Nonlinear change in the variability of North Pacific climate: are biological systems responding?

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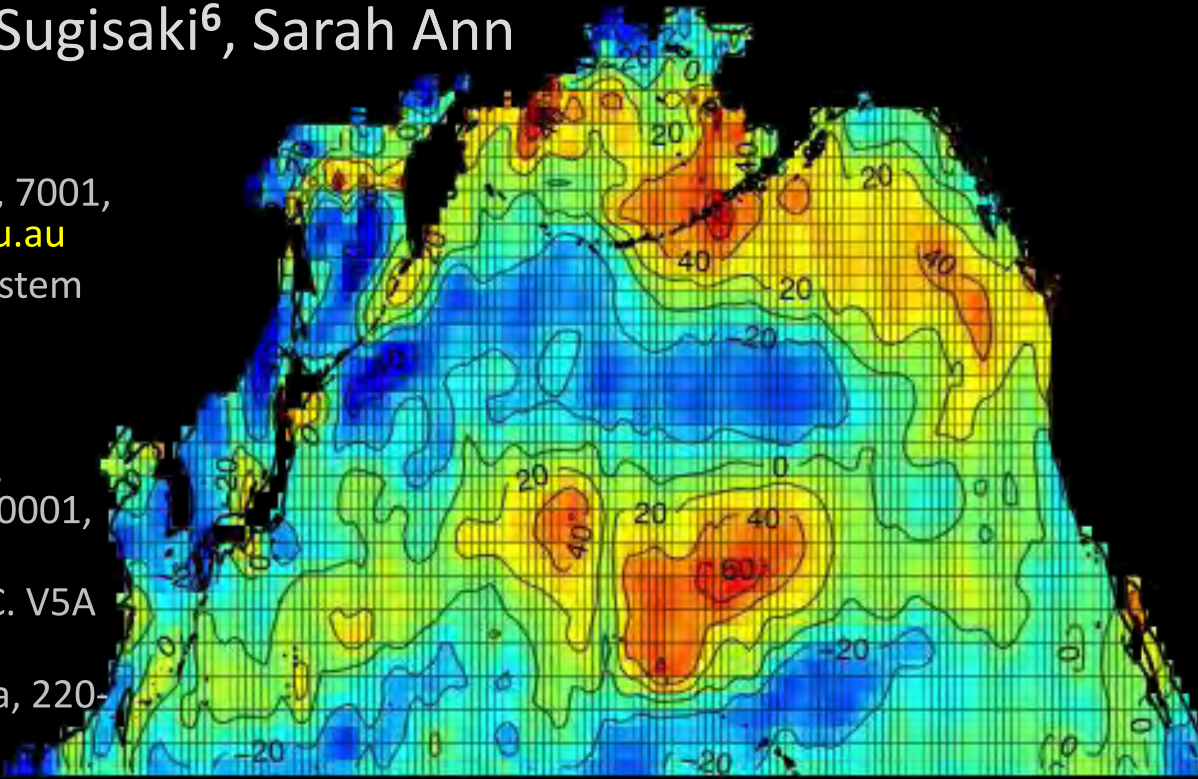


Motivation

Hansen et al. 2012 PNAS


PNAS PNAS PNAS

Perception of climate change

James Hansen[a,1], Makiko Sato[a], and Reto Ruedy[b]

[a]National Aeronautics and Space Administration Goddard Institu
[b]Trinnovim Limited Liability Company, New York, NY 10025

Contributed by James Hansen, March 29, 2012 (sent for review

"Climate dice," describing the chance of unusually warm
seasons, have become more and more "loaded" in the p
coincident with rapid global warming. The distribution of
mean temperature anomalies has shifted toward higher
tures and the range of anomalies has increased. An i
change is the emergence of a category of summertime e
hot outliers, more than three standard deviations (3σ) war
the climatology of the 1951–1980 base period. This hot
which covered much less than 1% of Earth's surface during
period, now typically covers about 10% of the land area.
that we can state, with a high degree of confidence, that
anomalies such as those in Texas and Oklahoma in 2
Moscow in 2010 were a consequence of global warming
their likelihood in the absence of global warming was ex
small. We discuss practical implications of this substantial,
climate change.

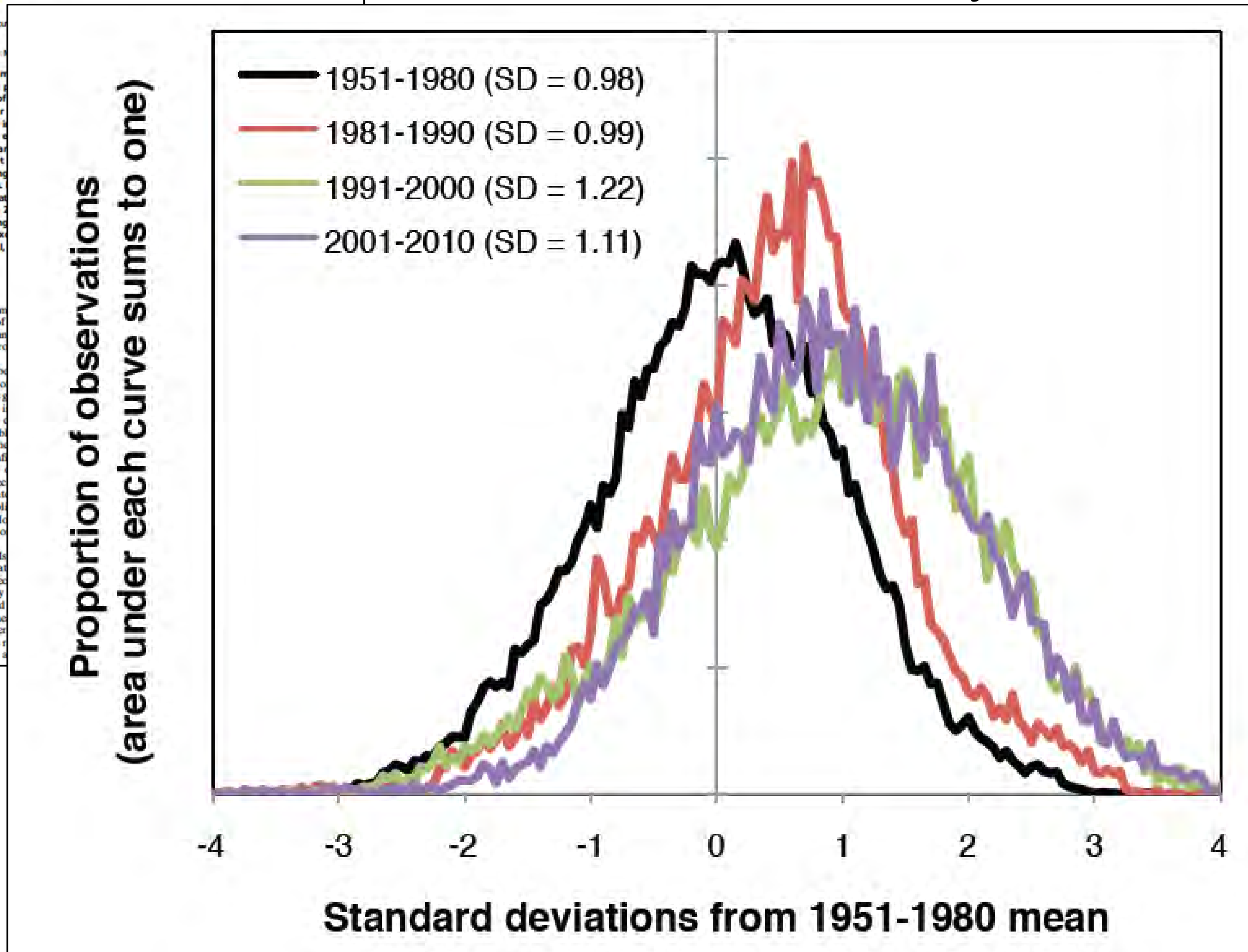
climate impacts | climate anomalies | heat waves

The greatest barrier to public recognition of hum
climate change is probably the natural variability of
mate. How can a person discern long-term climate chan
the notorious variability of local weather and climate fro
day and year to year?

This question assumes great practical importance be
the need for the public to appreciate the significance o
made global warming. Actions to stem emissions of the g
cause global warming are unlikely to approach what i
until the public recognizes that human-made climate c
underway and perceives that it will have unacceptab
quences if effective actions are not taken to slow the
change. A recent survey in the United States (1) confi
public opinion about the existence and importance o
warming depends strongly on their perceptions of rec
climate variations. Early public recognition of climat
is critical. Stabilizing climate with conditions resembli
of the Holocene, the world in which civilization develo
only be achieved if rapid reduction of fossil fuel emissio
soon (2).

It was suggested decades ago (3) that by the early 21s
the informed public should be able to recognize that
quency of unusually warm seasons had increased, bec
"climate dice," describing the probability of unusually
unusually cool seasons, would be sufficiently loaded
as to be discernible to the public. Recent high profile he
such as the one in Texas and Oklahoma in the summer
raise the question of whether these extreme events are r
the on-going global warming trend, which has been a

North Pacific SST variability 1951-2010



Ecological consequences of increasing climate variability

Climate

Climate forcing

Biology

Lagged feedback

How does increasing variability in this process…

Climate in year t:

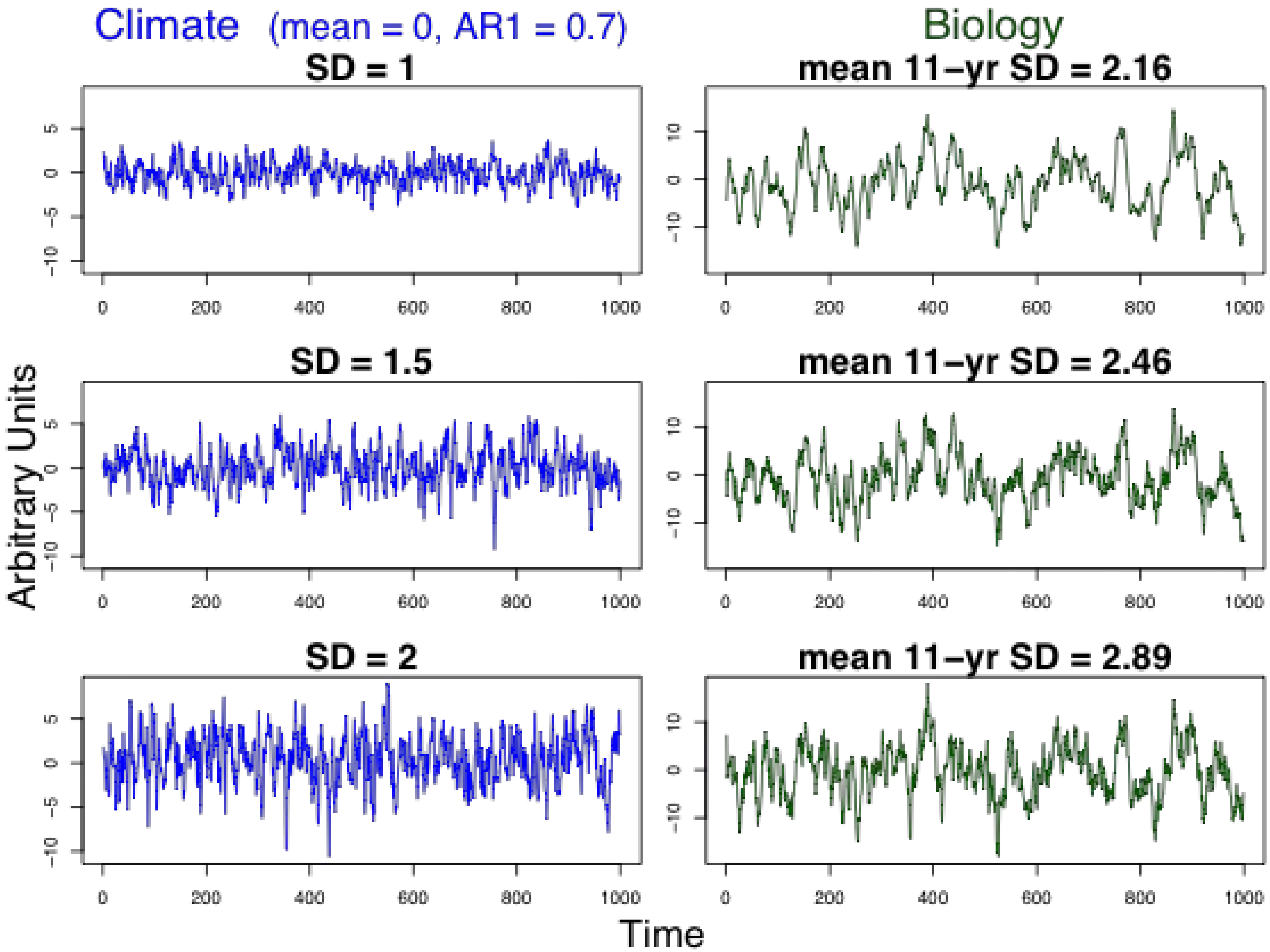
$$x_t = 0.7x_{t-1} + \varepsilon$$

…affect this process?

Biology in year t:

$$y_t = 0.9x_t + 0.9y_{t-1} + \varepsilon$$

Ecological consequences of increasing climate variability



Goals:

- Test for increasing variability in N. Pacific SST
  - Test for correlates to changing SST variability
- Test for accompanying variability increases in long-term biology observations

Approach (turns out to be important!)

Hansen et al. 2012 PNAS

Perception of climate change

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Approach

•Calculate variability with anomalies from base period:

$$(x - \bar{x}_{1951-1980}) / SD_{1951-1980}$$

Conclusion

Pervasive global increase in surface temperature variability

Huntingford et al. 2013 Nature

doi:10.1038/nature12310

No increase in global temperature variability despite changing regional patterns

Chris Huntingford[1], Philip D. Jones[2,3], Valerie N. Livina[4,5], Timothy M. Lenton[6] & Peter M. Cox[7]

Approach

•Calculate variability without reference to base period

Conclusions

•Variability increase an order of magnitude less than Hansen et al.

•Predict decreasing global variability with global warming

Basin-scale variability trend

Data:

- HadISST dataset
- 20°-66°N
- 1°×1° grid (4,491 cells)
- 1951-2012
- Weighted mean and variance
- Months including ice removed
- Annual anomalies (detrended data)

Goal 1: Test for increasing variability

Declining basin-scale variability

Data:

- HadISST dataset
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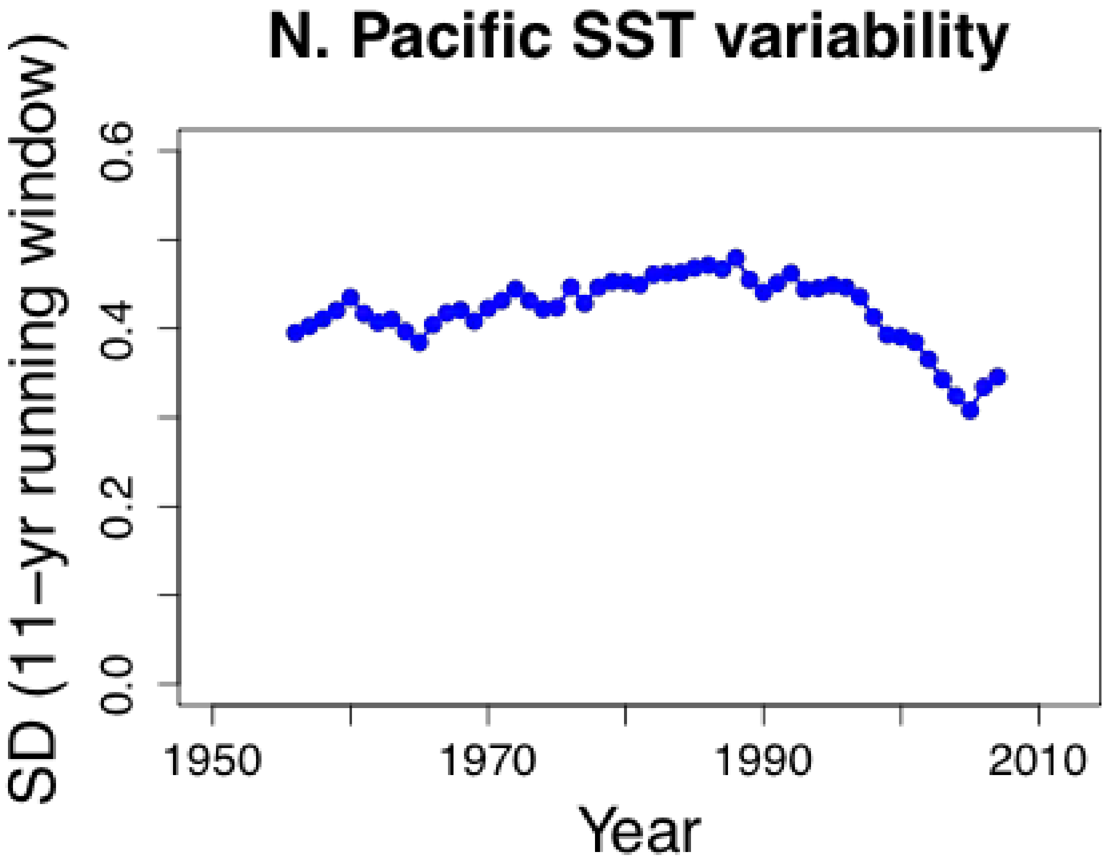

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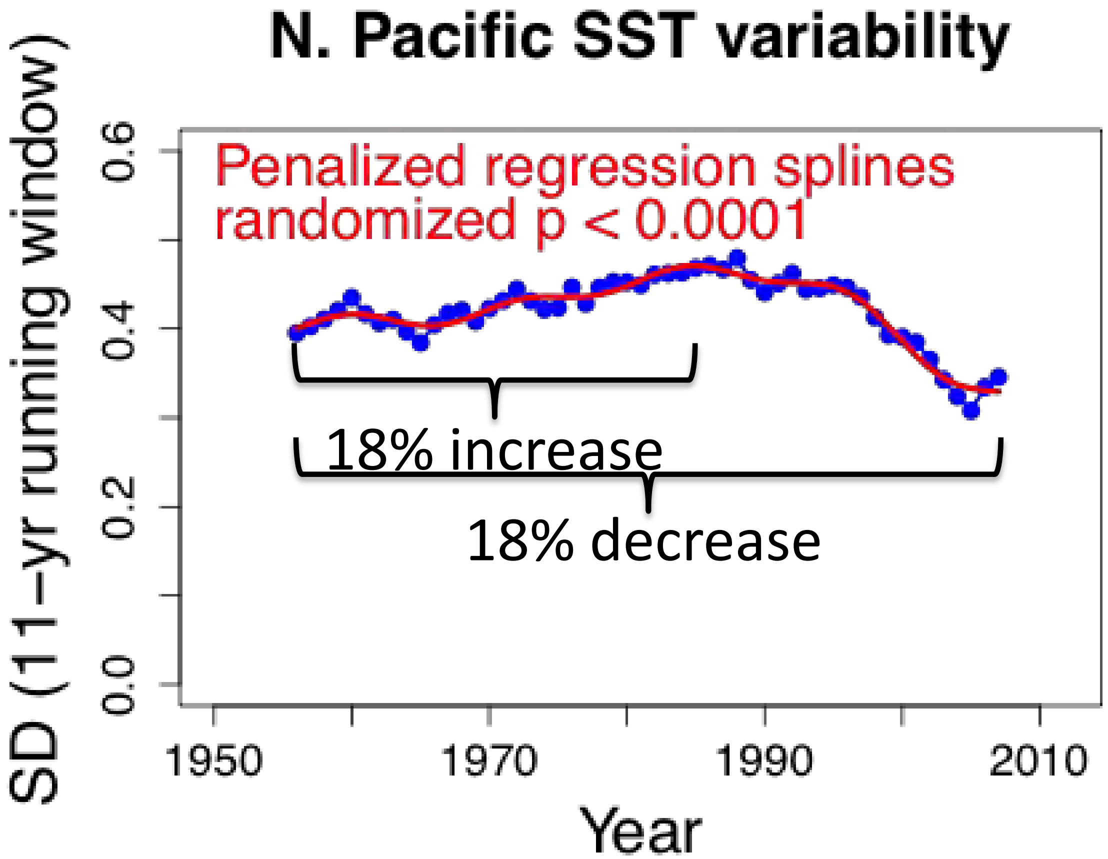
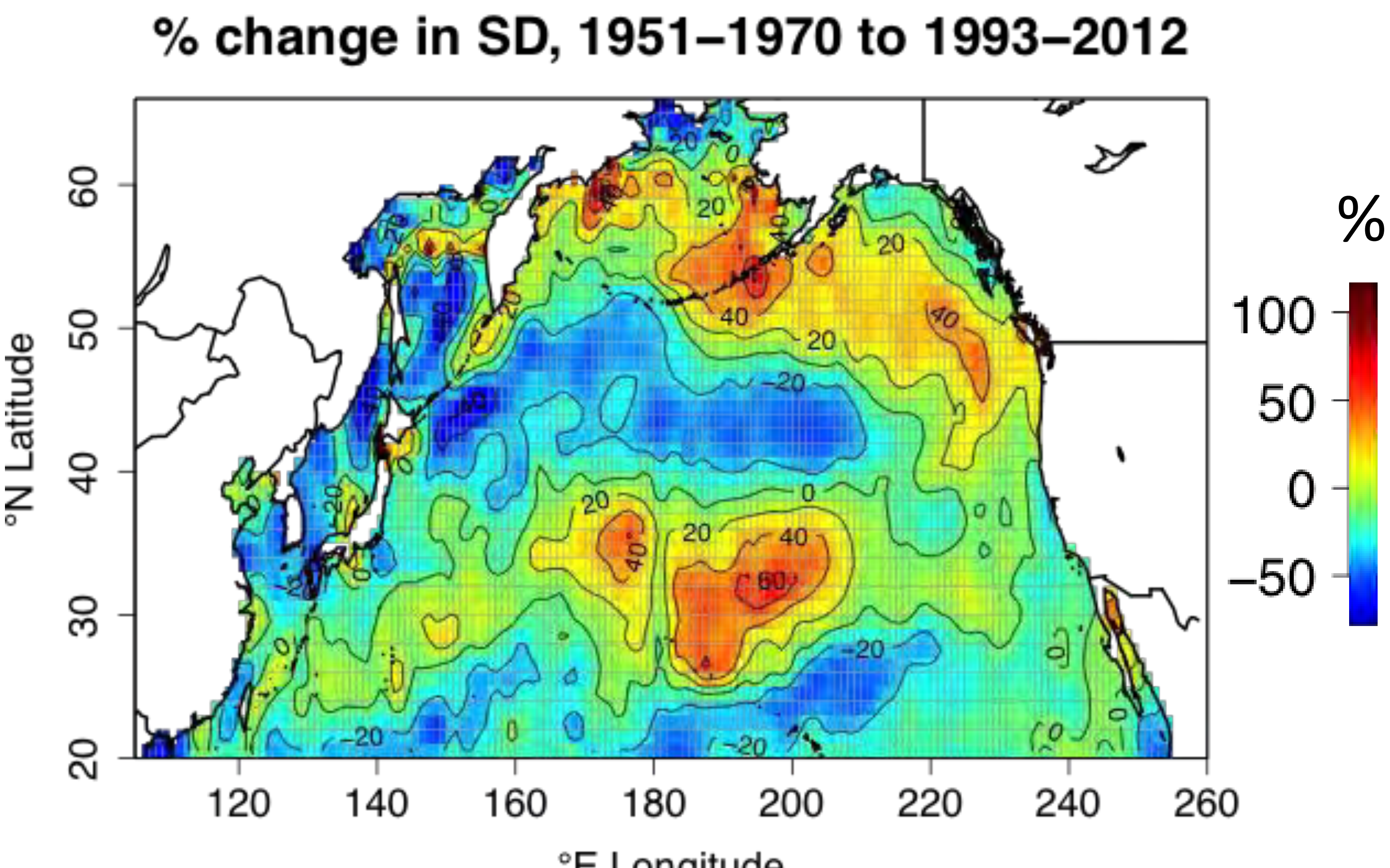


Goal 1: Test for increasing variability

Spatial pattern in variability trends



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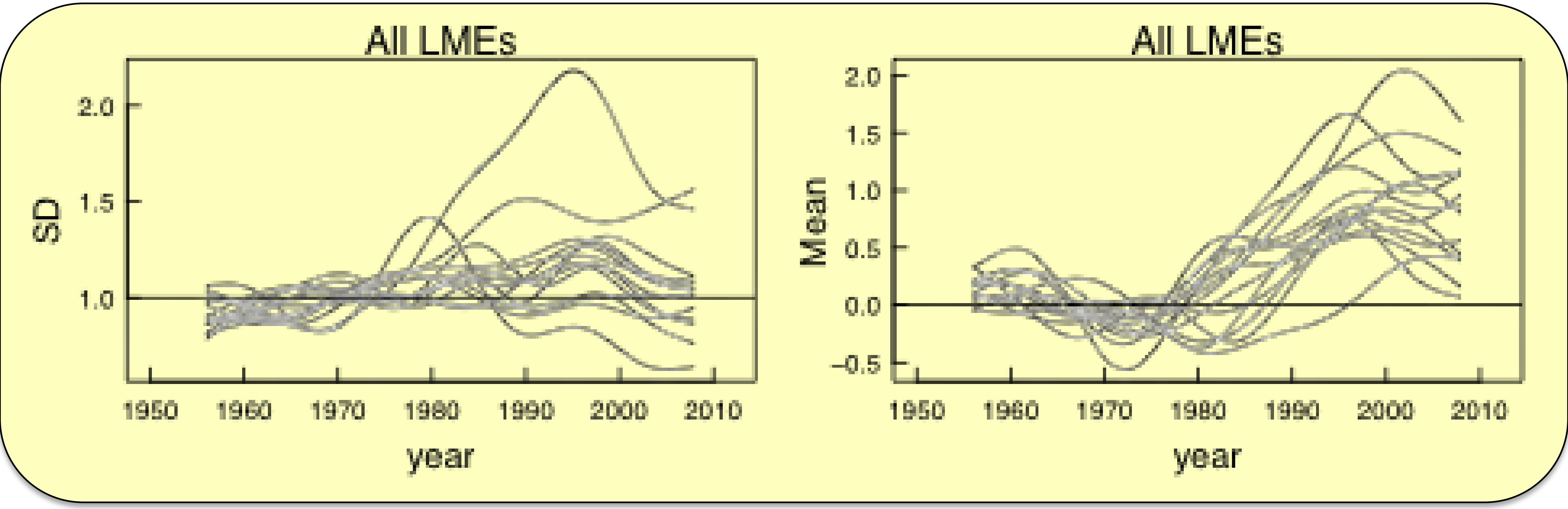
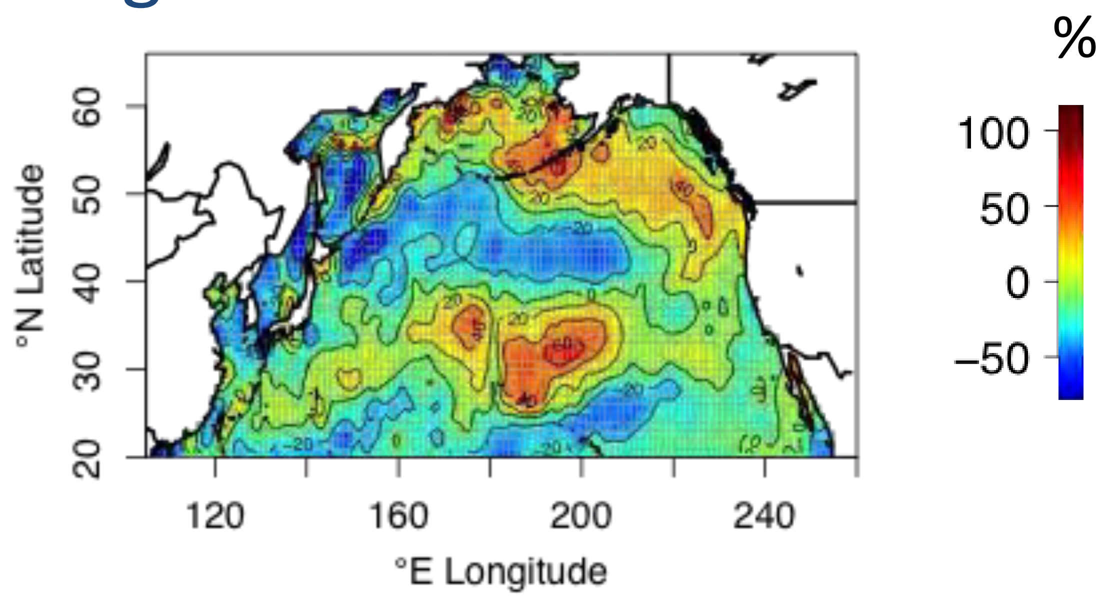


Goal 1: Test for increasing variability

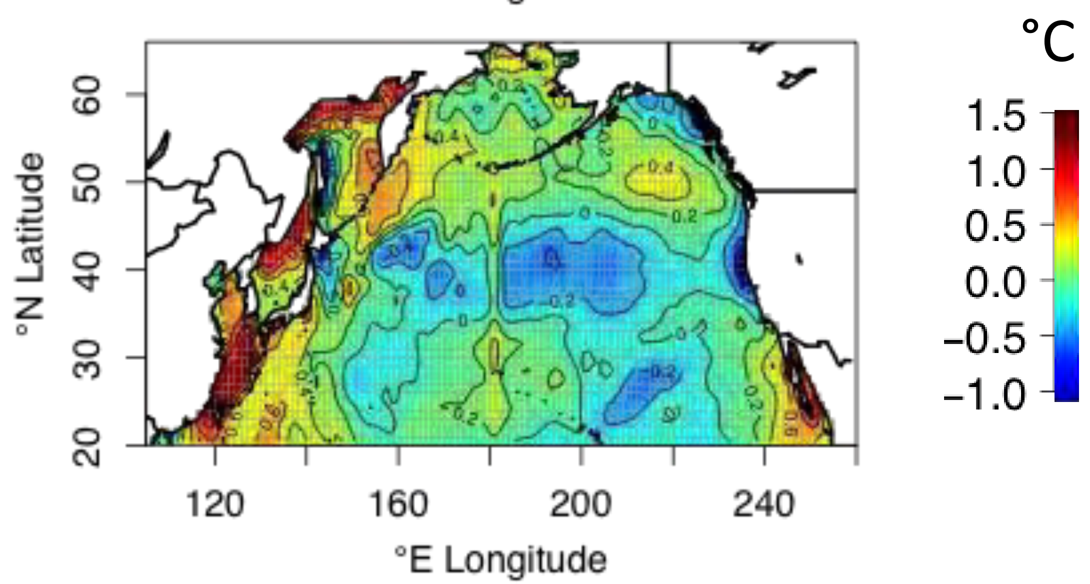
Possible correlates of changing variability – change in the mean?

Change in SD (%), 1951-1970 to 1993-2012

r = 0.06

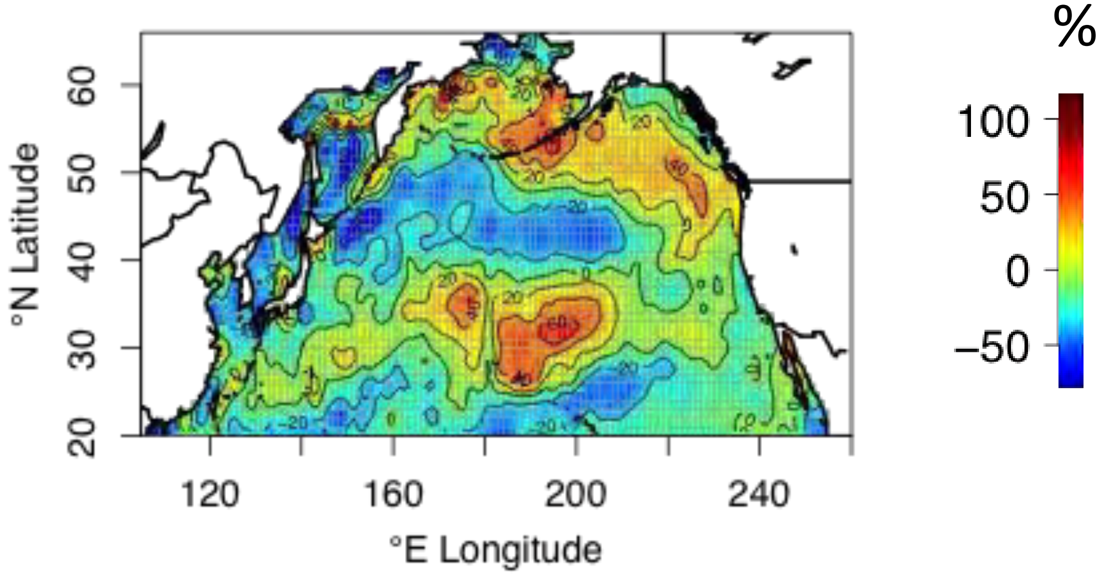


Change in mean (°C), 1951-1970 to 1993-2012

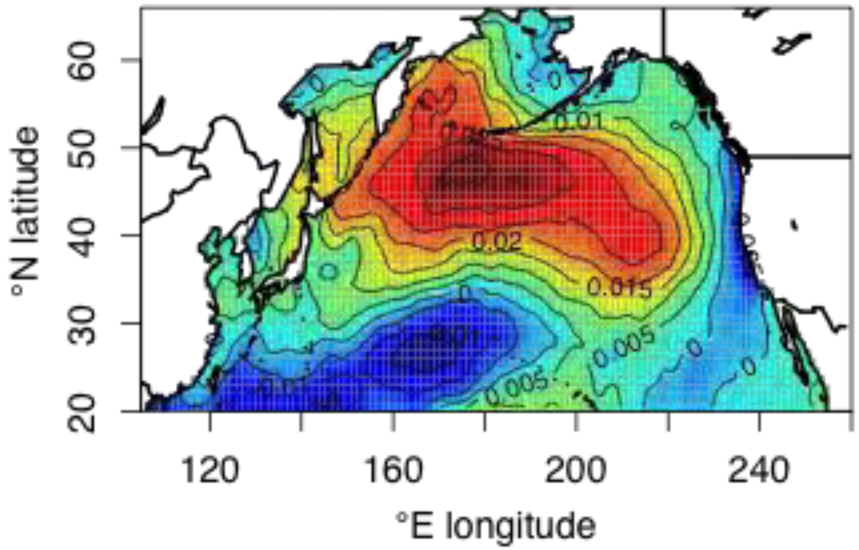


Possible correlates of changing variability – increased importance of the NPGO?

Change in SD (%), 1951-1970 to 1993-2012



NPGO pattern (EOF2 – SSTa)



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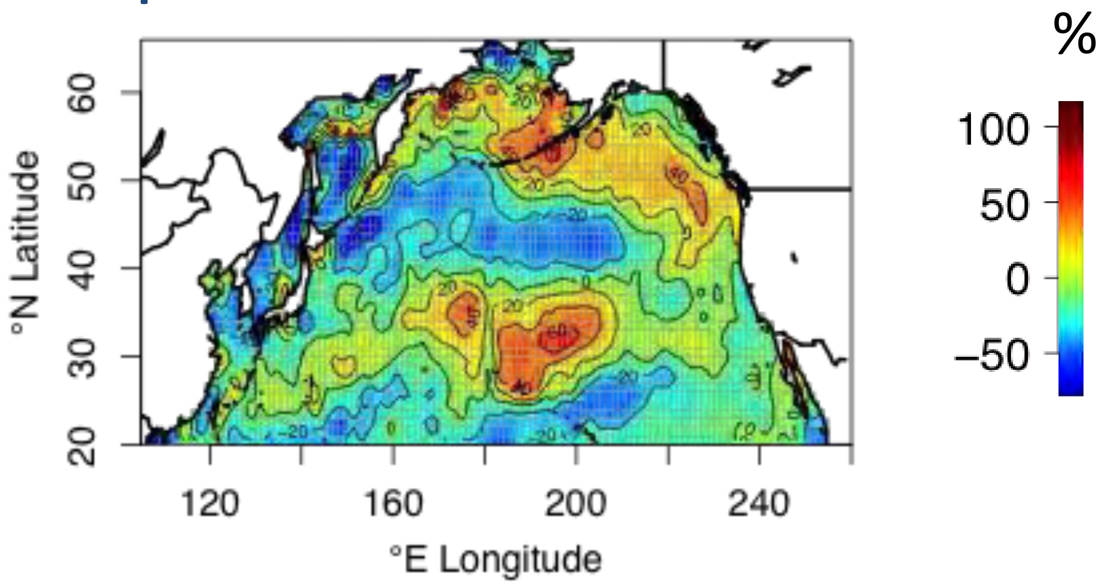
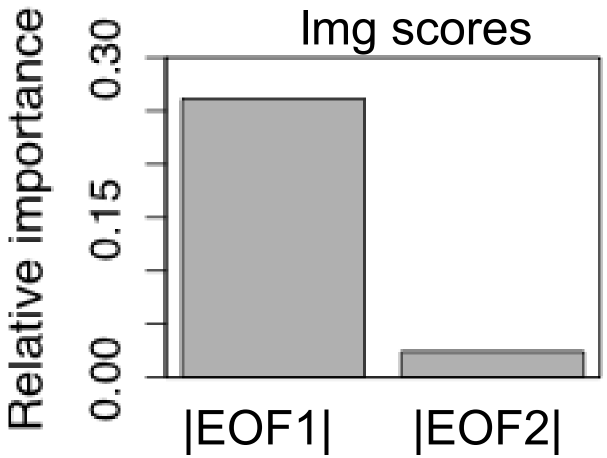
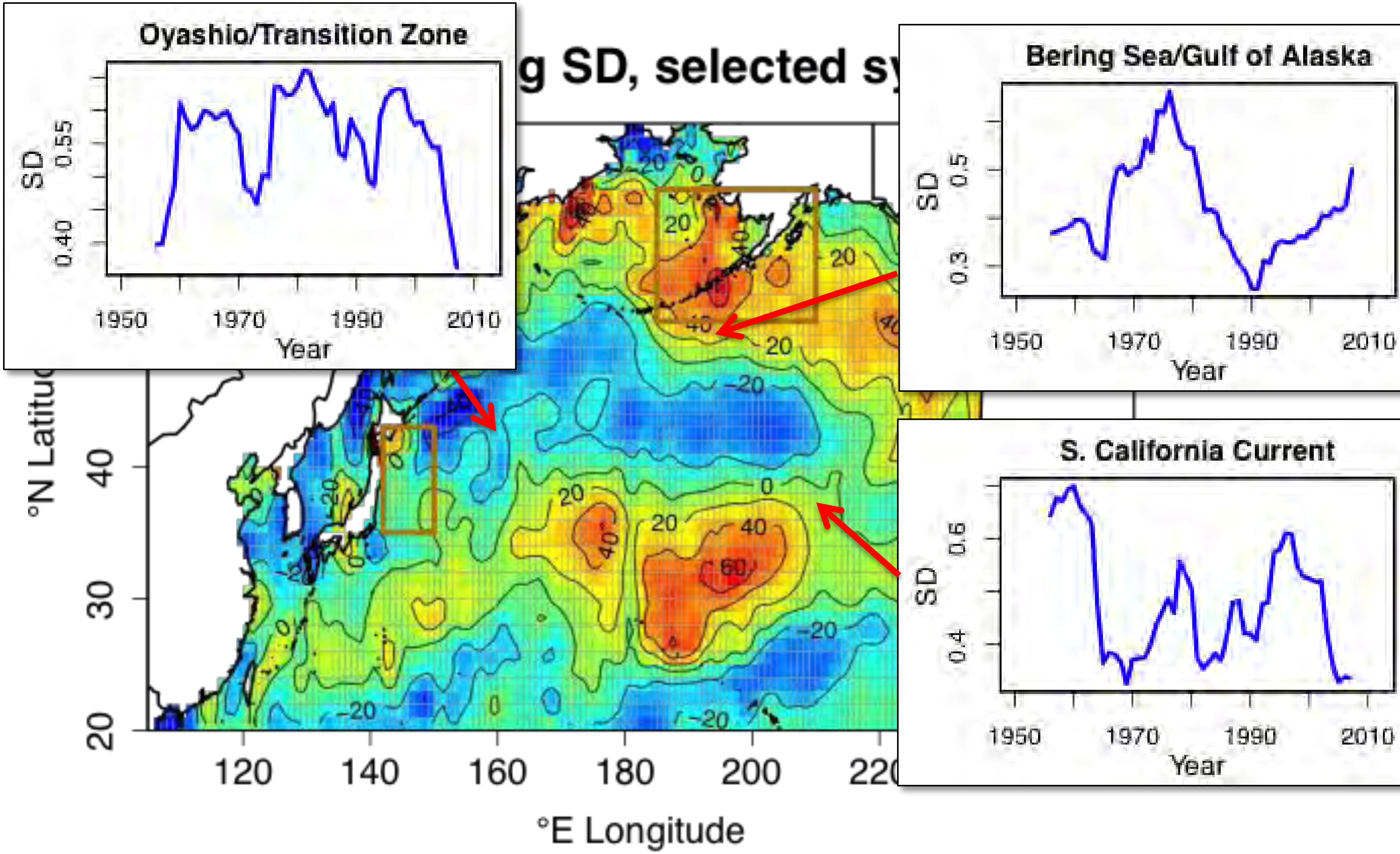


Overall R^2 = 0.29



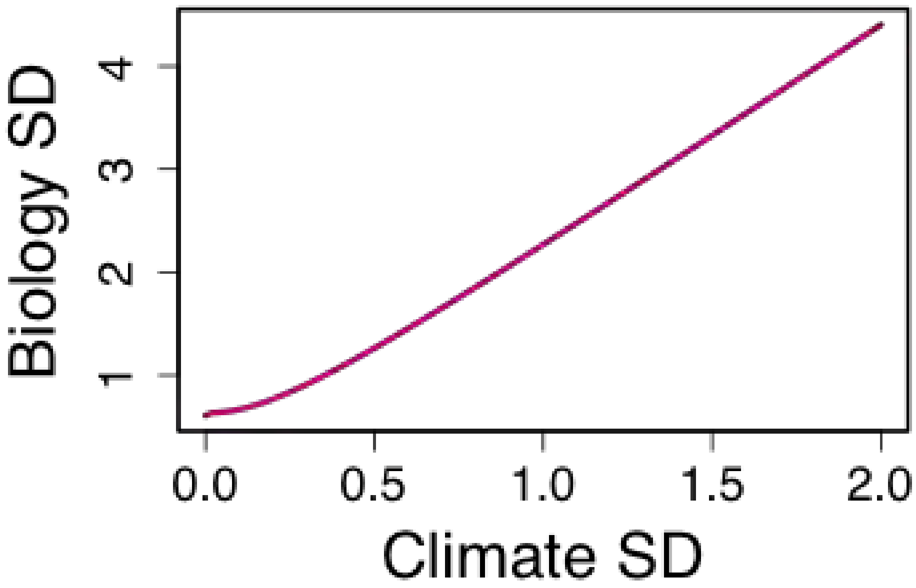
Goal 2: Test for increasing variability

Spatial pattern in variability trends



Goal 2: Test for increasing variability

Connected climatic & biological variability – a first-look hypothesis



Goal 2: Test for increasing variability

Connected climatic & biological variability – approach

System	Data	Years
Oyashio/Transition	abundance 10 spp. copepod	1960-2002
Bering Sea/ Gulf of Alaska	S-R residuals – pink, chum, sockeye salmon, walleye pollock, yellowfin sole pup production – northern fur seal	1961-2007
S. California Current	abundance - 9 taxa ichthyoplankton, 3 spp. euphausids	1951-2011

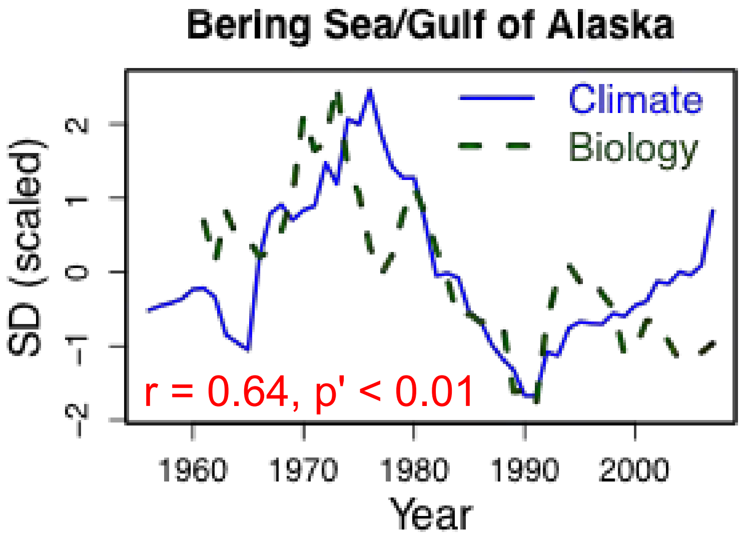
Connected climatic & biological variability – approach

Analysis

- Species/taxon as sampling unit
- All groups normalized/detrended
- Multiple imputation to estimate missing values in Bering/GOA
- SD calculated across all groups for 11-yr sliding windows

Goal 2: Test for increasing biological variability

Does biological variability track climatic variability?



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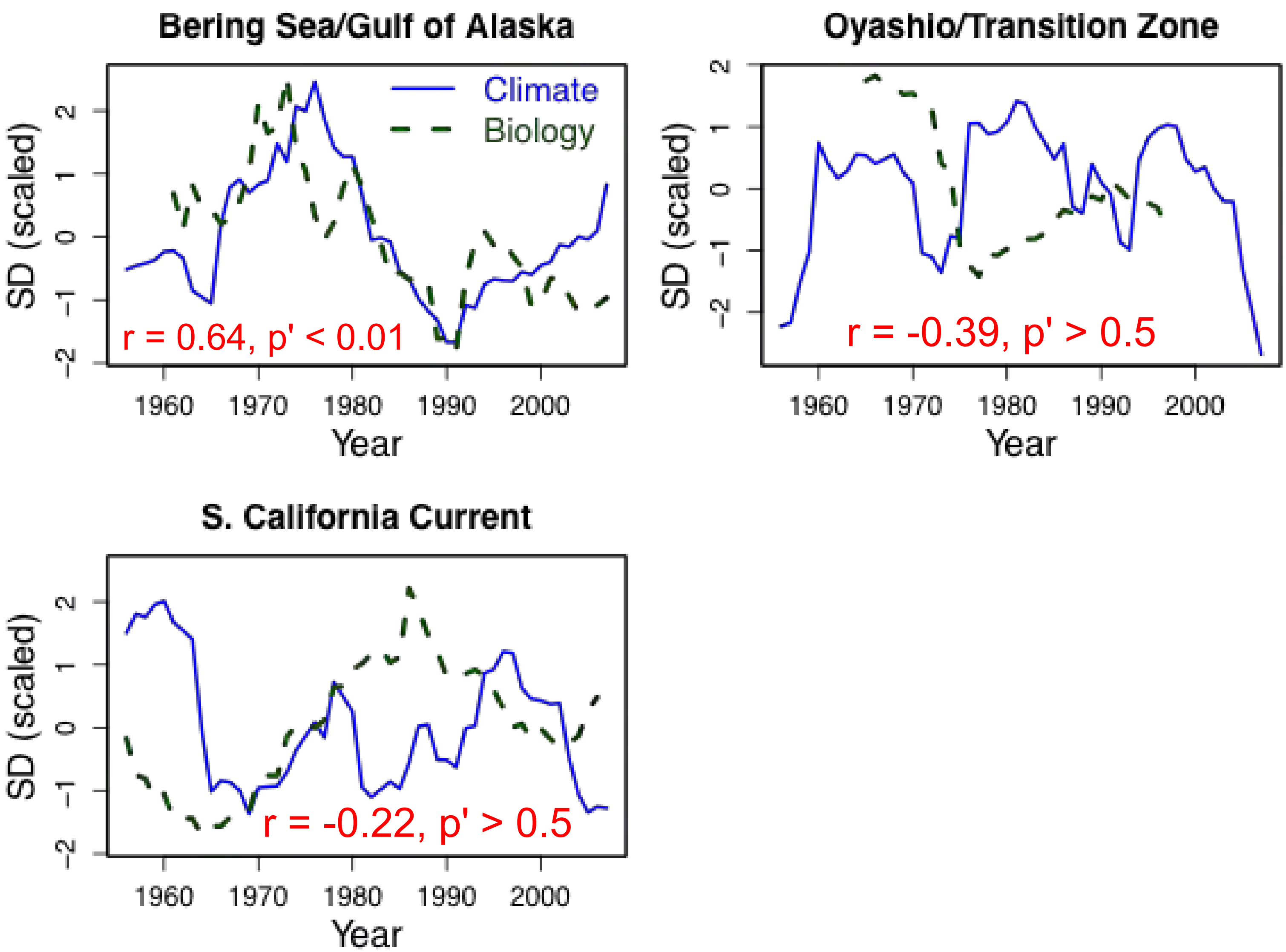

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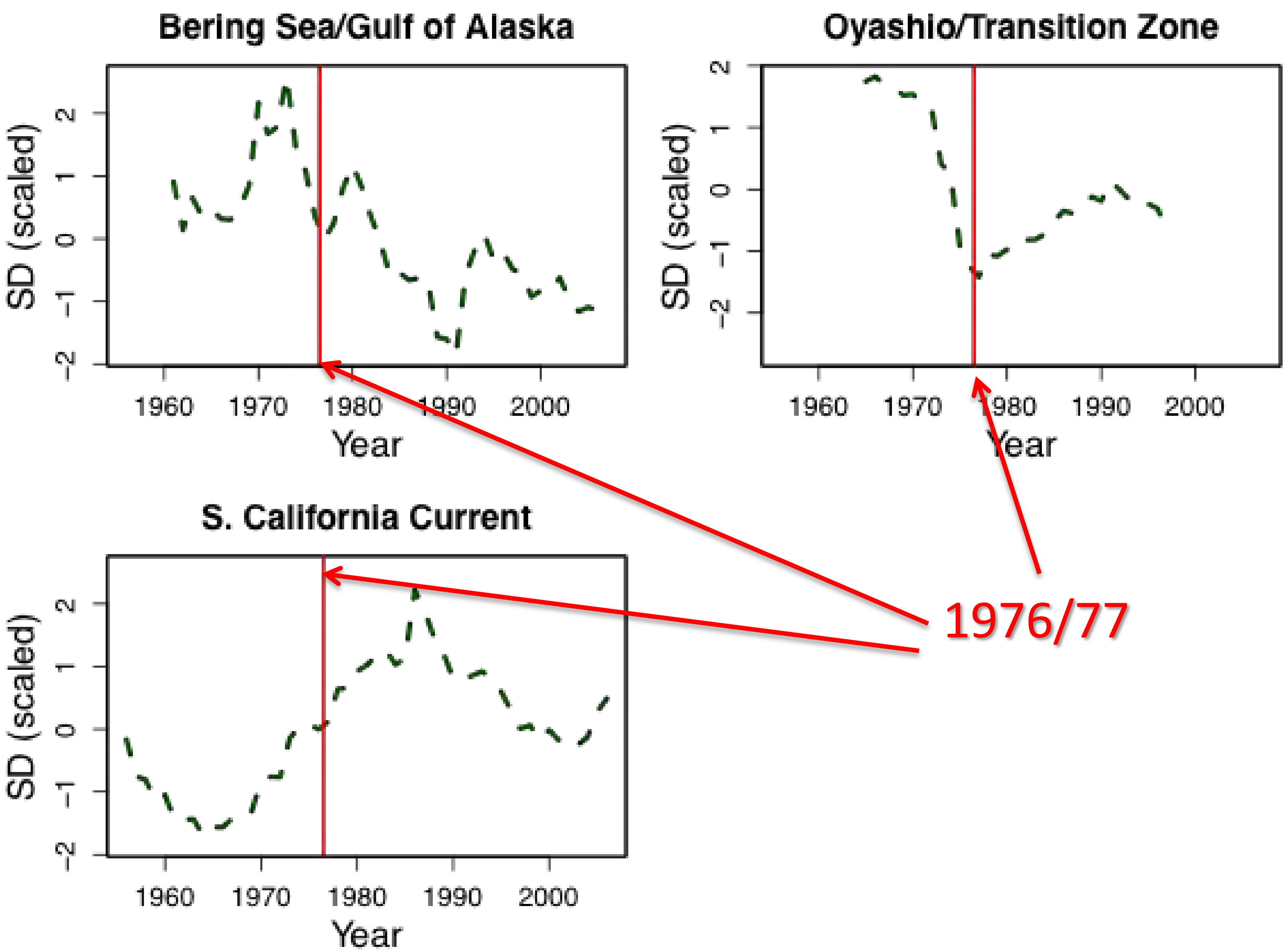
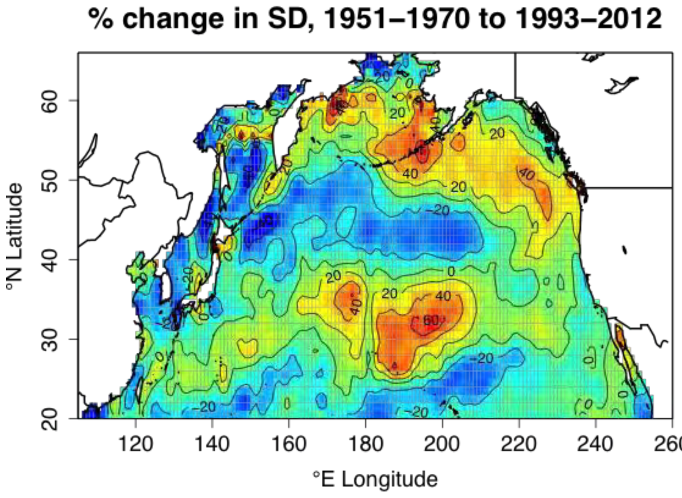


Conclusions

- Basin-scale decrease in SST variability
- Great variability in regional variability trends
- No uniform biological response to changing SST variability

→ Fundamentally regional-scale problems



Acknowledgements

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