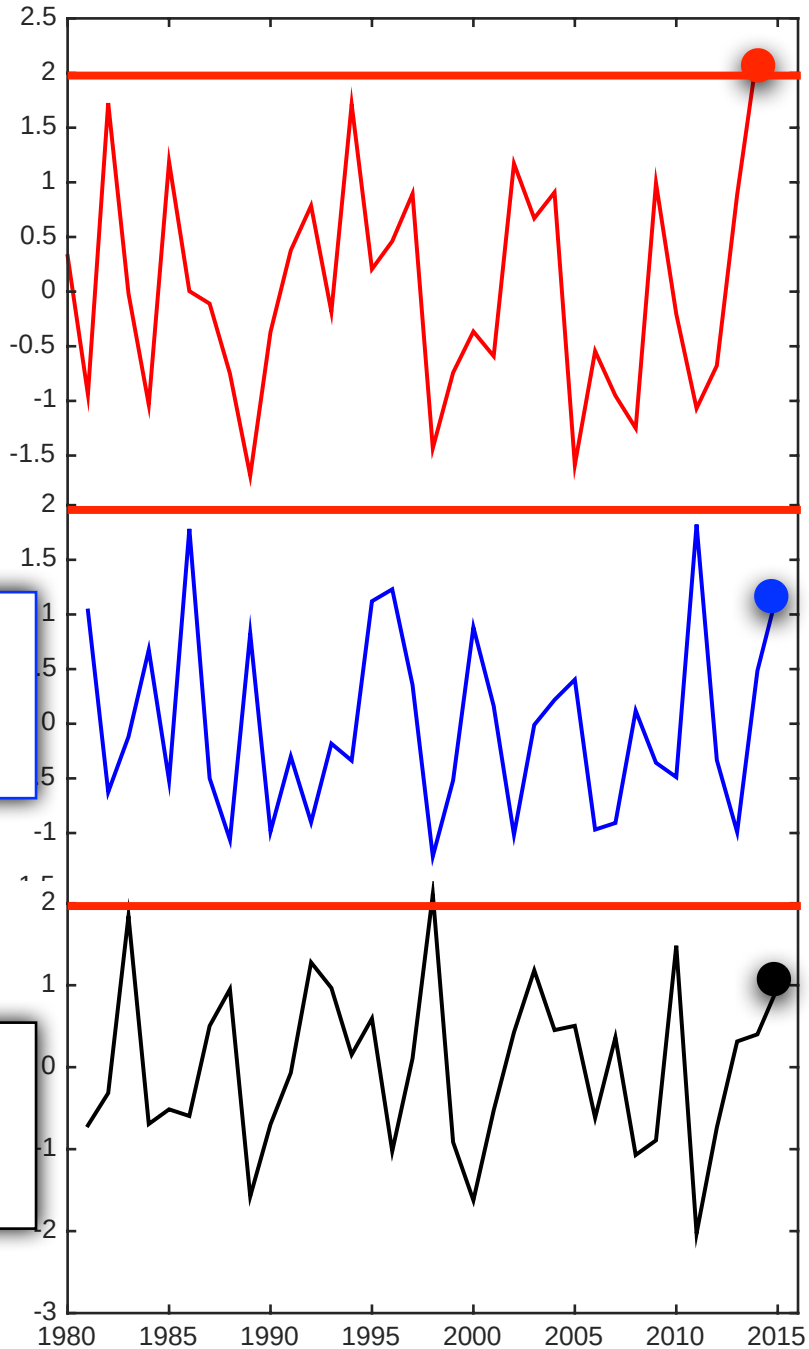
Winter SLPa (JFM)

=

Winter NP SLPa (JFM)

+

Fall ENSO SLPa (OND)



Winter 2015 North Pacific ~2.2

UNITS = std

NP contribution ~1.2

Tropical contribution ~1

Evolution of the warm blob

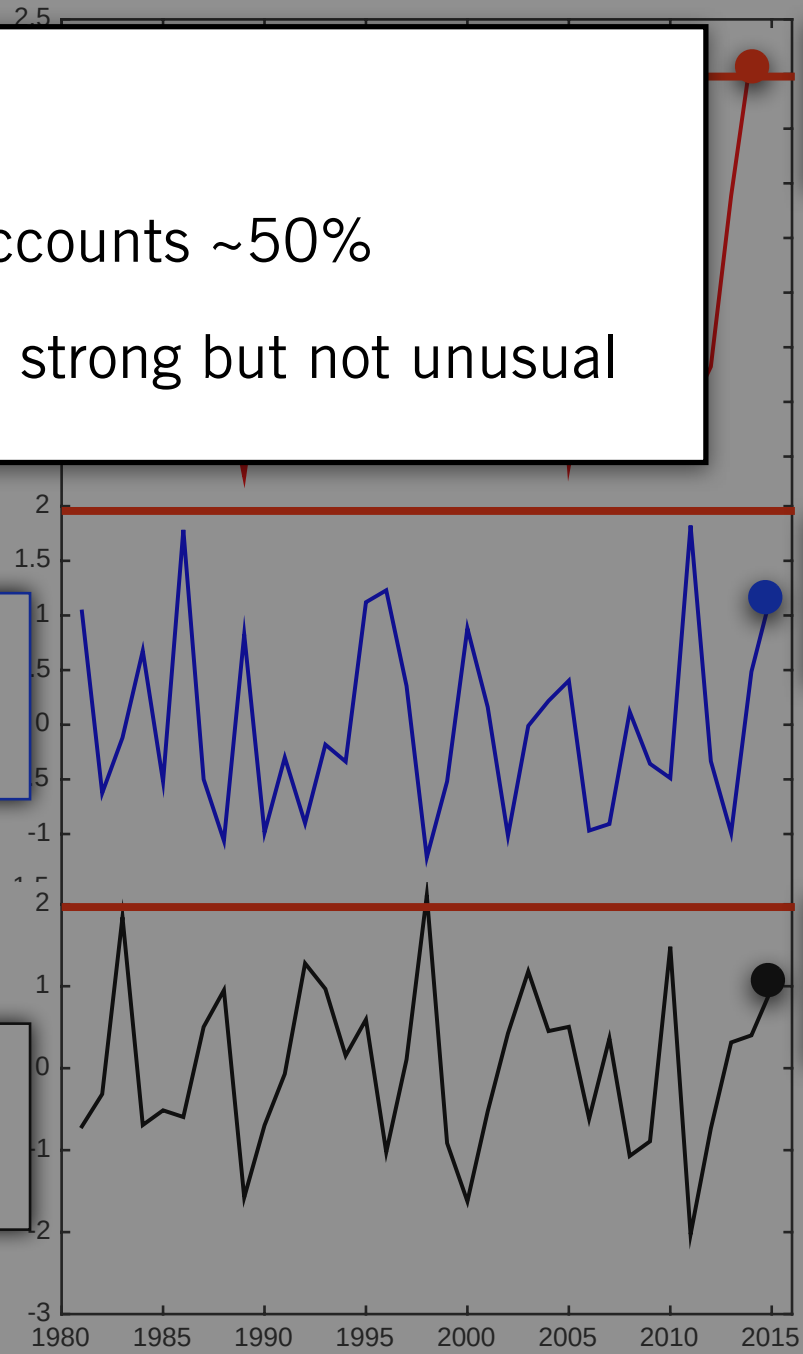
RESULTS

- Tropical teleconnection accounts ~50%
- North Pacific contribution strong but not unusual

Winter NP SLPa (JFM)

+

Fall ENSO SLPa (OND)



Winter 2015 North Pacific ~2.2

UNITS = std

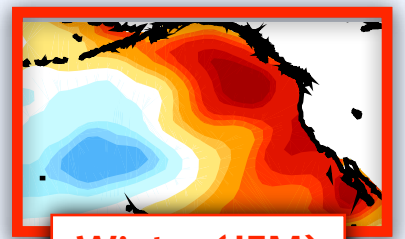
NP contribution ~1.2

Tropical contribution ~1

Evolution of the warm blob

EXTRA-TROPICS

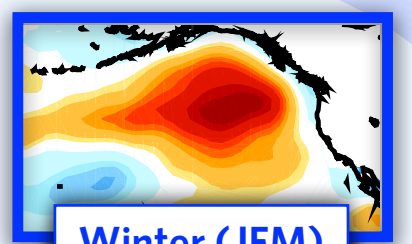
Aleutian Low
ATMOSPHERE



Winter (JFM)
2015

Pacific
Decadal Oscillation
OCEAN

North Pacific
Oscillation
ATMOSPHERE



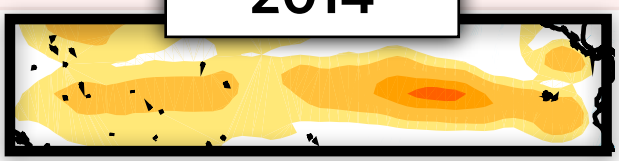
Winter (JFM)
2014

North Pacific
Gyre Oscillation
OCEAN

ENSO

TROPICS

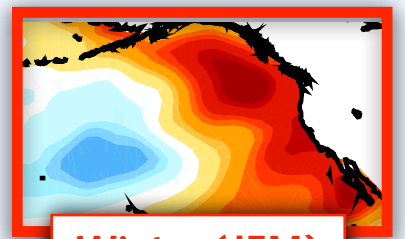
Fall (OND)
2014



Evolution of the warm blob

EXTRA-TROPICS

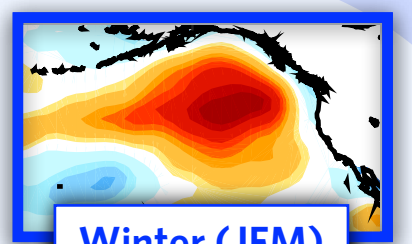
Aleutian Low
ATMOSPHERE



Winter (JFM)
2015

Pacific
Decadal Oscillation
OCEAN

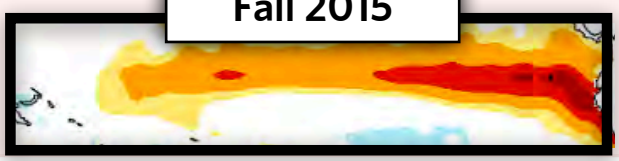
North Pacific
Oscillation
ATMOSPHERE



Winter (JFM)
2014

North Pacific
Gyre Oscillation
OCEAN

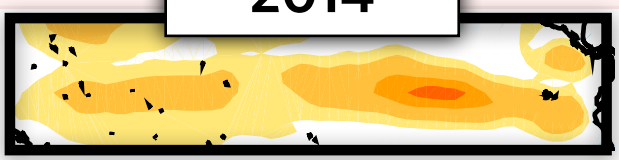
ENSO



Fall 2015

?

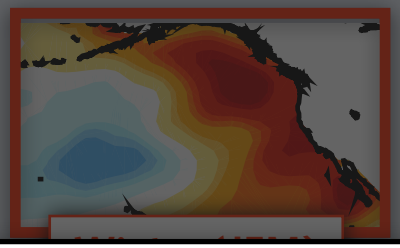
Fall (OND)
2014



Evolution of the warm blob

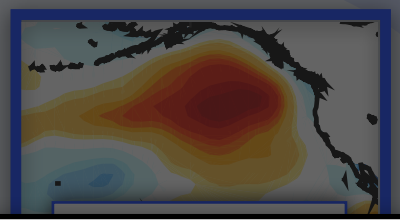
EXTRA-TROPICS

Aleutian Low
ATMOSPHERE



Pacific
Decadal Oscillation
OCEAN

North Pacific
Oscillation
ATMOSPHERE

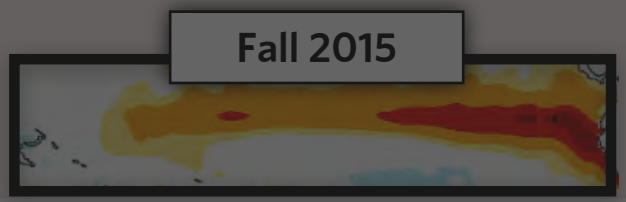


North Pacific
Gyre Oscillation
OCEAN

QUESTION

Are these extreme climate events becoming more frequent?

ENSO



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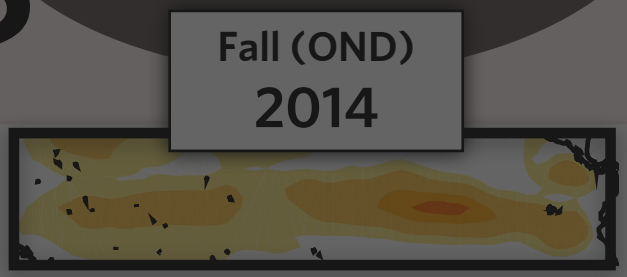
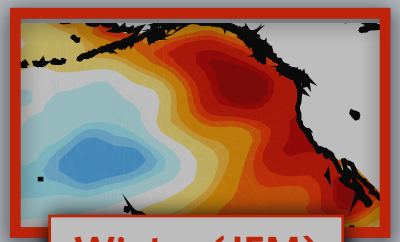


Evolution of the warm blob

EXTRA-TROPICS

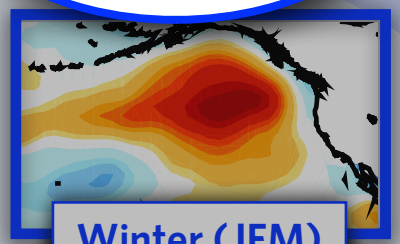
Aleutian Low
ATMOSPHERE



Winter (JFM)
2015

Pacific
Decadal Oscillation
OCEAN

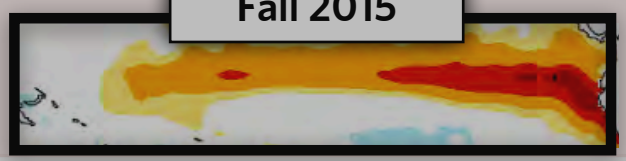
North Pacific
Oscillation
ATMOSPHERE



Winter (JFM)
2014

North Pacific
Gyre Oscillation
OCEAN

ENSO



Fall 2015

?

Fall (OND)
2014

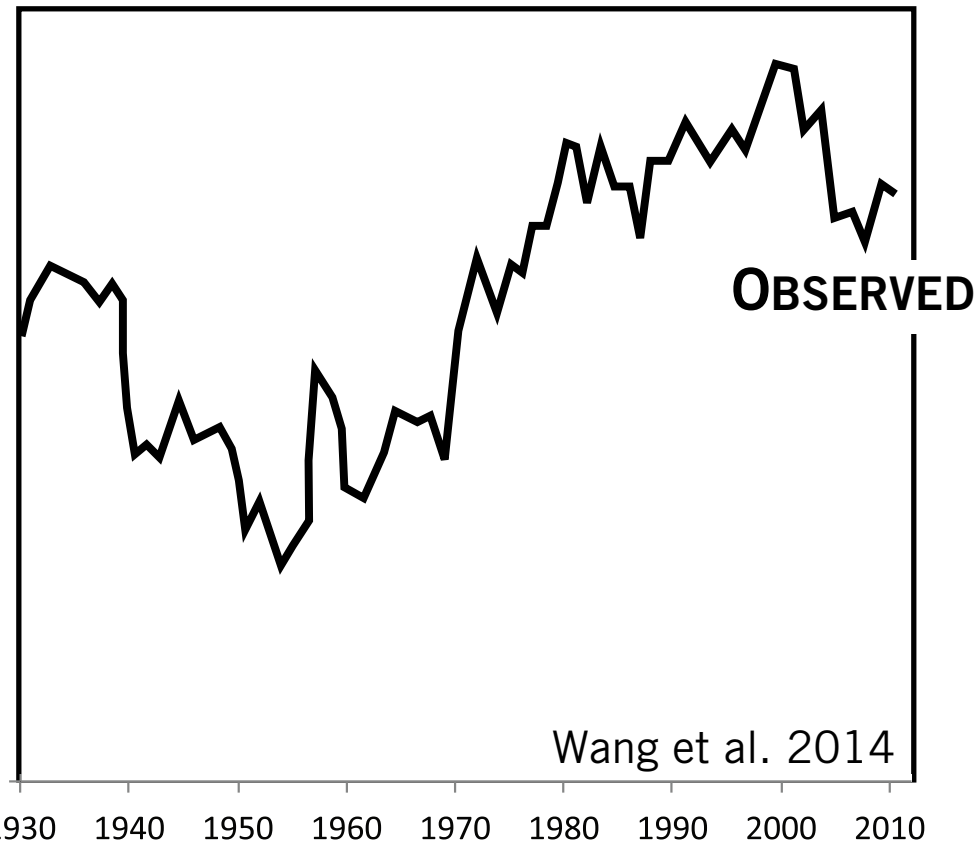
Evolution of the warm blob

EXTRA-TROPICS

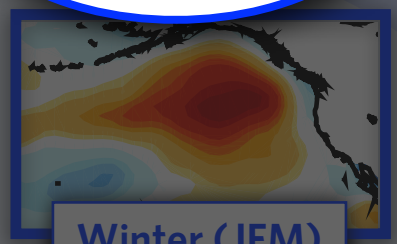
Aleutian Low

STRENGTH

of tropical/extra-tropical coupling



North Pacific Oscillation
ATMOSPHERE



Winter (JFM)
2014

North Pacific Gyre Oscillation
OCEAN

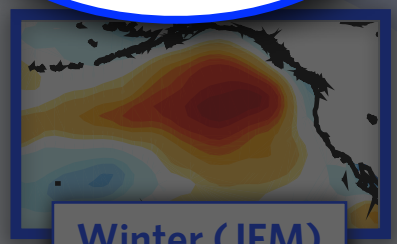
Evolution of the warm blob

EXTRA-TROPICS

Aleutian Low

North Pacific Oscillation
ATMOSPHERE

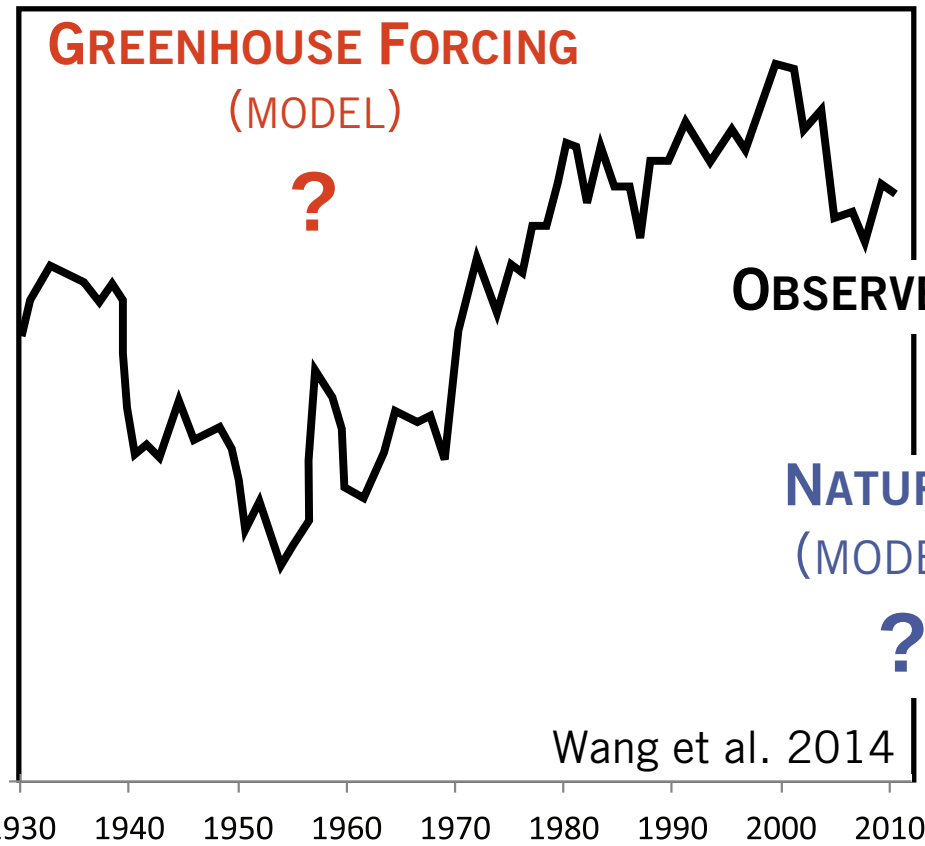
North Pacific Gyre Oscillation
OCEAN



Winter (JFM)
2014

STRENGTH

of tropical/extra-tropical coupling



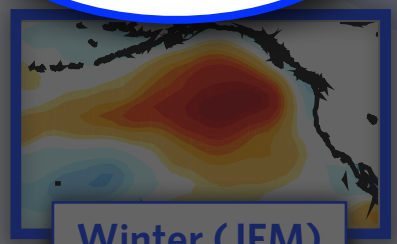
Evolution of the warm blob

EXTRA-TROPICS

Aleutian Low

North Pacific Oscillation
ATMOSPHERE

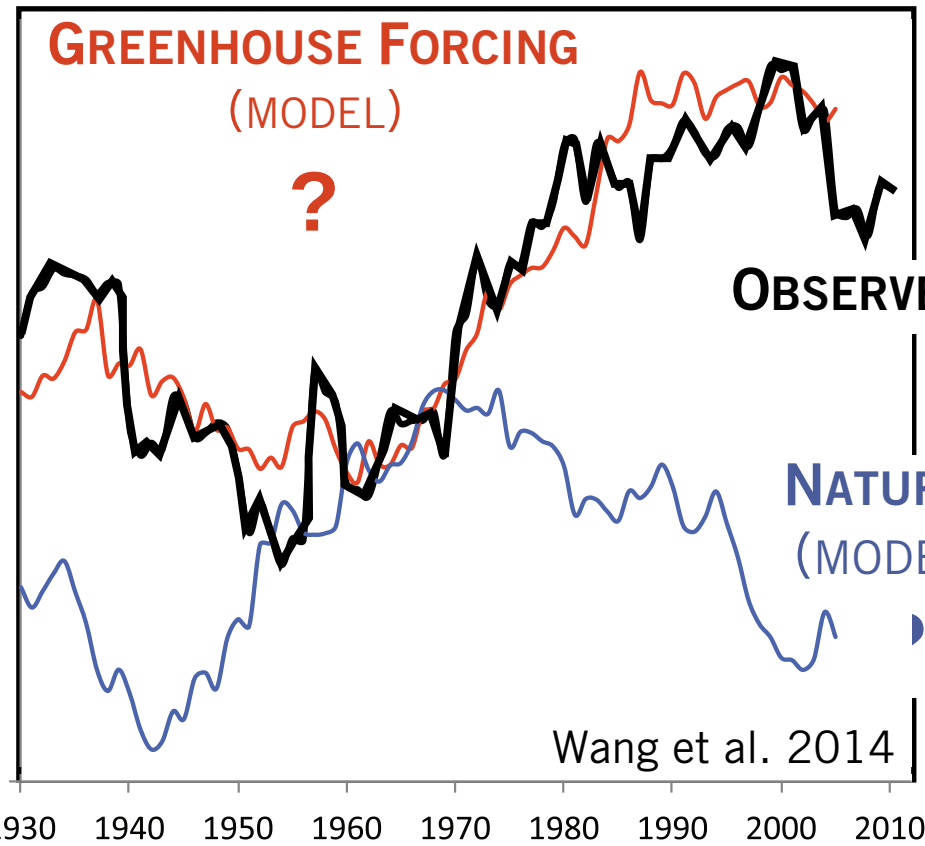
North Pacific Gyre Oscillation
OCEAN



Winter (JFM)
2014

STRENGTH

of tropical/extra-tropical coupling



Evolution of the warm blob

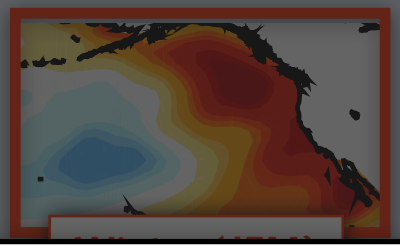
EXTRA-TROPICS

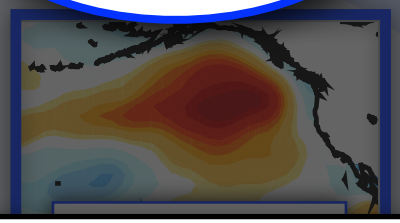
Aleutian Low
ATMOSPHERE

North Pacific
Oscillation
ATMOSPHERE

North Pacific
Gyre Oscillation
OCEAN

Pacific
Decadal Oscillation
OCEAN





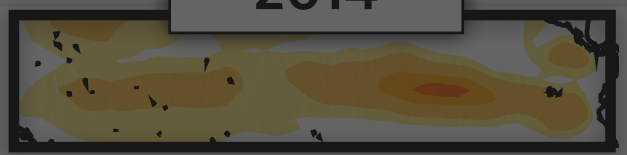
QUESTION

Why would this connection become stronger?

ENSO

TROPICS

Fall (OND)
2014



Evolution of the warm blob

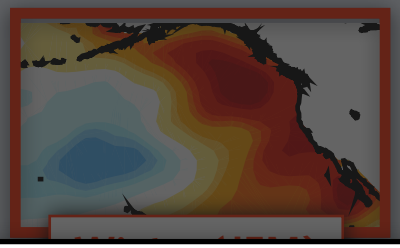
EXTRA-TROPICS

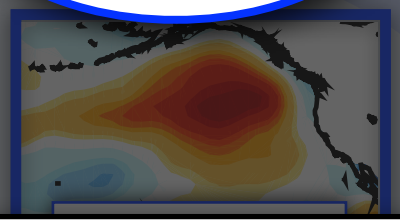
Aleutian Low
ATMOSPHERE

North Pacific
Oscillation
ATMOSPHERE

North Pacific
Gyre Oscillation
OCEAN

Pacific
Decadal Oscillation
OCEAN





QUESTION

Why would this connection become stronger?

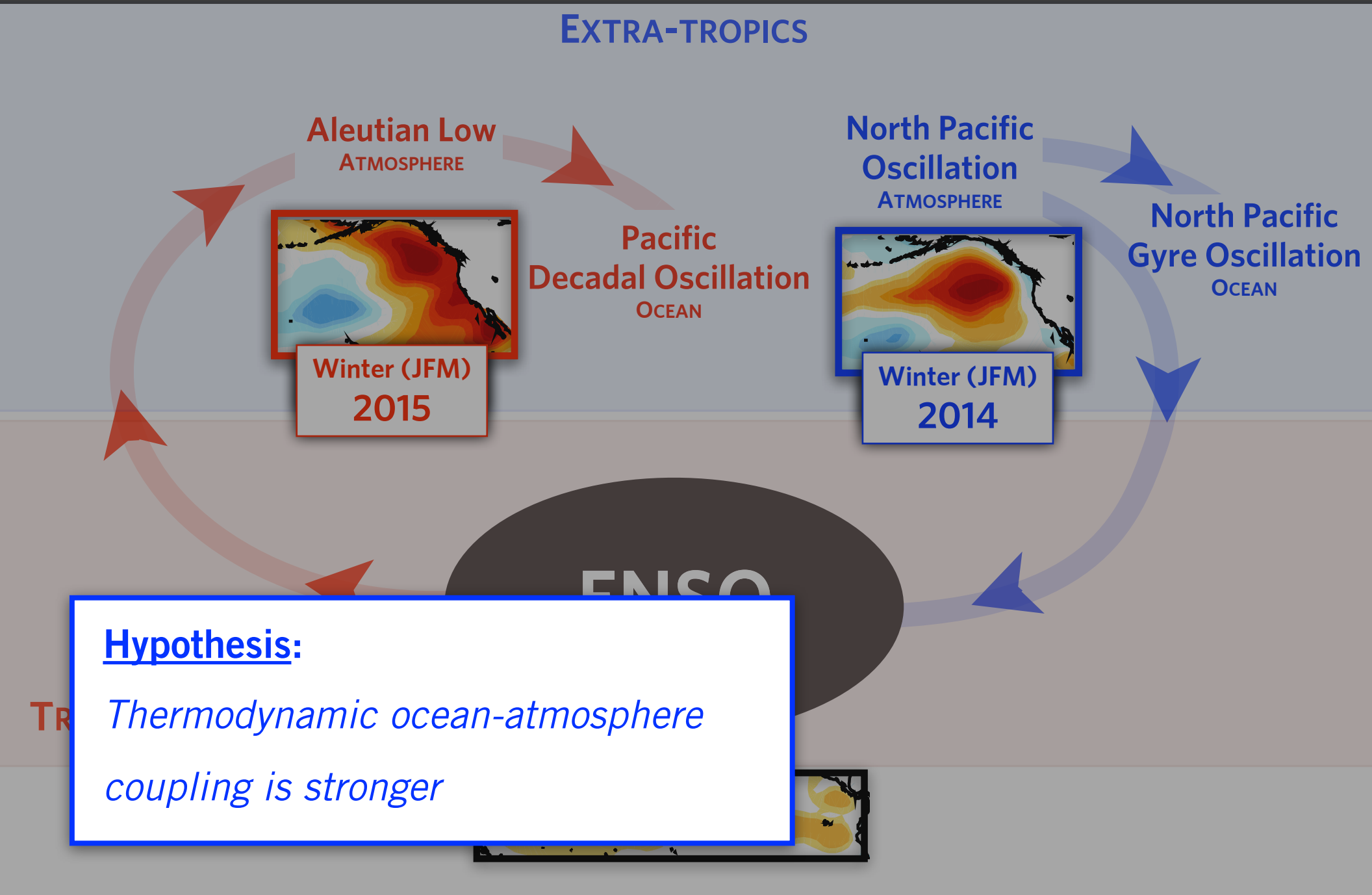
ENSO

TR

Hypothesis:

Thermodynamic ocean-atmosphere coupling is stronger

Evolution of the warm blob



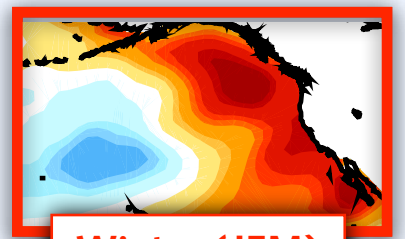
Hypothesis:

Thermodynamic ocean-atmosphere coupling is stronger

Evolution of the warm blob

EXTRA-TROPICS

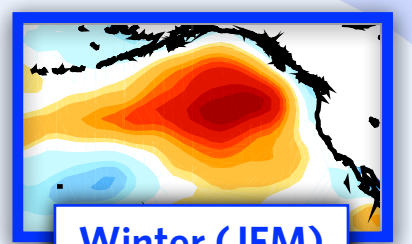
Aleutian Low
ATMOSPHERE



Winter (JFM)
2015

Pacific
Decadal Oscillation
OCEAN

North Pacific
Oscillation
ATMOSPHERE



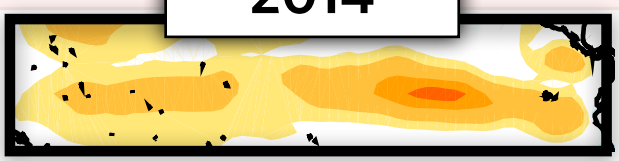
Winter (JFM)
2014

North Pacific
Gyre Oscillation
OCEAN

ENSO

TROPICS

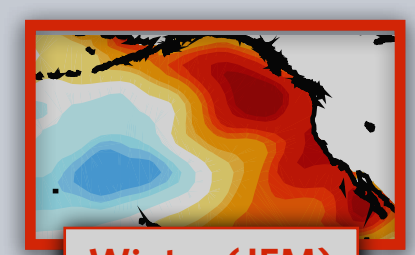
Fall (OND)
2014



Evolution of the warm blob

EXTRA-TROPICS

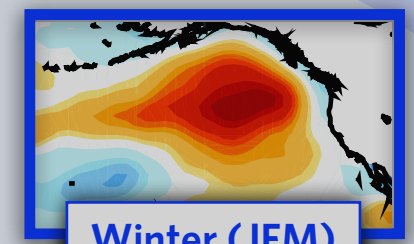
Aleutian Low
ATMOSPHERE



Winter (JFM)
2015

Pacific
Decadal Oscillation
OCEAN

North Pacific
Oscillation
ATMOSPHERE



Winter (JFM)
2014

North Pacific
Gyre Oscillation
OCEAN

ENSO

TROPICS

Working Hypothesis for generation of persistence, stronger and more frequent of climate event in the North Pacific