NORTH AMERICA'S WINTER CIRCULATION HAS CHANGED

BUT FOR HOW LONG?

Simon S-Y Wang, Utah State University

Jin-Ho Yoon (GIST), Emily Becker (CPC)

5-day temperature forecast for the 2018 New Year week

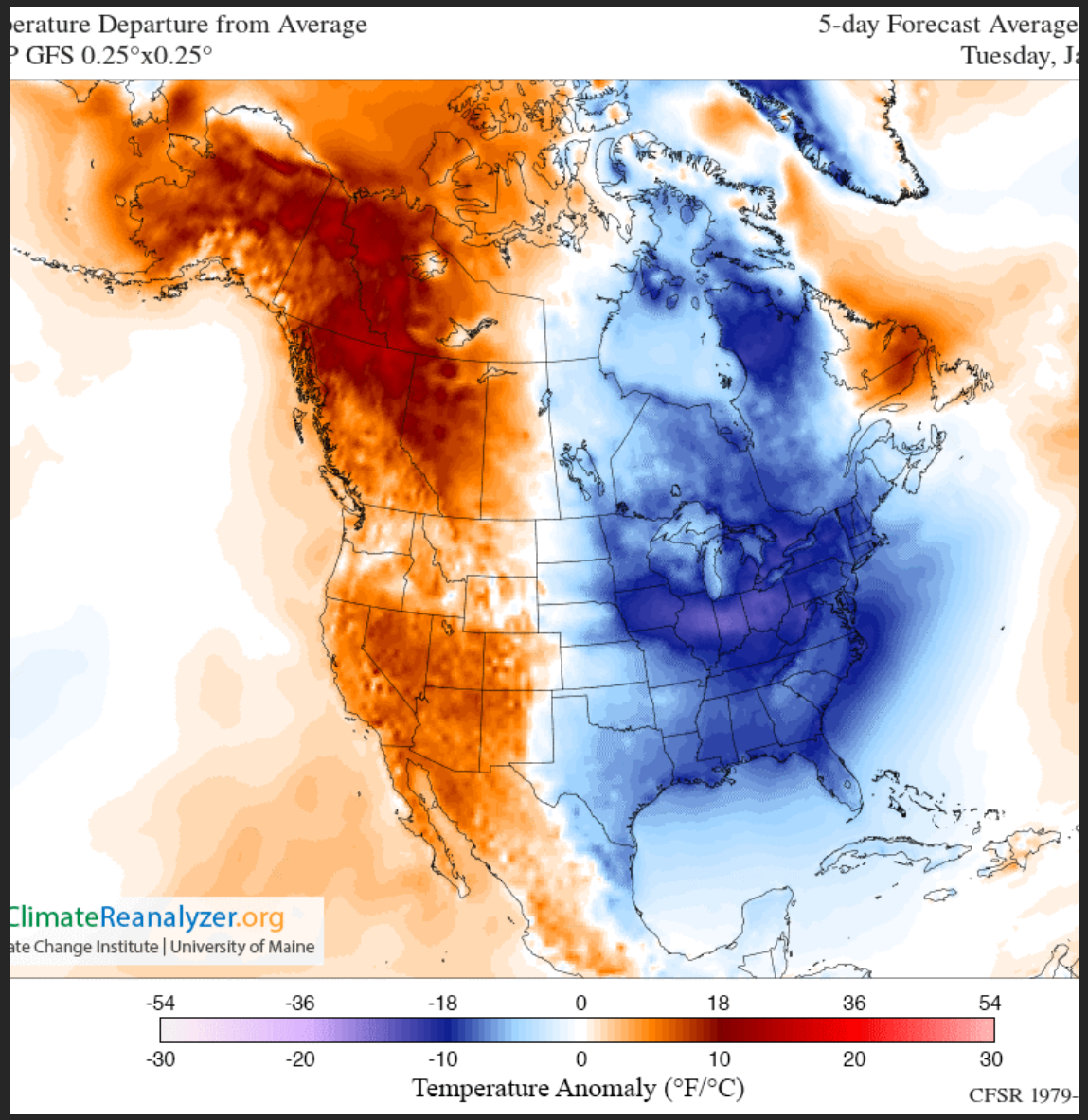
The Washington Post

Business • Analysis

The Bomb Cyclone Breezes Into the Natural Gas Market: Gadfly

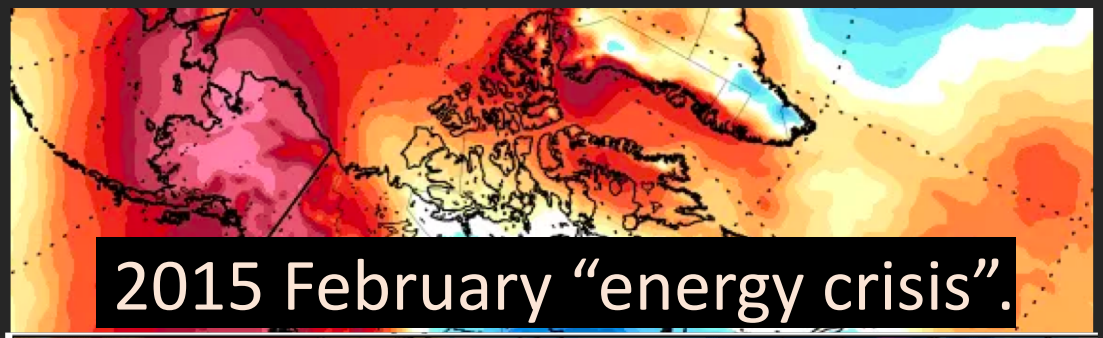
Jan 4, 2018

a miserable market…that thrives on your misery : …
in the depths of winter

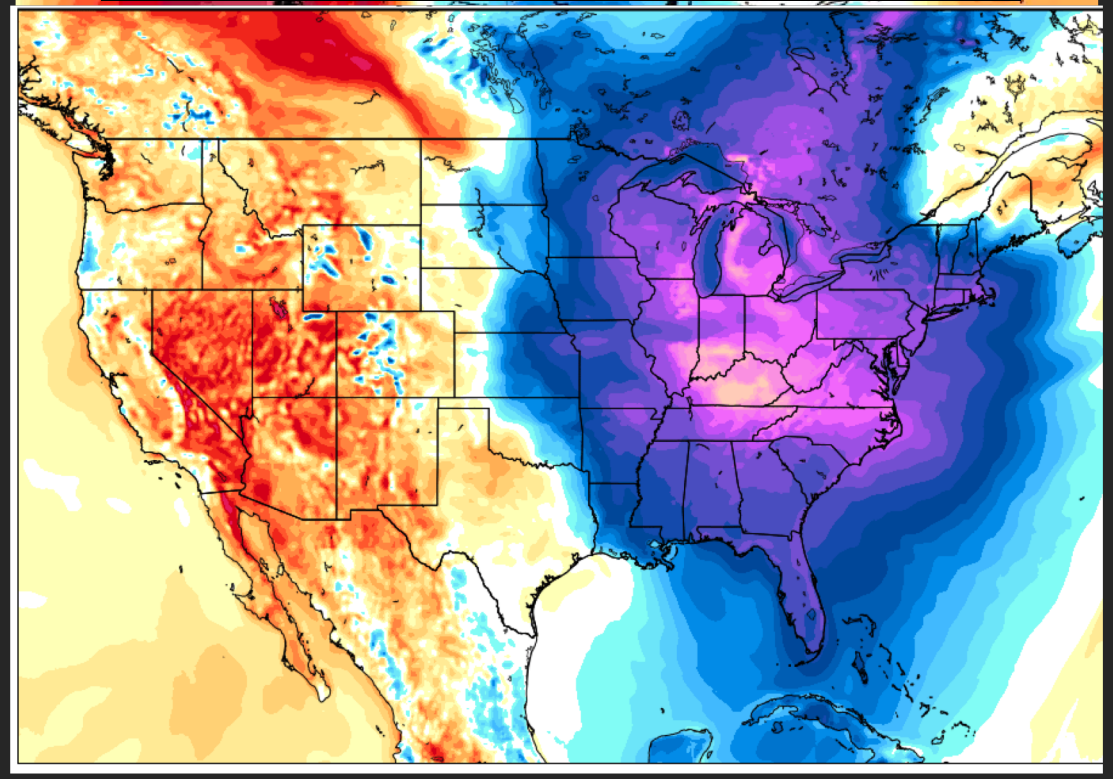


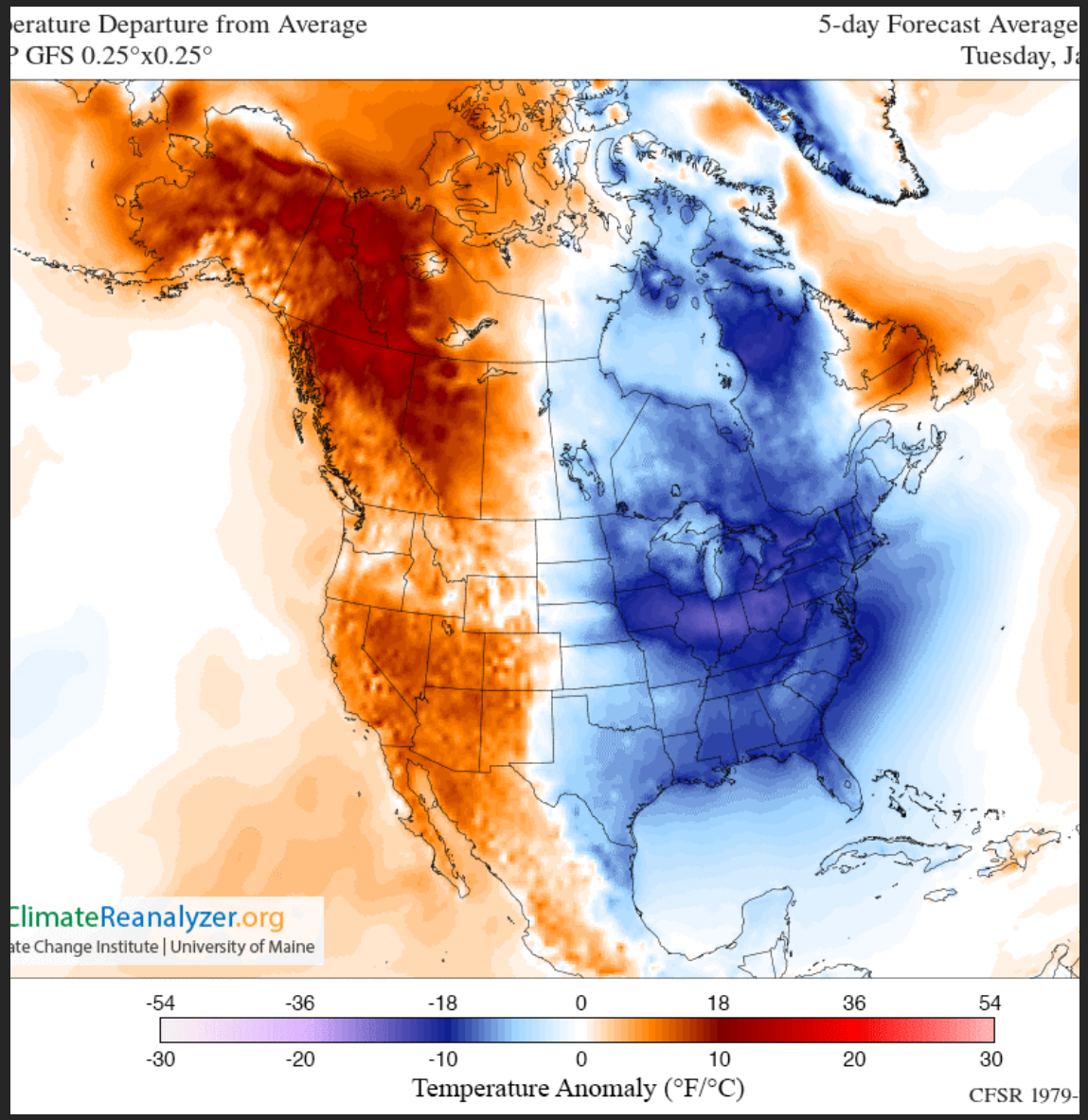
5-day temperature forecast for the 2018 New Year week

2014 January "polar vortex"



2015 February "energy crisis".

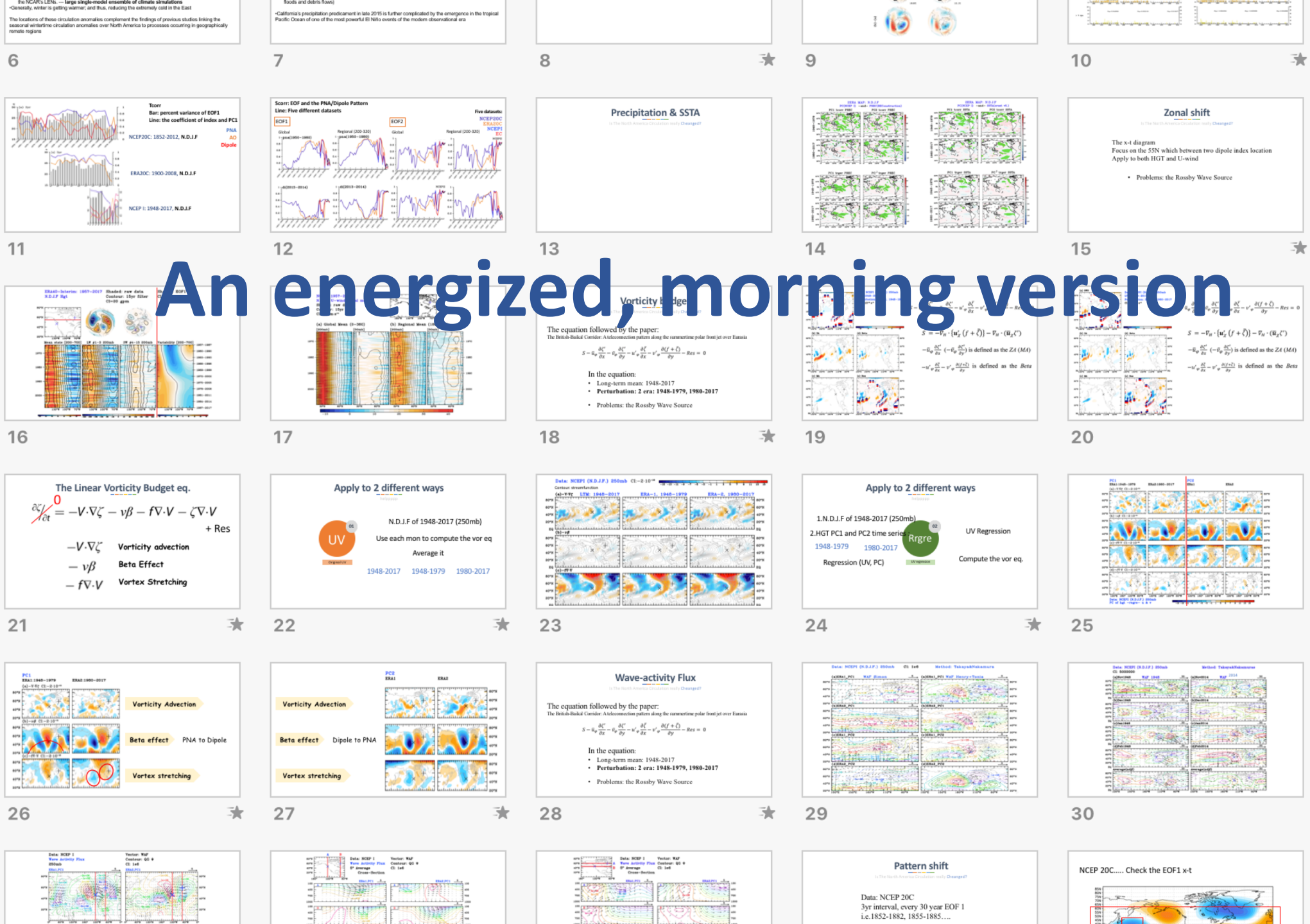




Global warming makes colder winters?

Dipo
wha
is
it
?

An energized, morning version



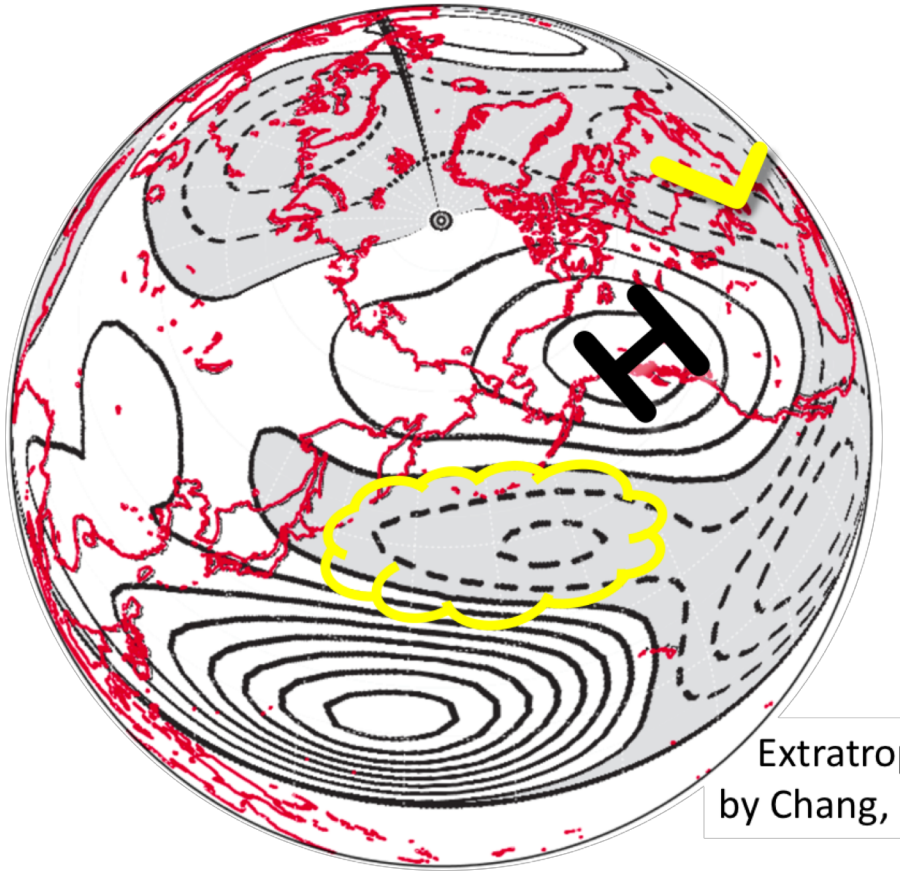
Jet stream and orography alone can change the stationary waves

POLVANI ET AL. (1999)

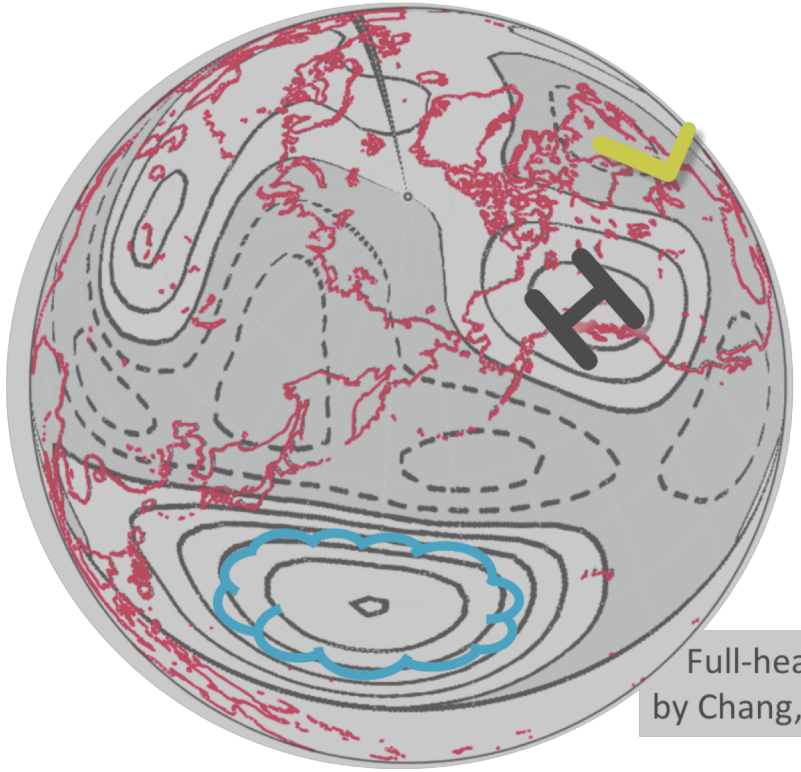
Jet stream and orography

+ tropical heating

+ extra-tropical heating



Extratropical heating + orographic exp.
by Chang, E. (2009)

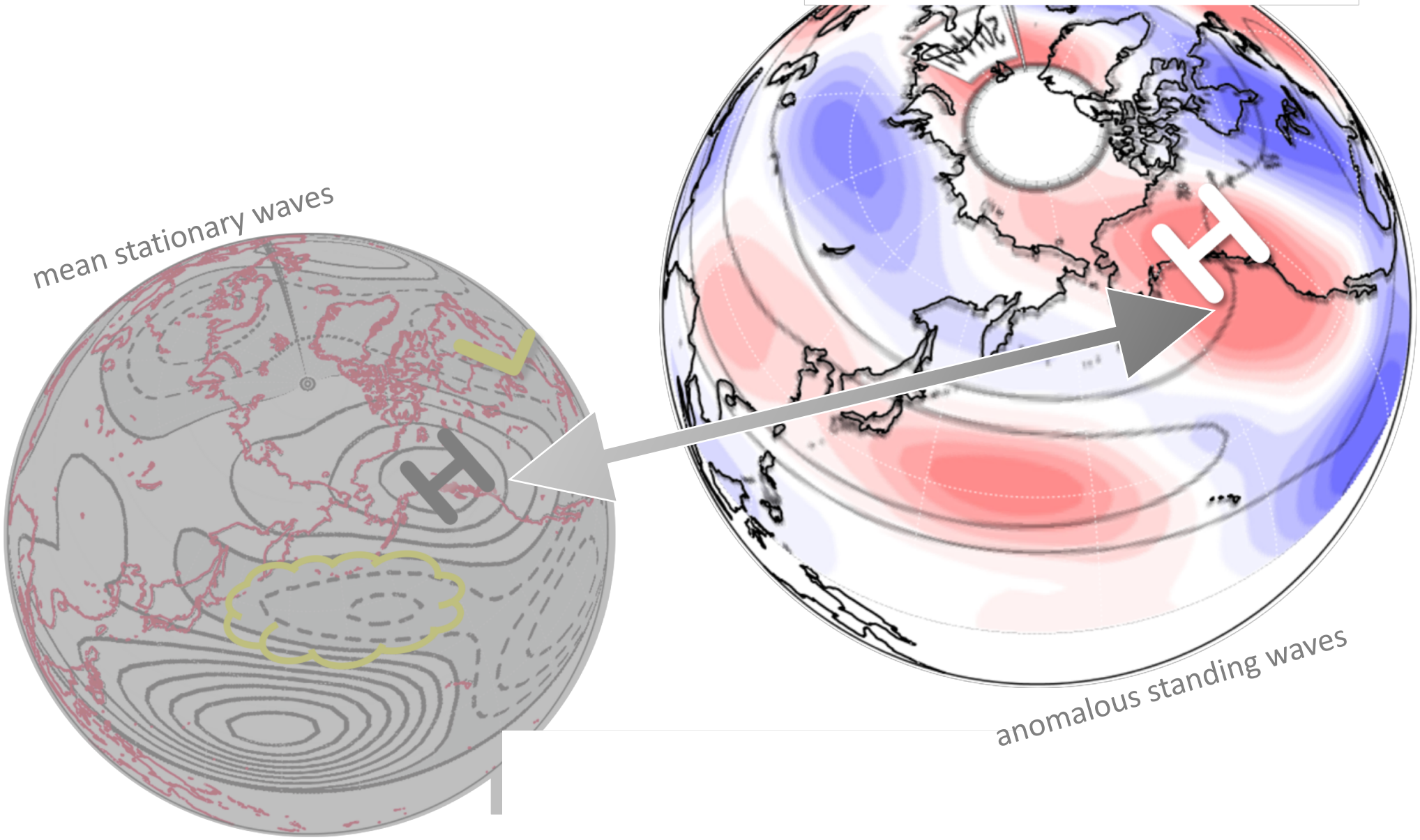


Full-heat orographic exp.
by Chang, E. (2009)

POLVANI ET AL. (1999)

2014 January - CA drought

(Teng and Branstator 2016)

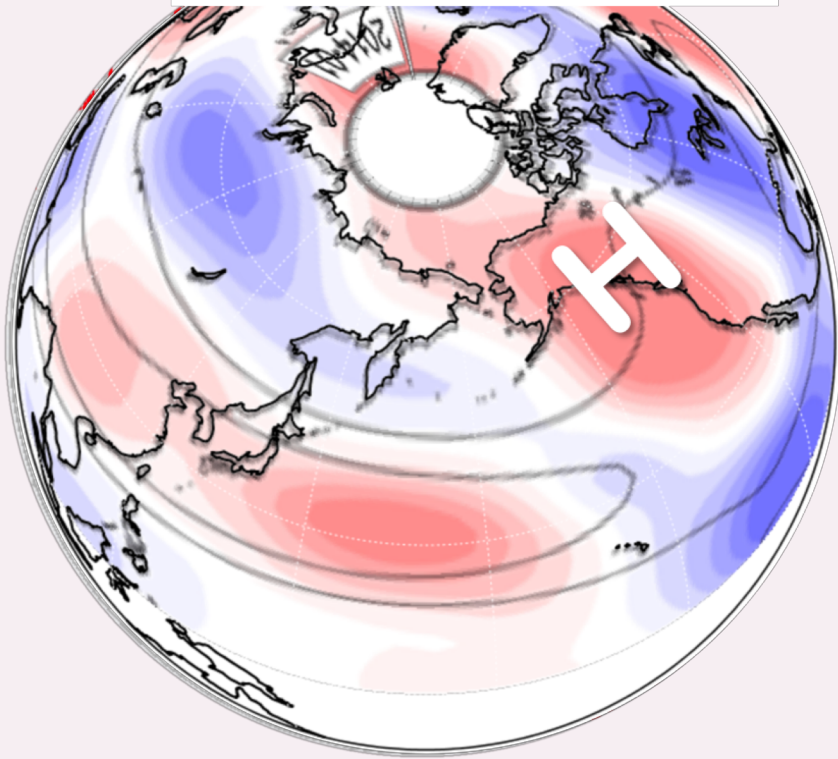


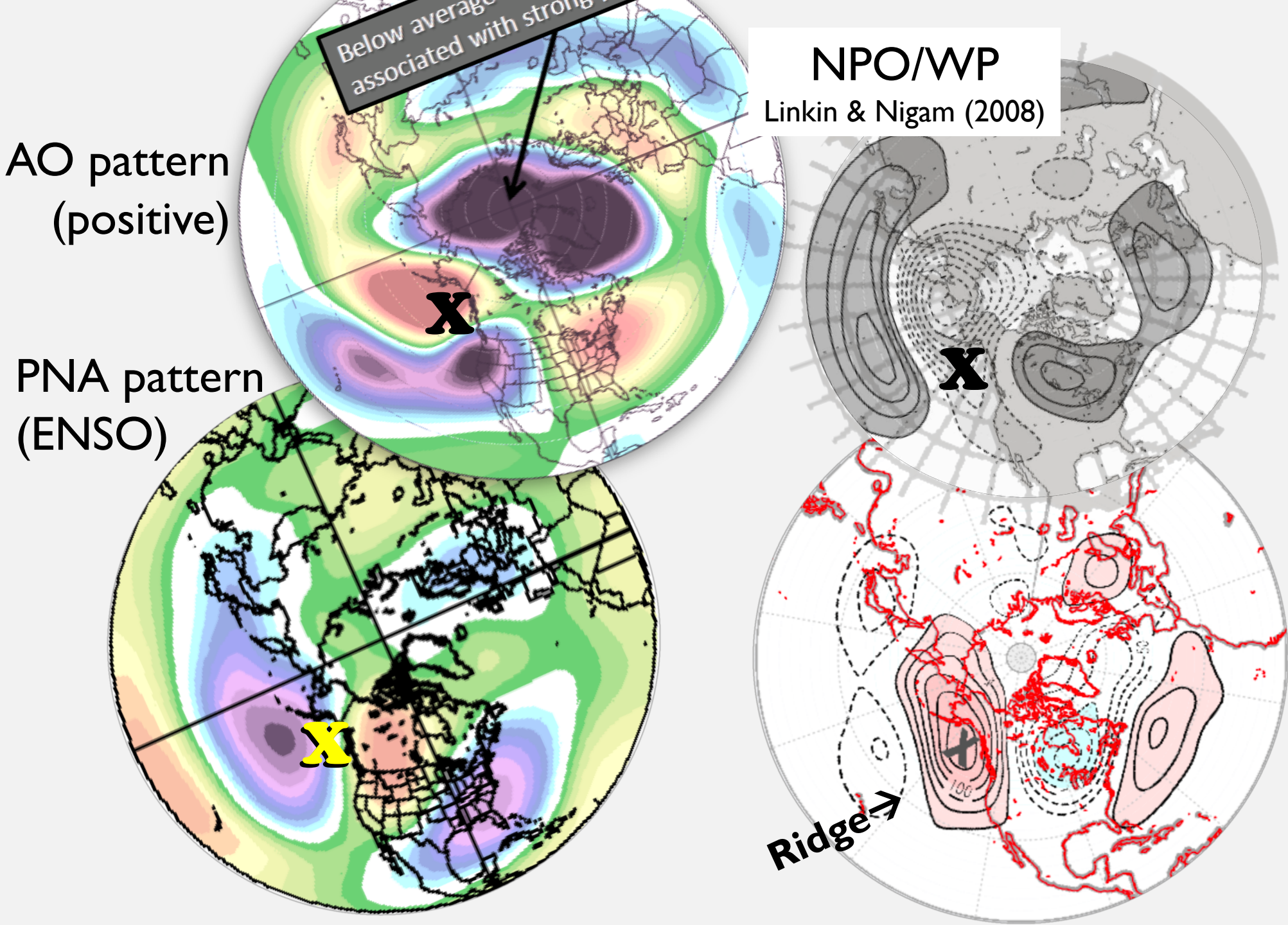
THIS **DIPOLE** IS NOT A NEW MODE!

IT'S ONE THAT HAS

CRAWLED BACK

2014 January - CA drought
(Teng and Branstator 2016)

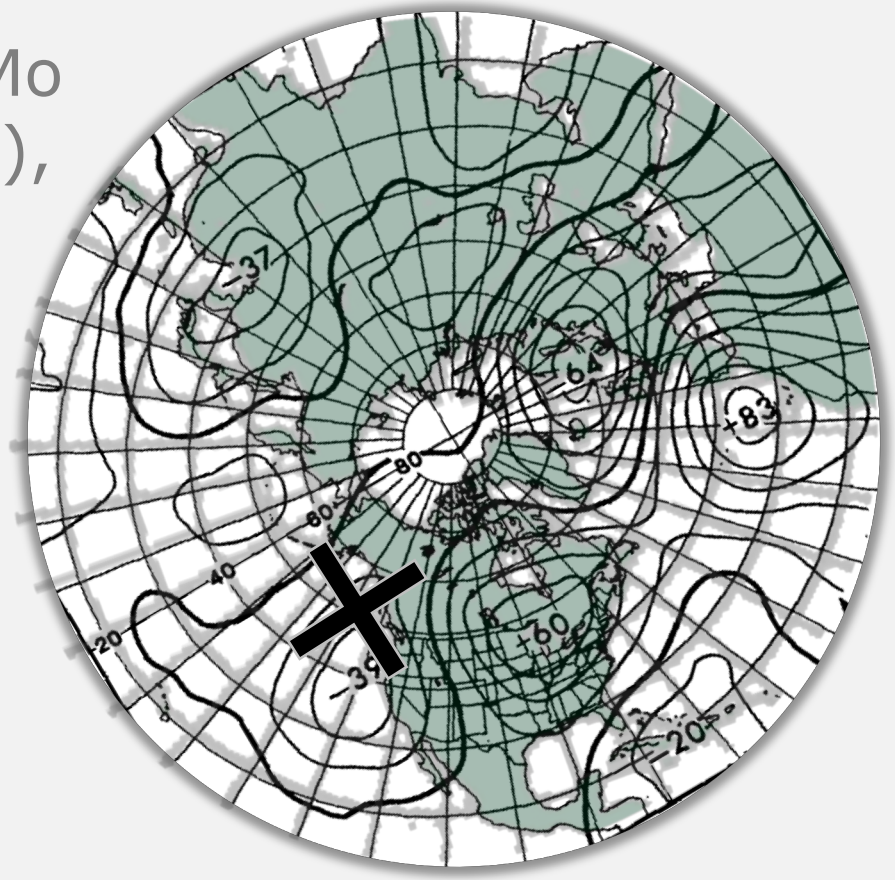



Below average
associated with strong
AO pattern
(positive)
PNA pattern
(ENSO)
NPO/WP
Linkin & Nigam (2008)
X
X
X
Ridge→

TNH: Tropical-Northern Hemispheric pattern

first classified by Mo and Livezey (1986), and appears as a prominent wintertime mode.

(CPC website)



JUNE 1987 BARNSTON AND LIVEZEY

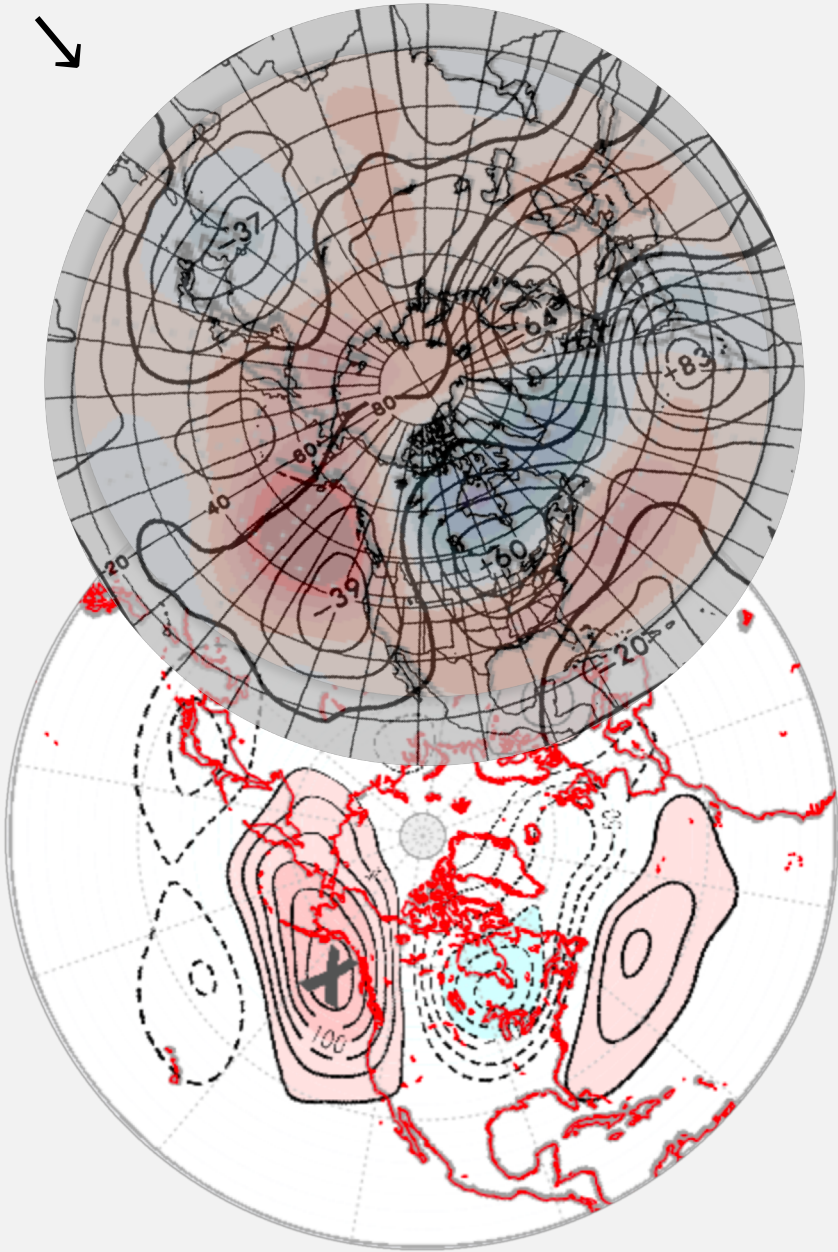
TNH: Tropical-Northern Hemispheric pattern ↘

Mo and Livezey (1986)

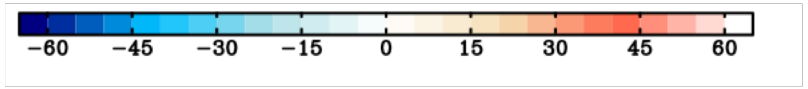
Barnston and Livezey (1987)

MODE 9
6.3%

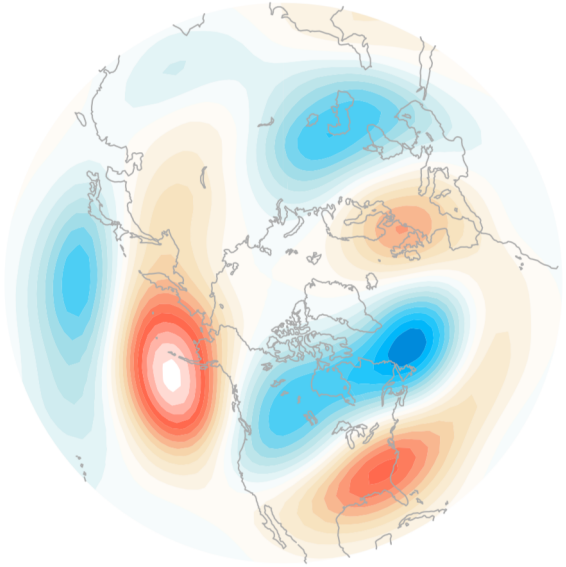
??



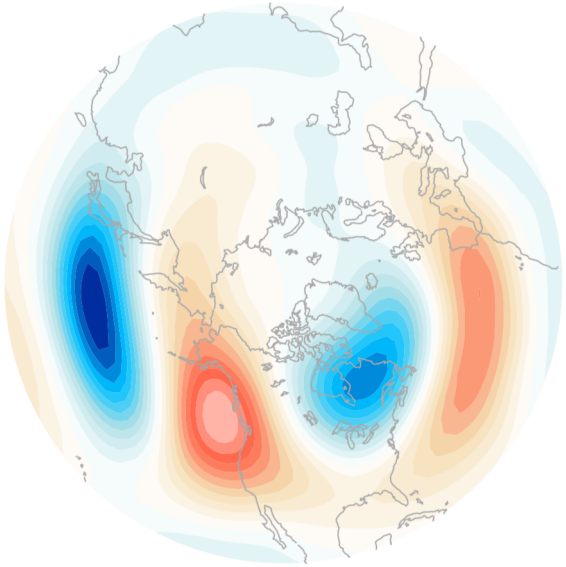
NCEPI: 1948–2017
HGT 250mb eddies
Shaded: EOF1



N.D.J.F
(month-to-month/subseasonal variability)



18.6%



18.8%

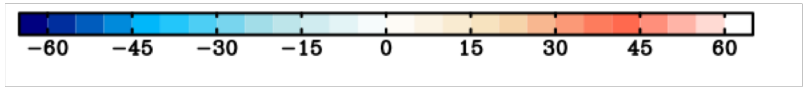
Before 1980

1948-1979

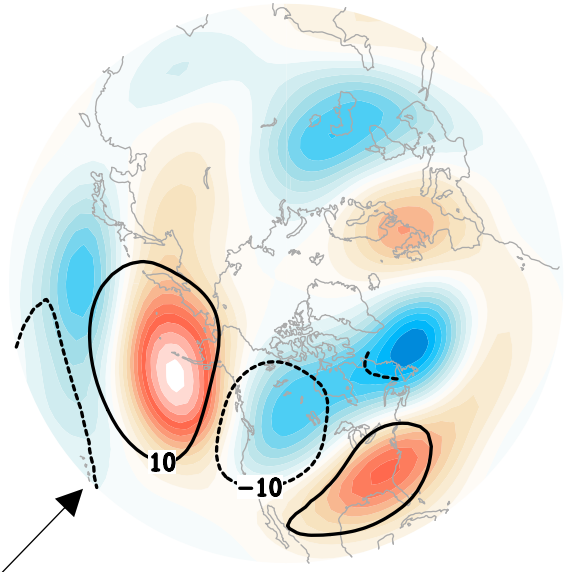
After 1980

1980-2017

NCEPI: 1948–2017
HGT 250mb
Shaded: EOF1



N.D.J.F
PNA

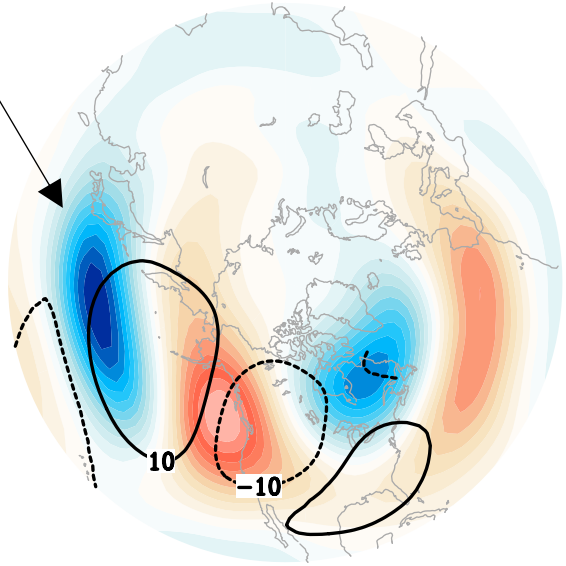


18.6%

Before 1980

1948-1979

PNA pattern

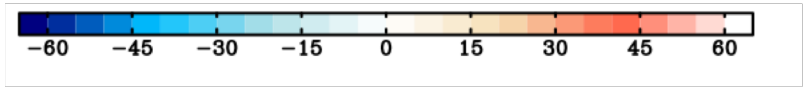


18.8%

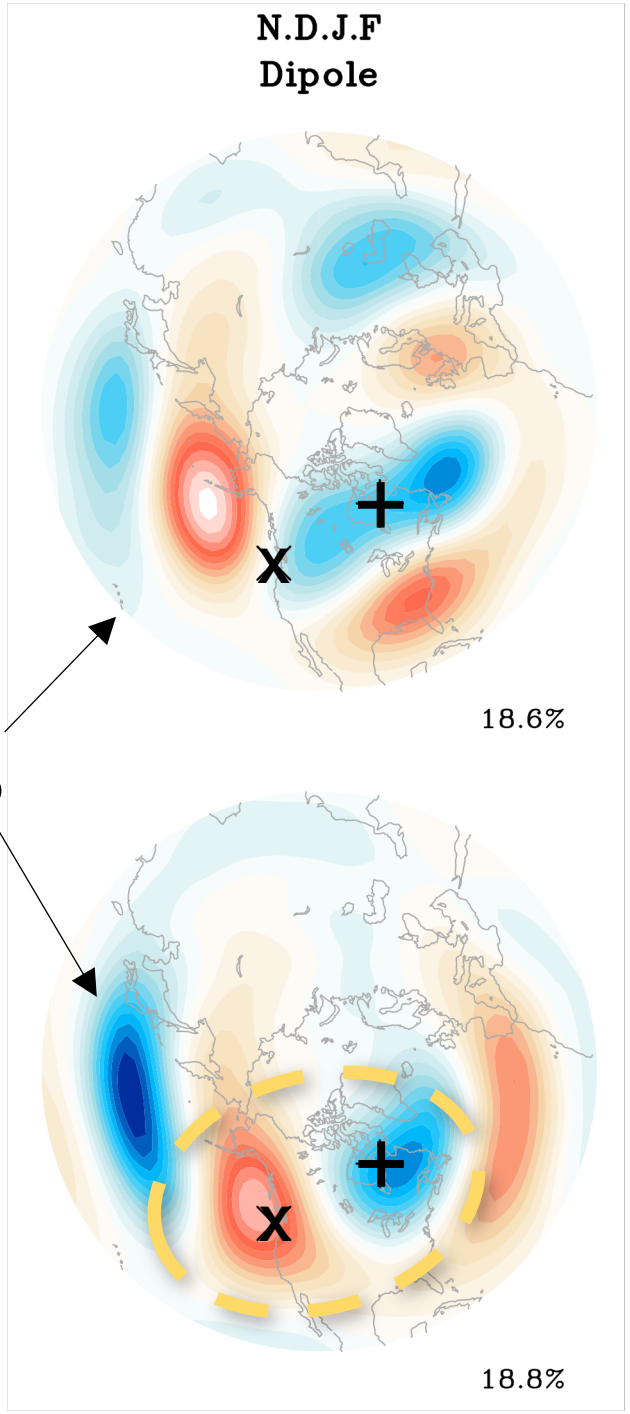
After 1980

1980-2017

NCEPI: 1948–2017
HGT 250mb
Shaded: EOF1



Dipole centers

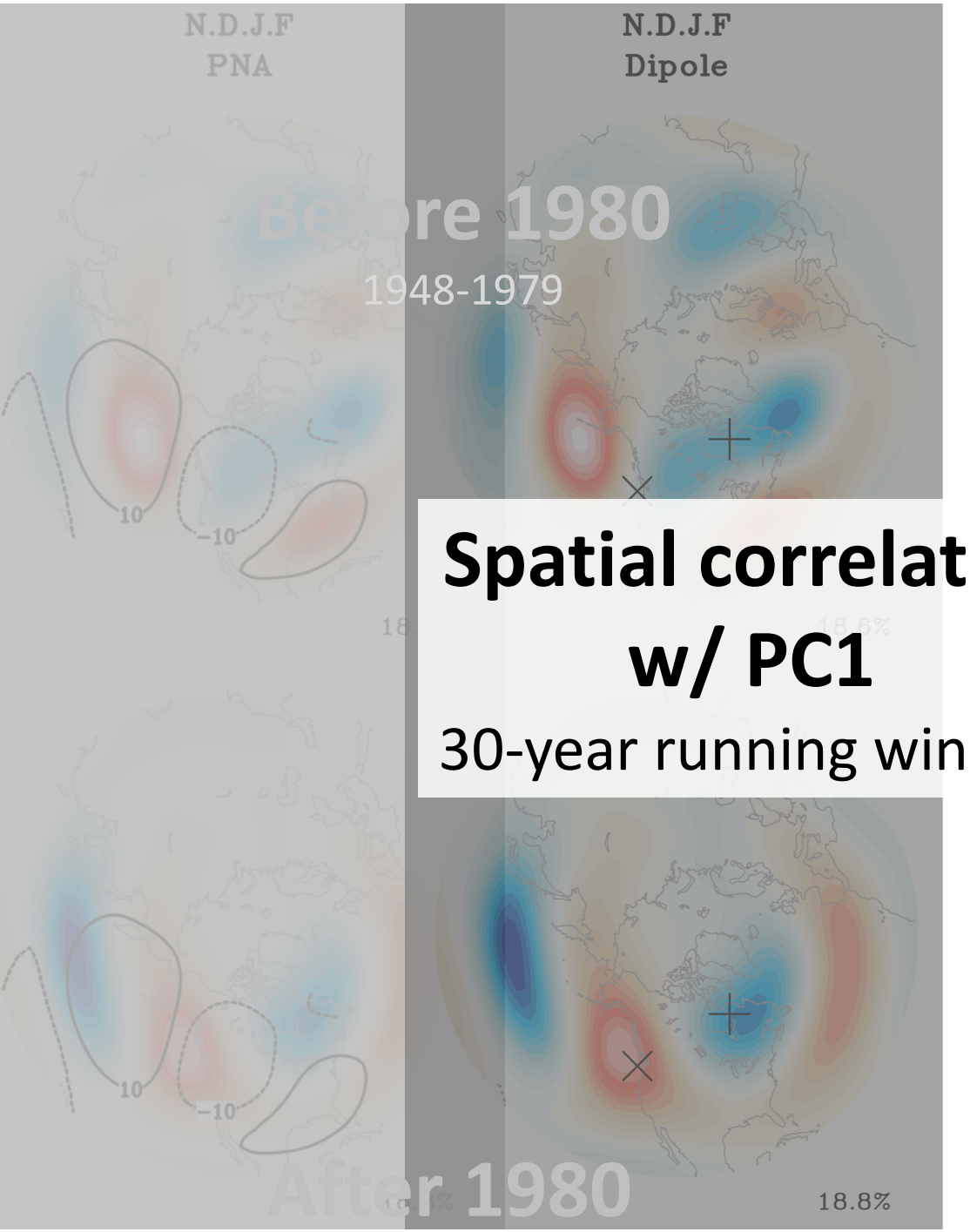


Before 1980

1948-1979

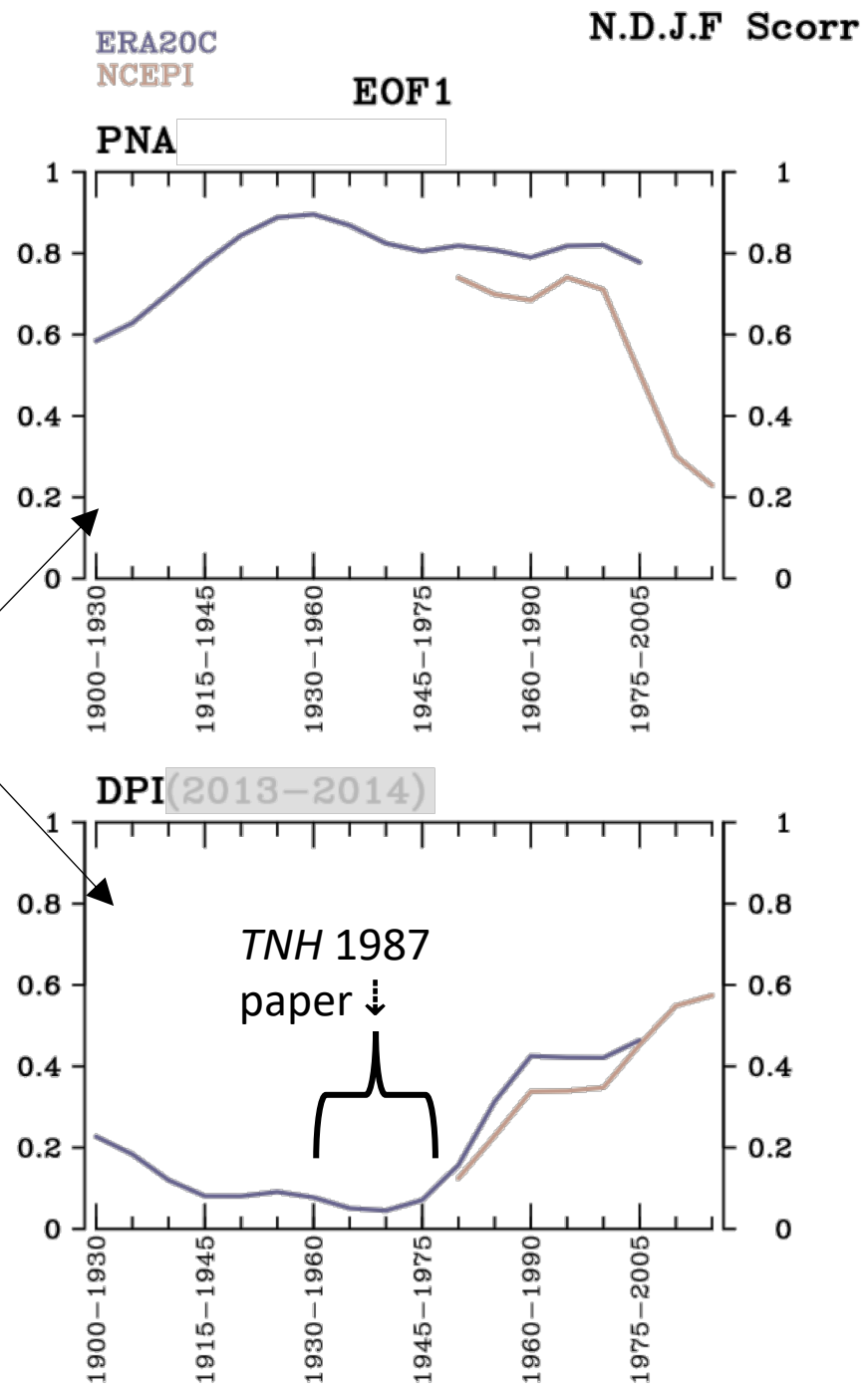
After 1980

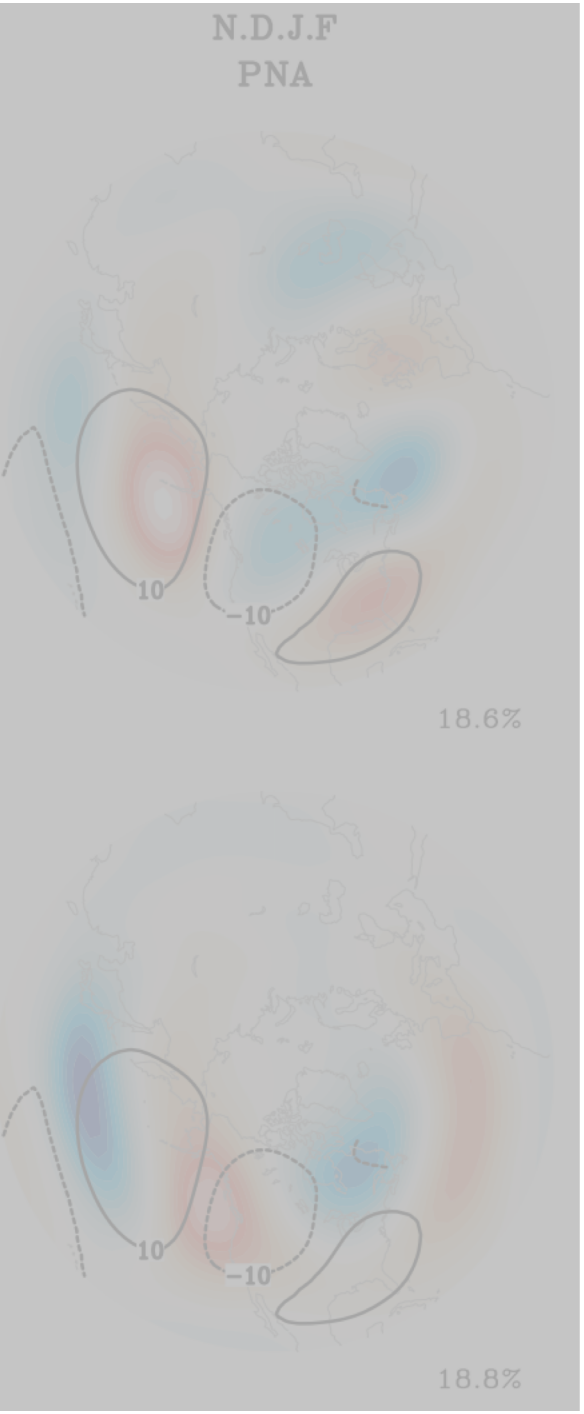
1980-2017



Spatial correlation w/ PC1

30-year running window

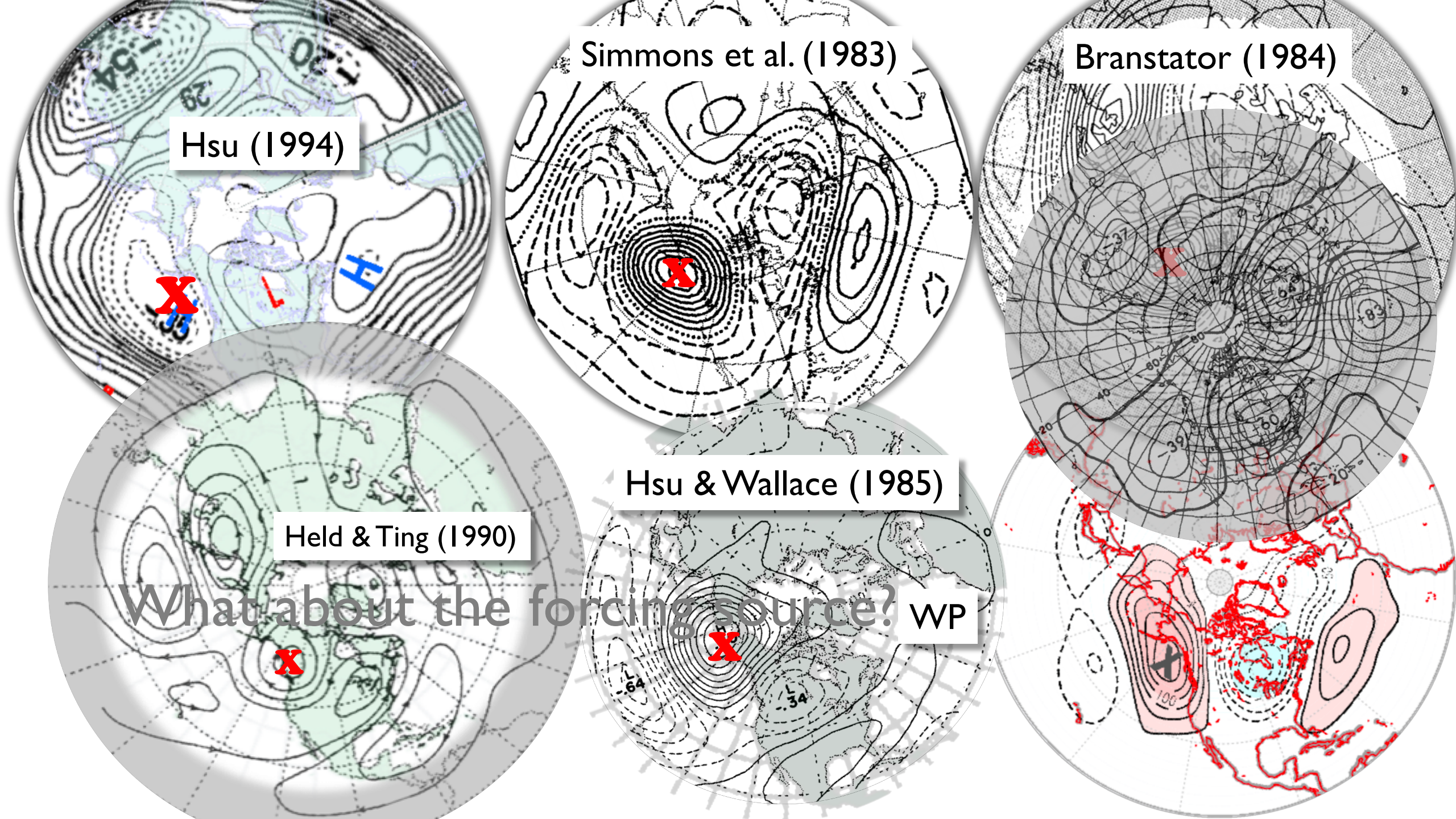


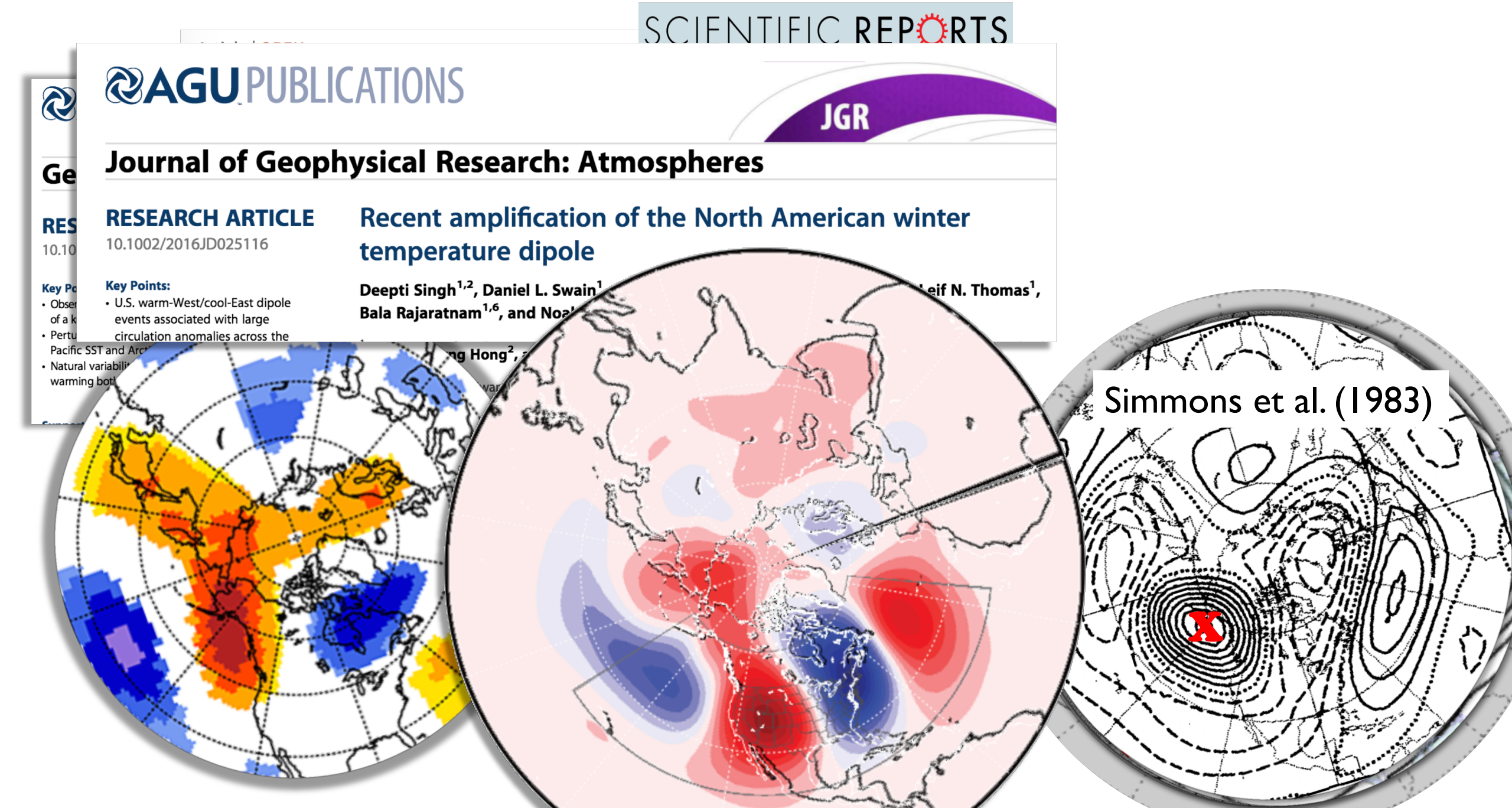


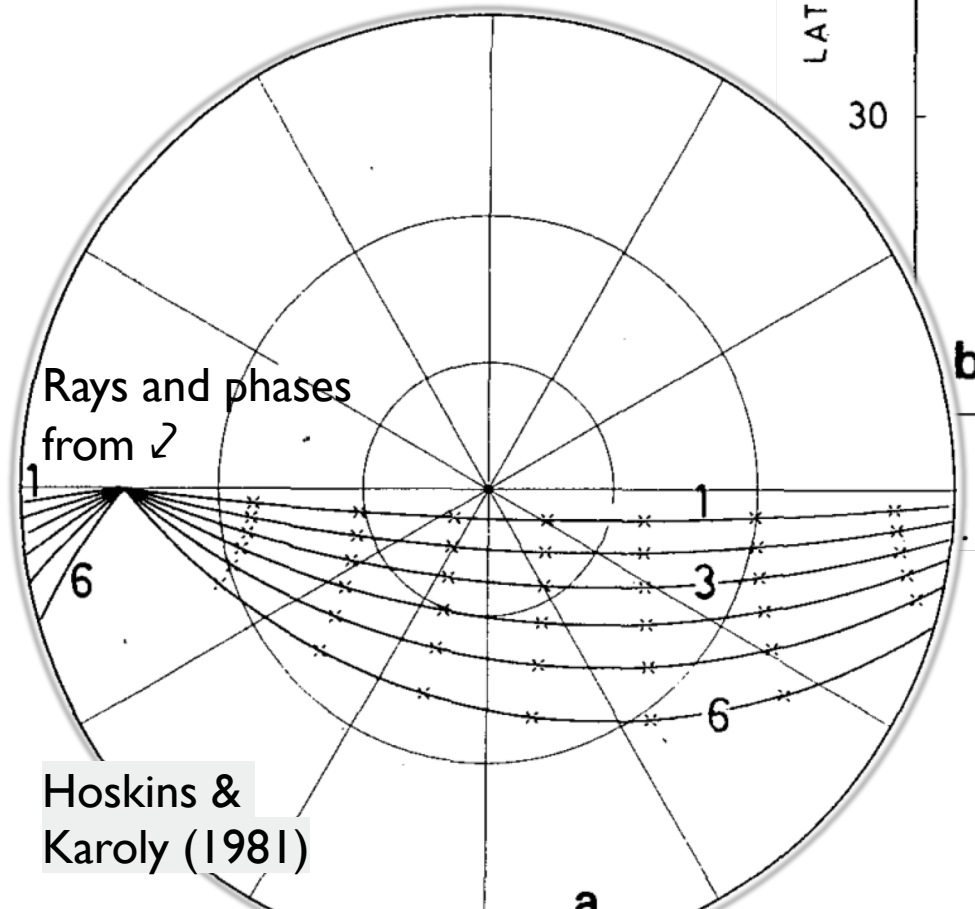
PNA weakening

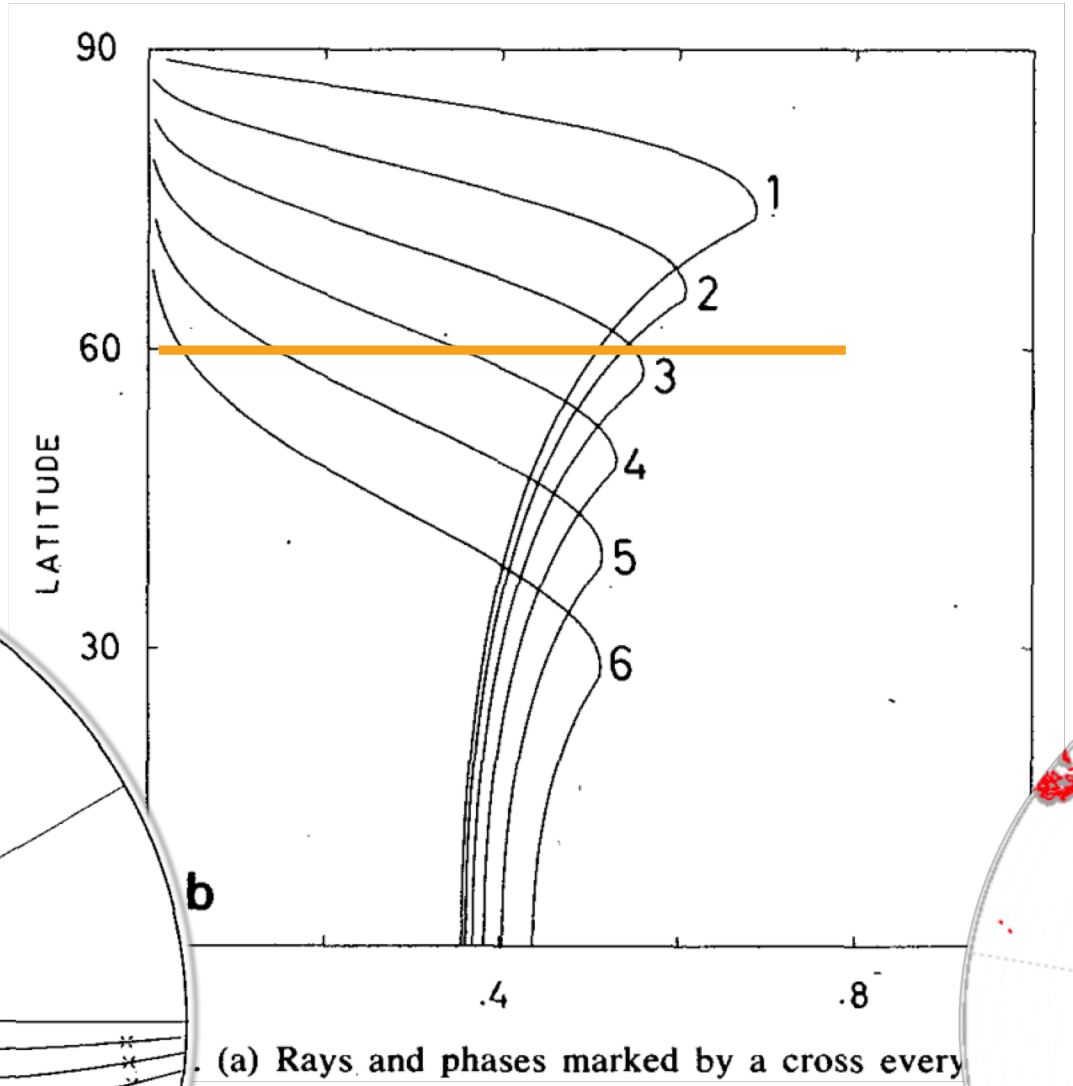
vs.

Dipole/TNH amplifying?

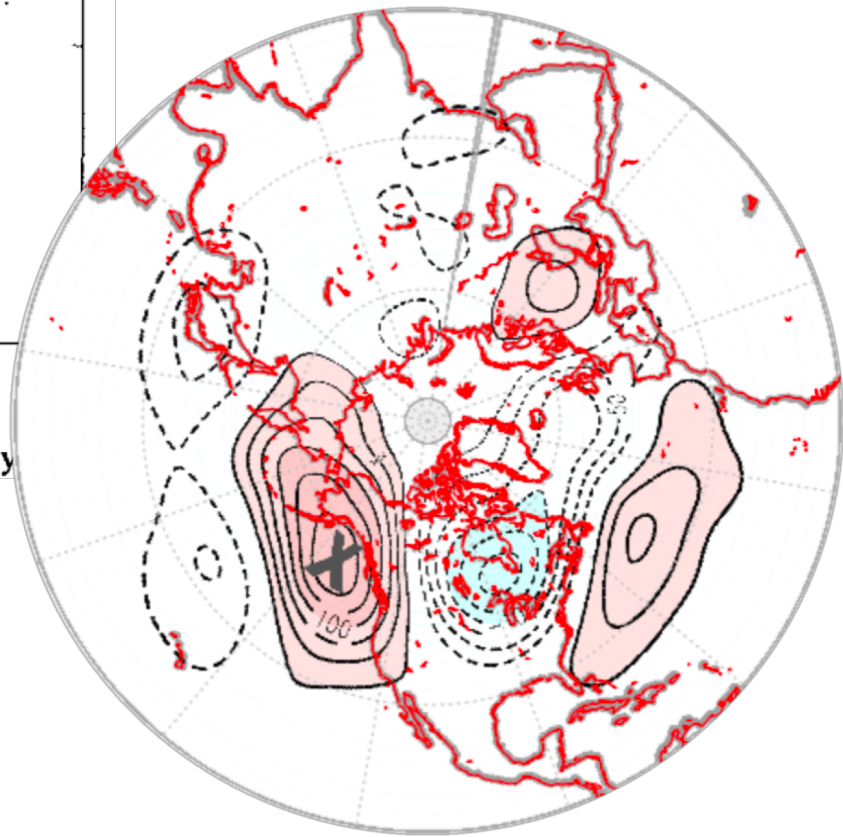

Hsu (1994)
Simmons et al. (1983)
Branstator (1984)
Held & Ting (1990)
Hsu & Wallace (1985)
WP
What about the forcing source?


SCIENTIFIC REPORTS
AGU PUBLICATIONS
JGR
Journal of Geophysical Research: Atmospheres
RESEARCH ARTICLE
10.1002/2016JD025116
Recent amplification of the North American winter temperature dipole
Key Points:
• U.S. warm-West/cool-East dipole events associated with large circulation anomalies across the
Simmons et al. (1983)





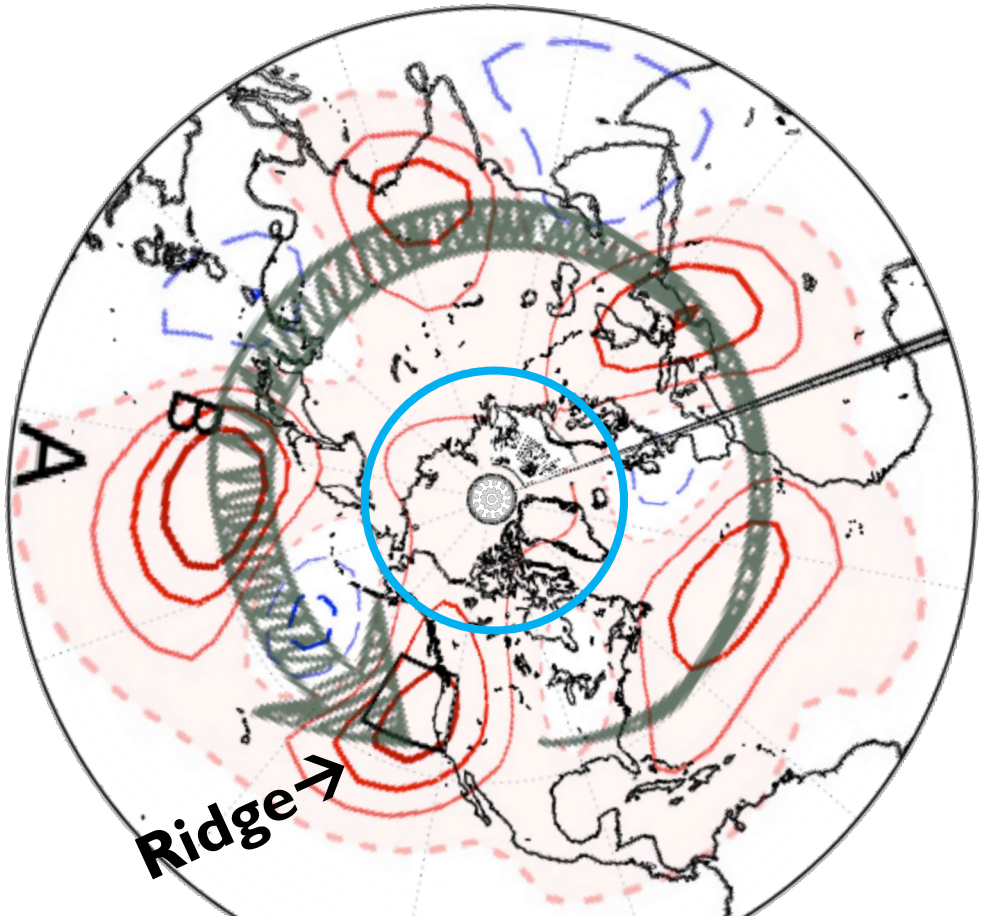
. (a) Rays and phases marked by a cross every



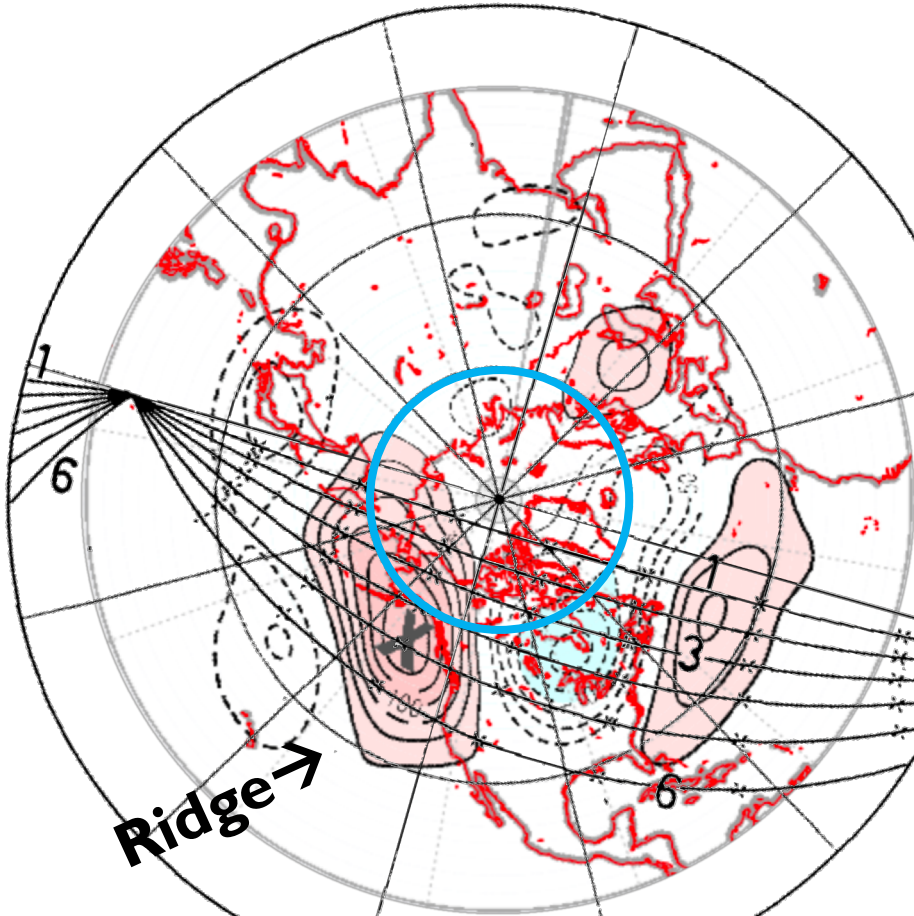
Hoskins &
Karoly (1981)

jet-waveguide, wave-5 pattern

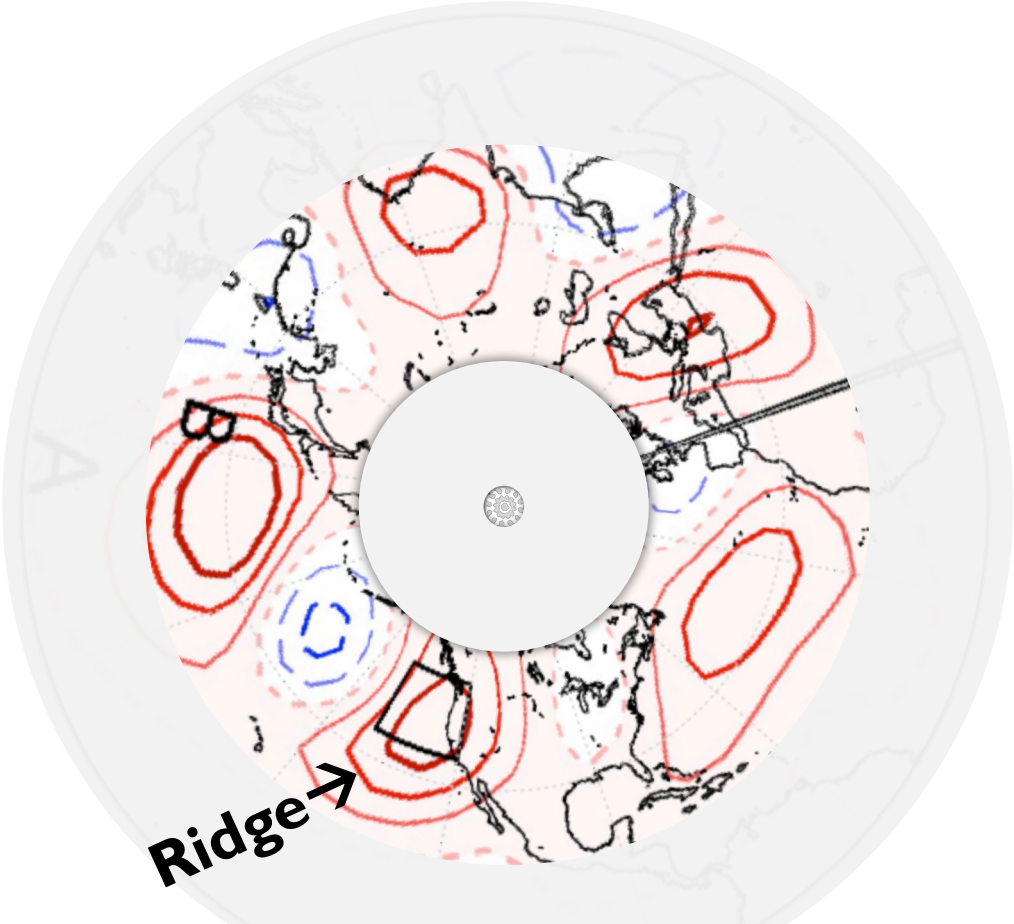
Teng and Branstator (2017)



60°N

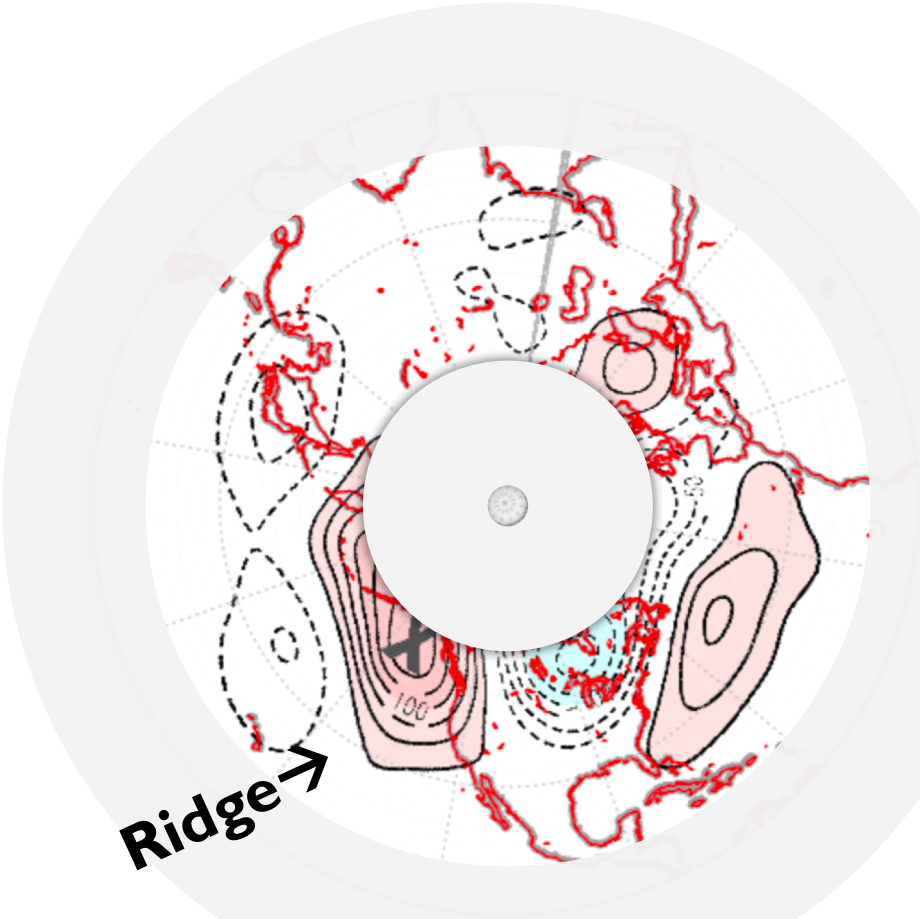


short-wave ✓

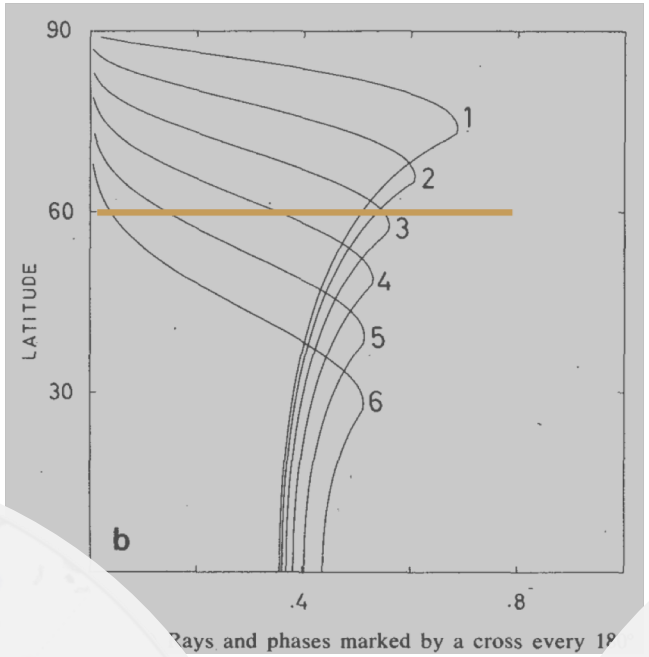


vs.

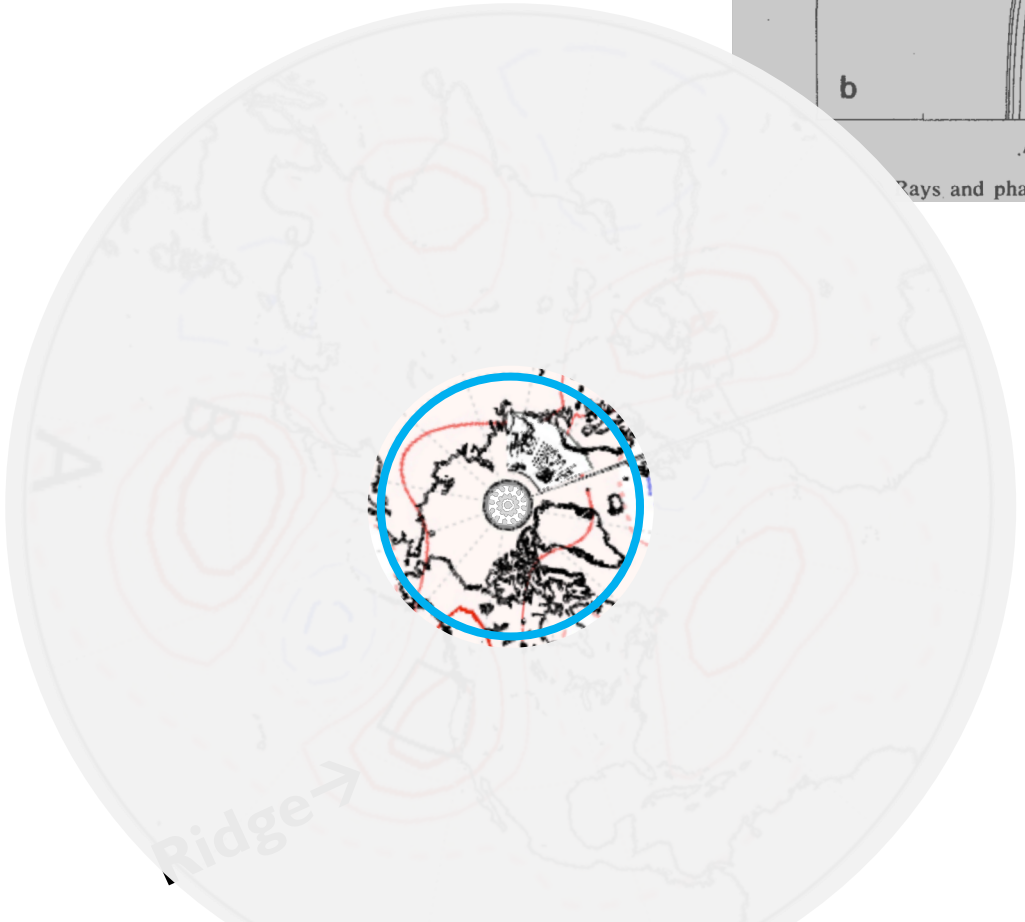
short-wave ✓

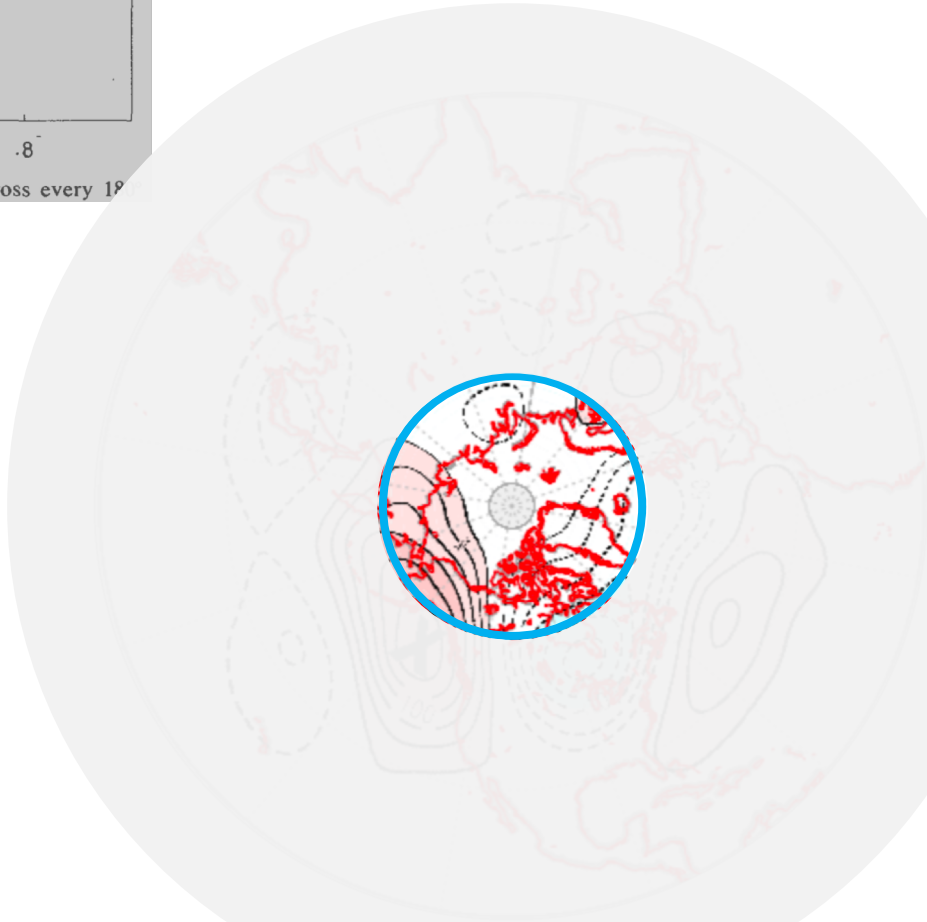


long-wave ✗



long-wave ✓





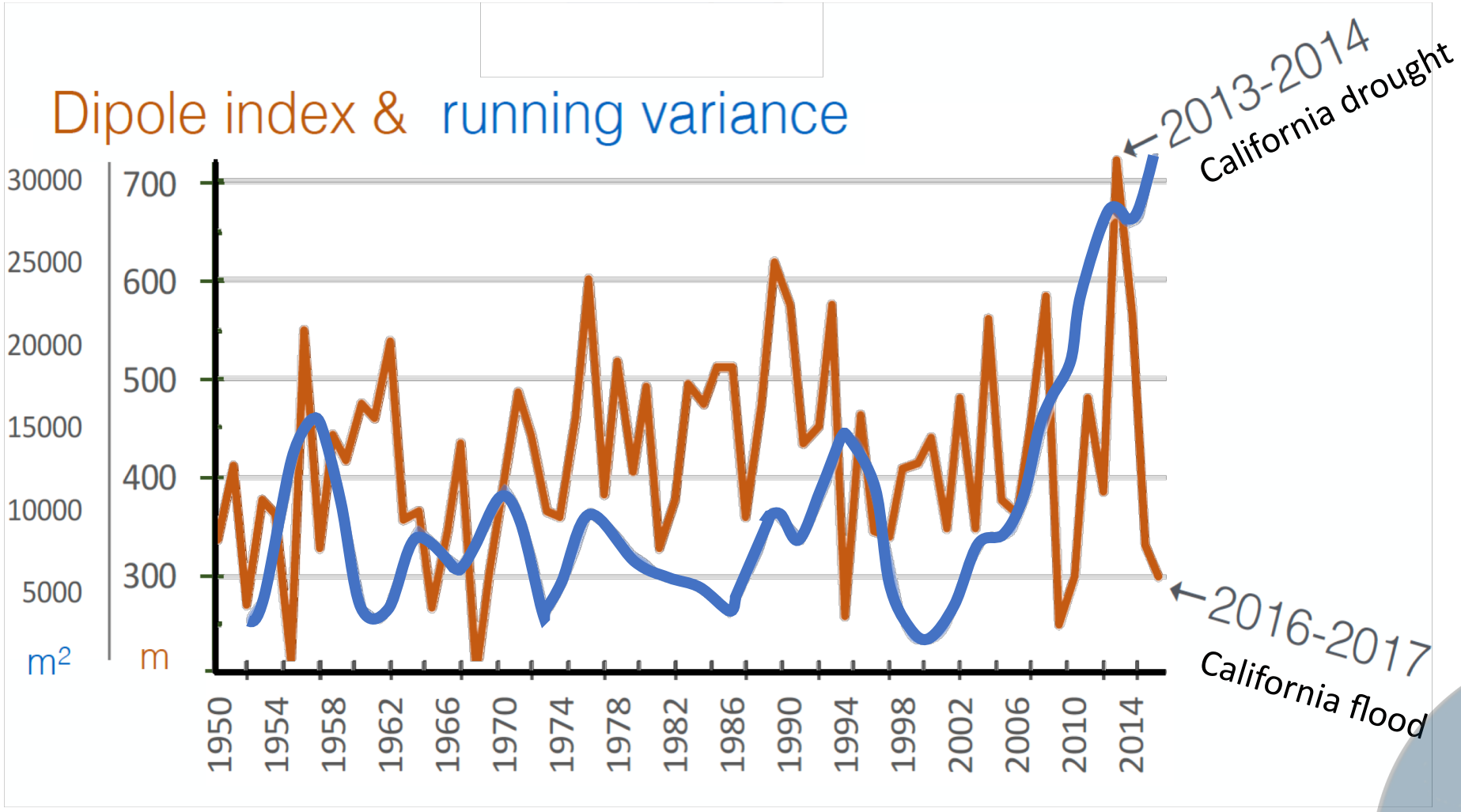
Was the North American extreme climate in winter 2013/14 a SST forced response?

Peitao Peng, Arun Kumar, Mingyue Chen, Zeng-Zhen Hu, Bhaskar Jha

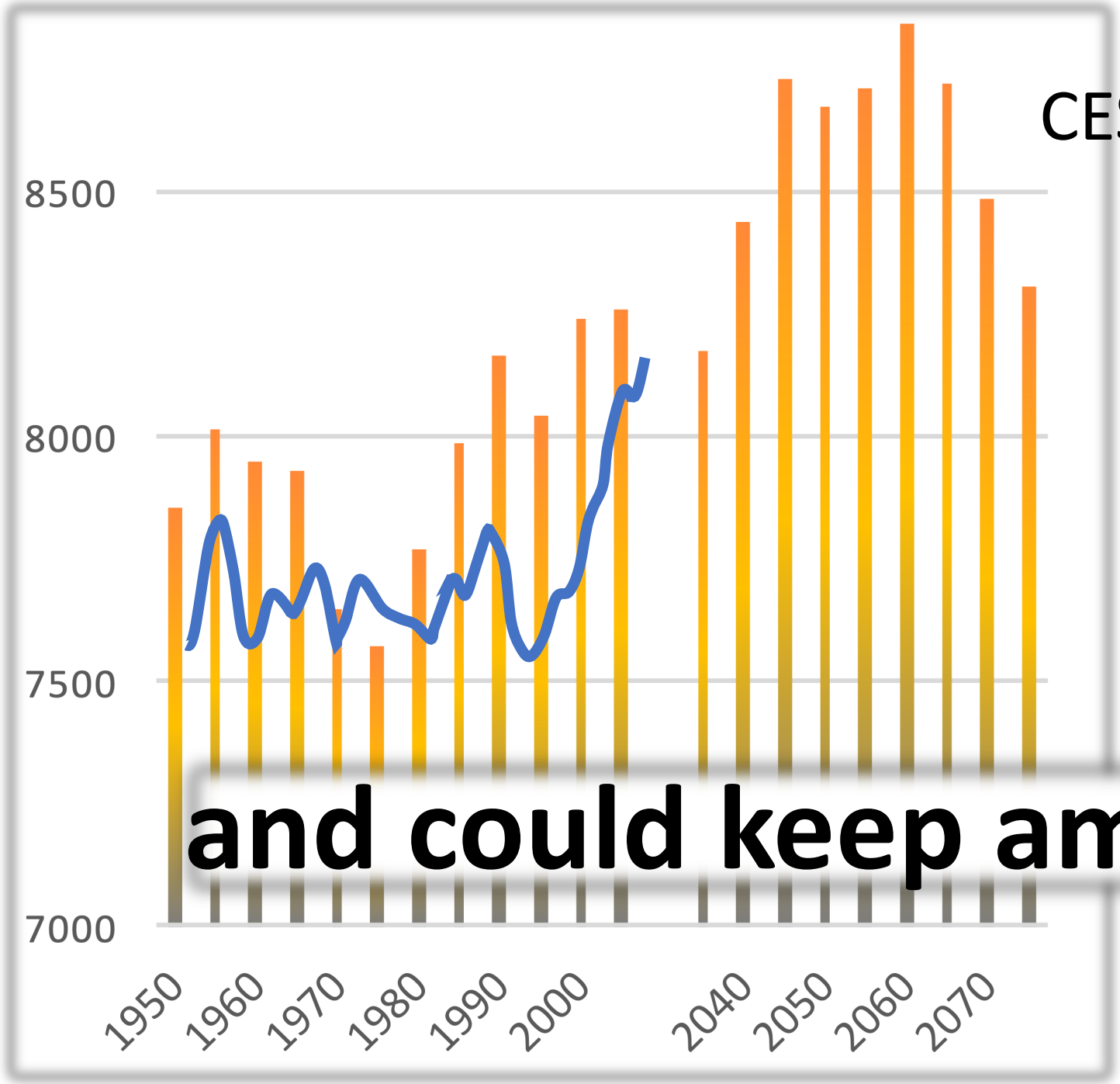
Climate Dynamics, 1-12, 2018

+ a book chapter

and many more…



the dipole has amplified



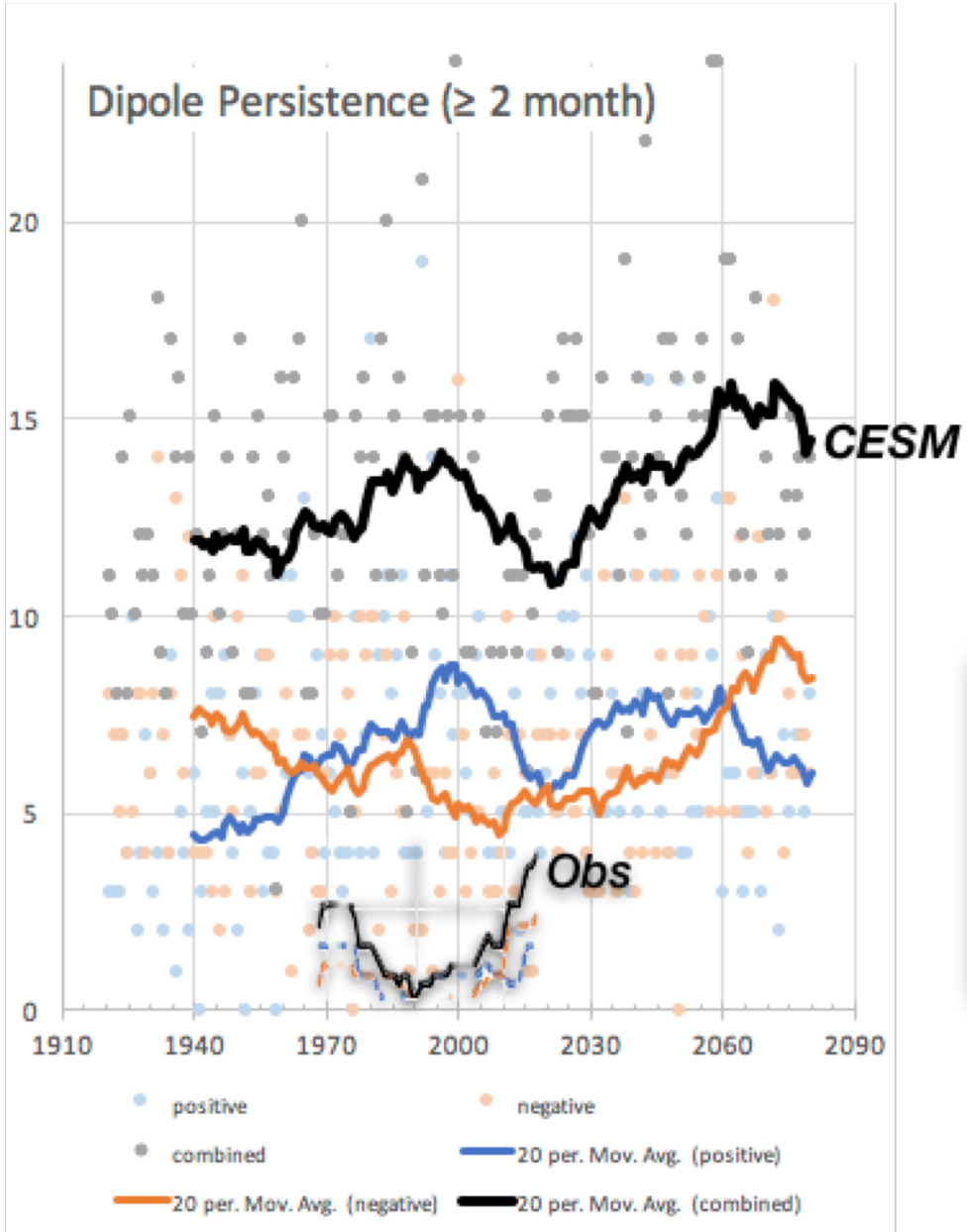
CESM Large Ensemble (x40):

30-yr dipole variance

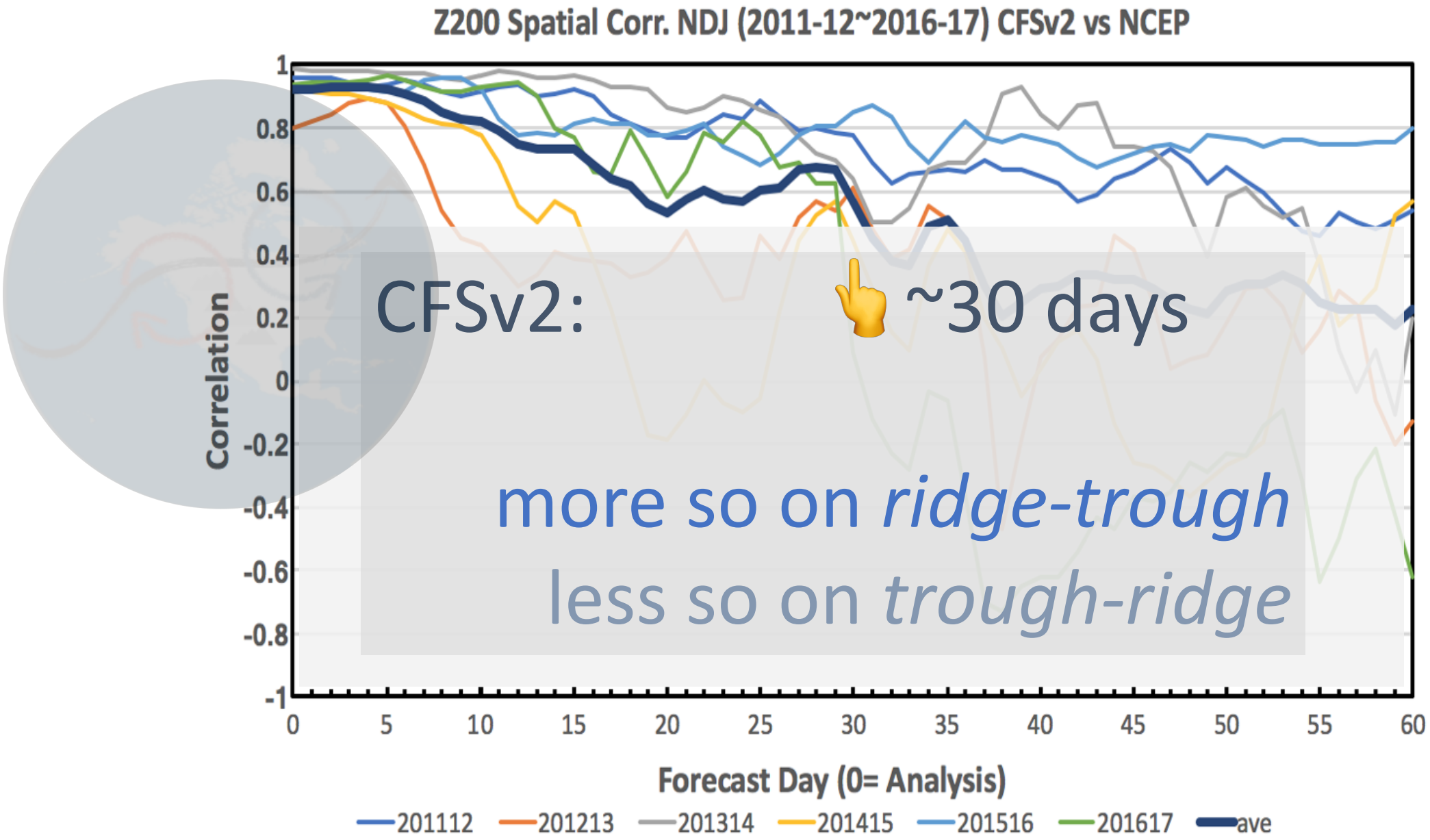
and could keep amplifying

CESM Large Ensemble (x40):

# of back-to-back cases

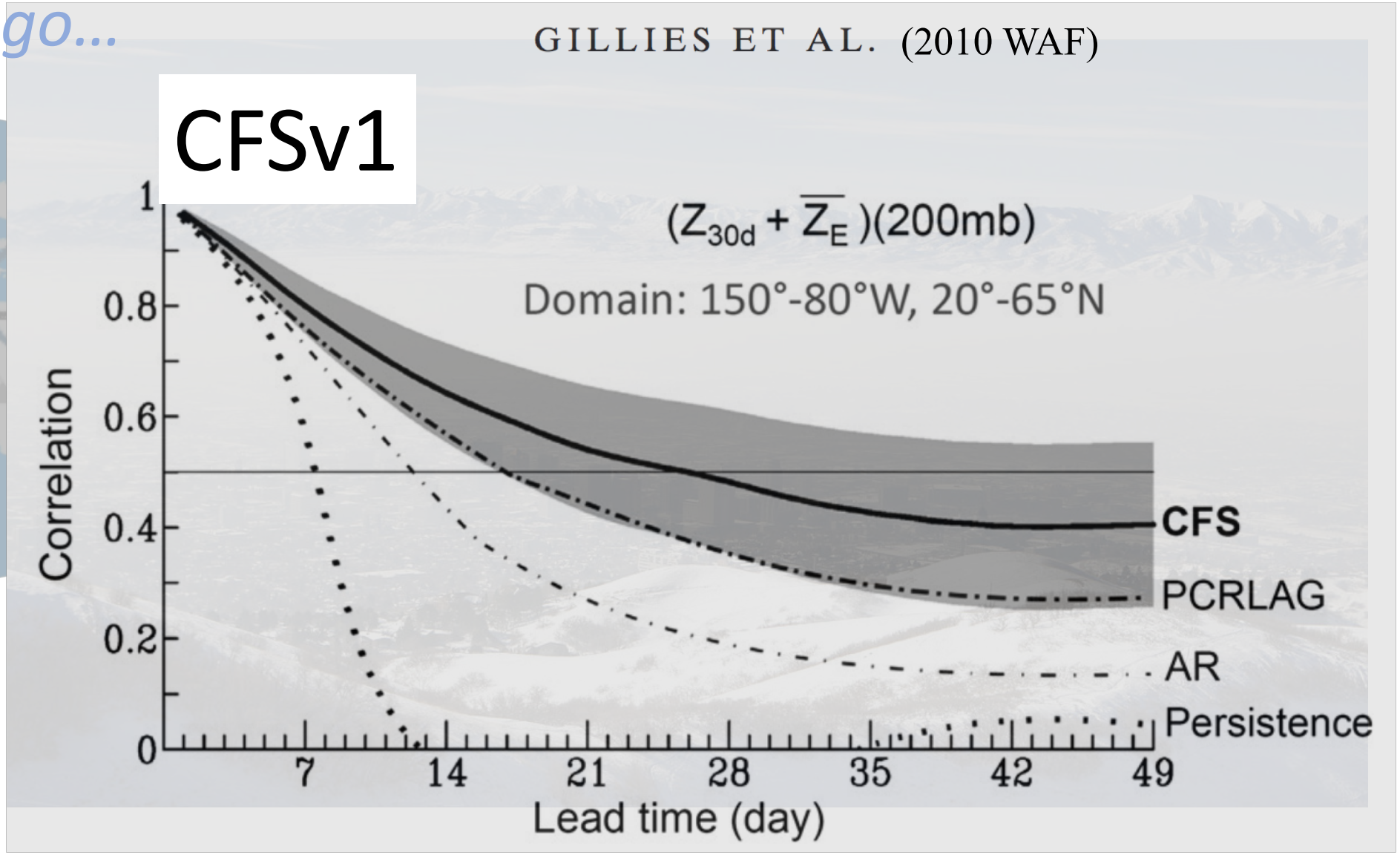


while becoming more persistent


Z200 Spatial Corr. NDJ (2011-12~2016-17) CFSv2 vs NCEP
Correlation
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
5
10
15
20
25
30
35
40
45
50
55
60
Forecast Day (0= Analysis)
201112
201213
201314
201415
201516
201617
ave
CFSv2:
👆 ~30 days
more so on *ridge-trough*
less so on *trough-ridge*

10 years ago…

GILLIES ET AL. (2010 WAF)



”prolonged” winter inversion + bad air
(@ Salt Lake City, Utah)

S2S dipole forecast

CFSv1 ~26 days

CFSv2 ~31 days

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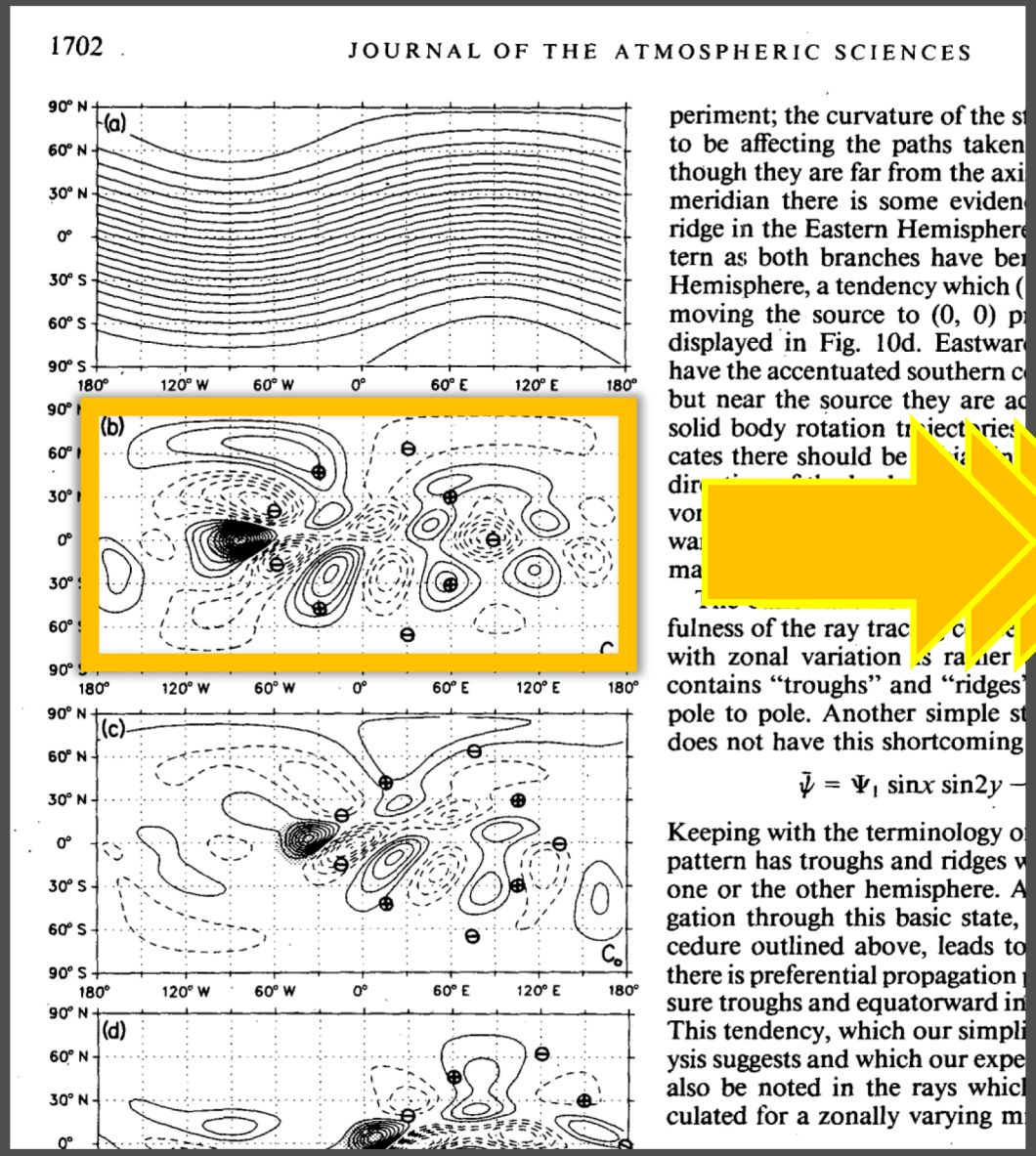
CFS X ~ ? ?

Sharing a secret…



1702 JOURNAL OF THE ATMOSPHERIC SCIENCES

(a) (b) (c) (d)

90° N 60° N 30° N 0° 30° S 60° S 90° S

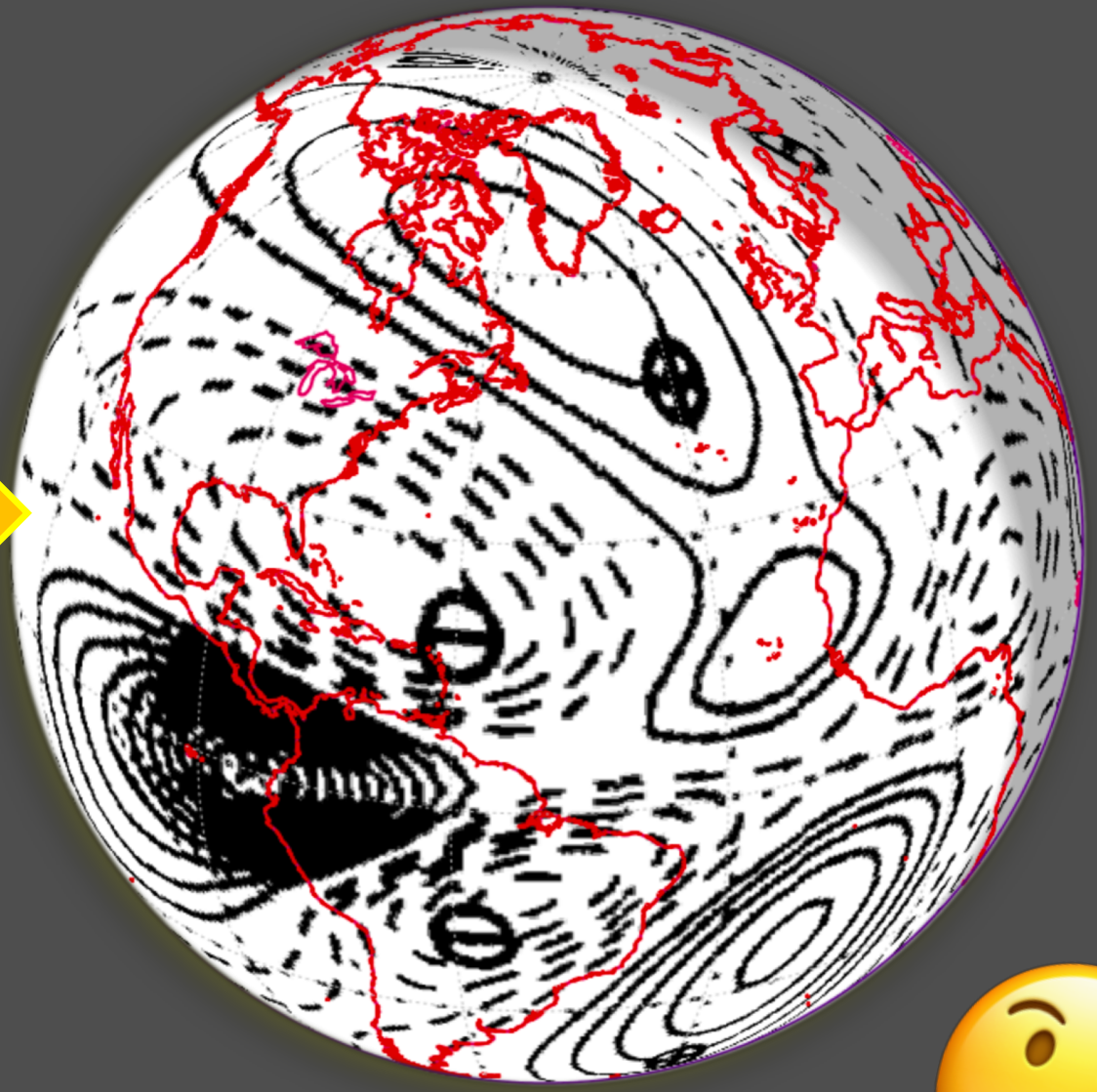
180° 120° W 60° W 0° 60° E 120° E 180°

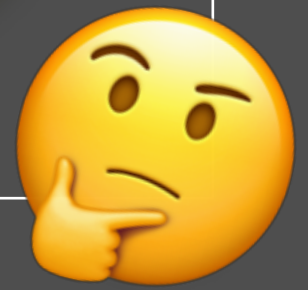
periment; the curvature of the st
to be affecting the paths taken
though they are far from the axi
meridian there is some eviden
ridge in the Eastern Hemisphere
tern as both branches have be
Hemisphere, a tendency which (
moving the source to (0, 0) p
displayed in Fig. 10d. Eastwar
have the accentuated southern c
but near the source they are ac
solid body rotation tr ies
cates there should be
dir
vor
wa
ma

fulness of the ray trac
with zonal variation is ra er
contains "troughs" and "ridges"
pole to pole. Another simple st
does not have this shortcoming

$$\bar{\psi} = \Psi_1 \sin x \sin 2y -$$

Keeping with the terminology o
pattern has troughs and ridges w
one or the other hemisphere. A
gation through this basic state,
cedure outlined above, leads to
there is preferential propagation
sure troughs and equatorward in
This tendency, which our simpli
ysis suggests and which our expe
also be noted in the rays whic
culated for a zonally varying m





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& Groups
ns
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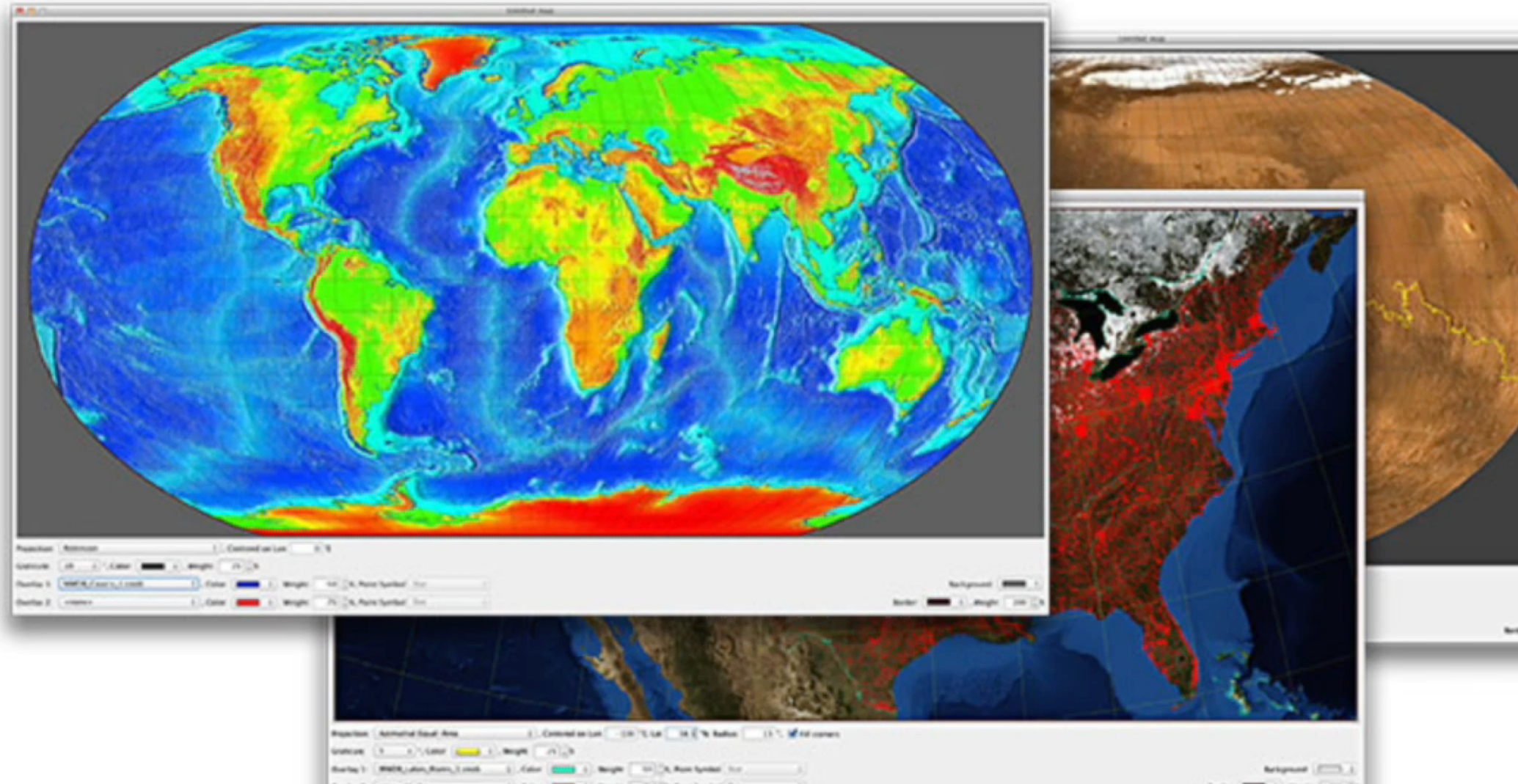
ss

G.Projector — Global Map Projector



References:

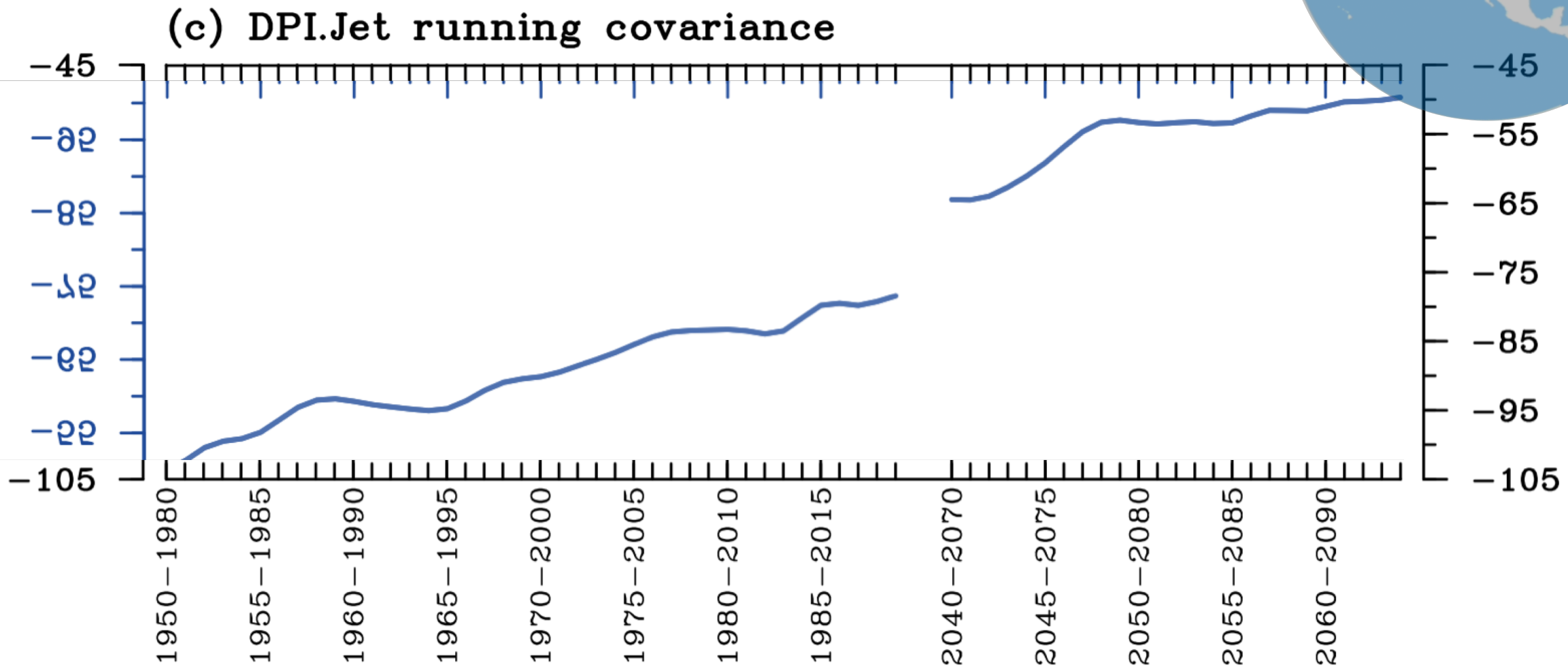
2017: **California from drought to deluge**. *Nature Climate Change*, 7, 465-468.

2015: **Increasing Water Cycle Extremes in California and in Relation to ENSO Cycle Under Global Warming**. *Nature Communications*, DOI: 10.1038/ncomms9657

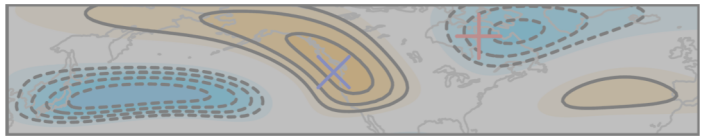
2015: **The North American winter 'dipole' and extremes activity: A CMIP5 assessment**. *Atmospheric Science Letters*, doi: 10.1002/asl2.565.

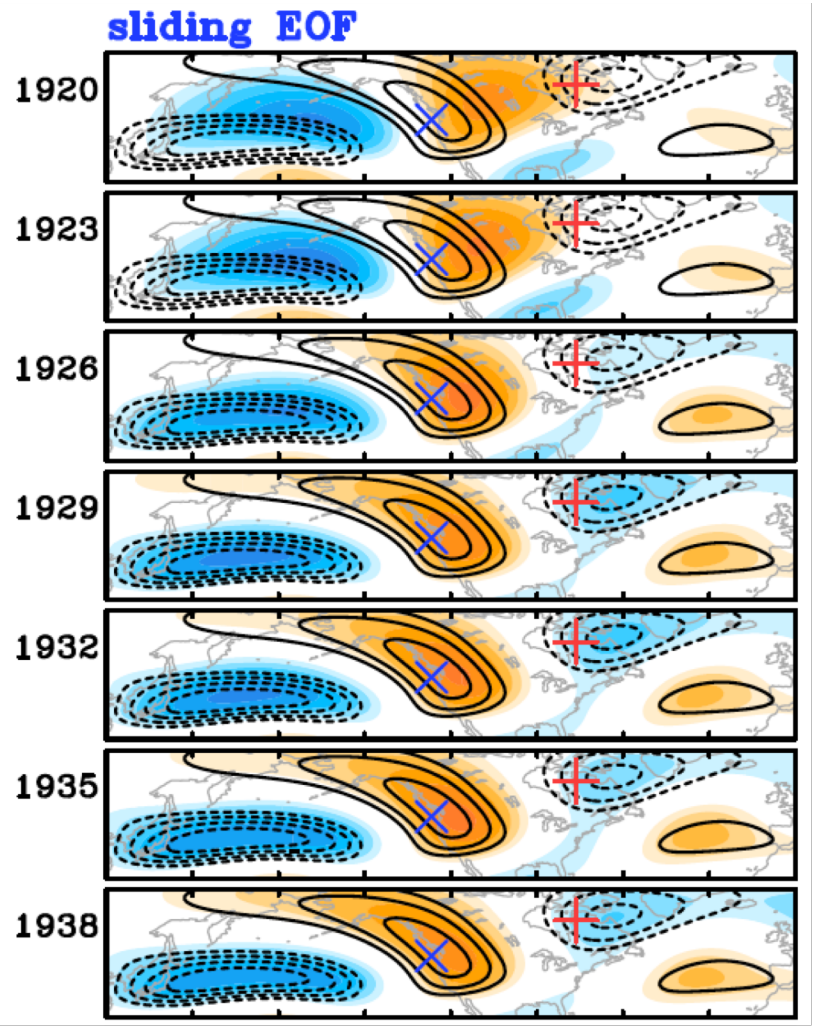
2014: **Probable causes of the abnormal ridge accompanying the 2013-14 California drought**... *Geophysical Research Letters*. DOI: 10.1002/2014GL059748

CESM Large Ensemble (40 members)

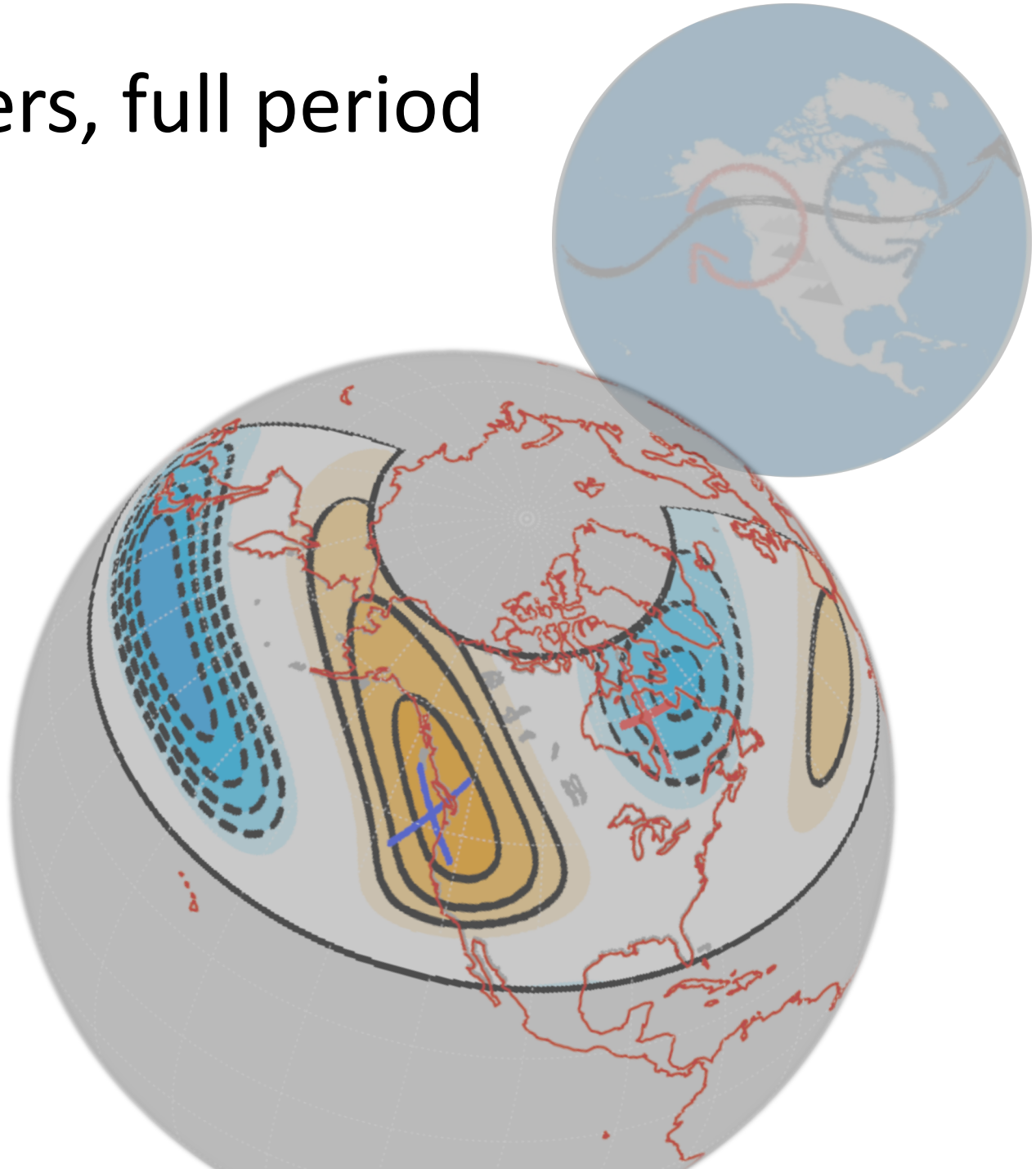


CESM LE's EOF1: all members, full period

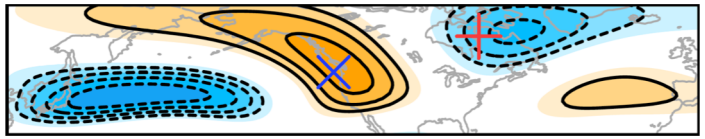


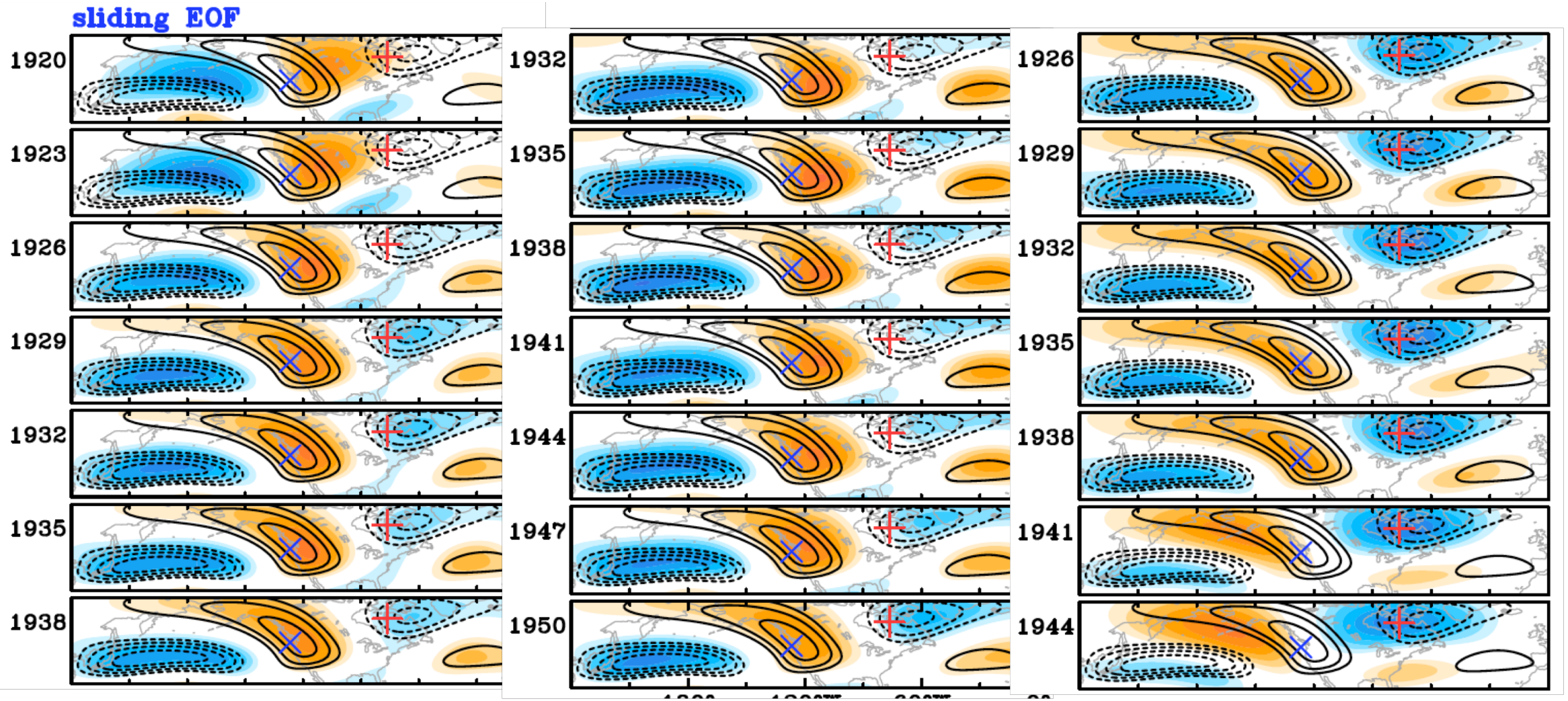


e05



CESM LE's EOF1 (dipole pattern variation)

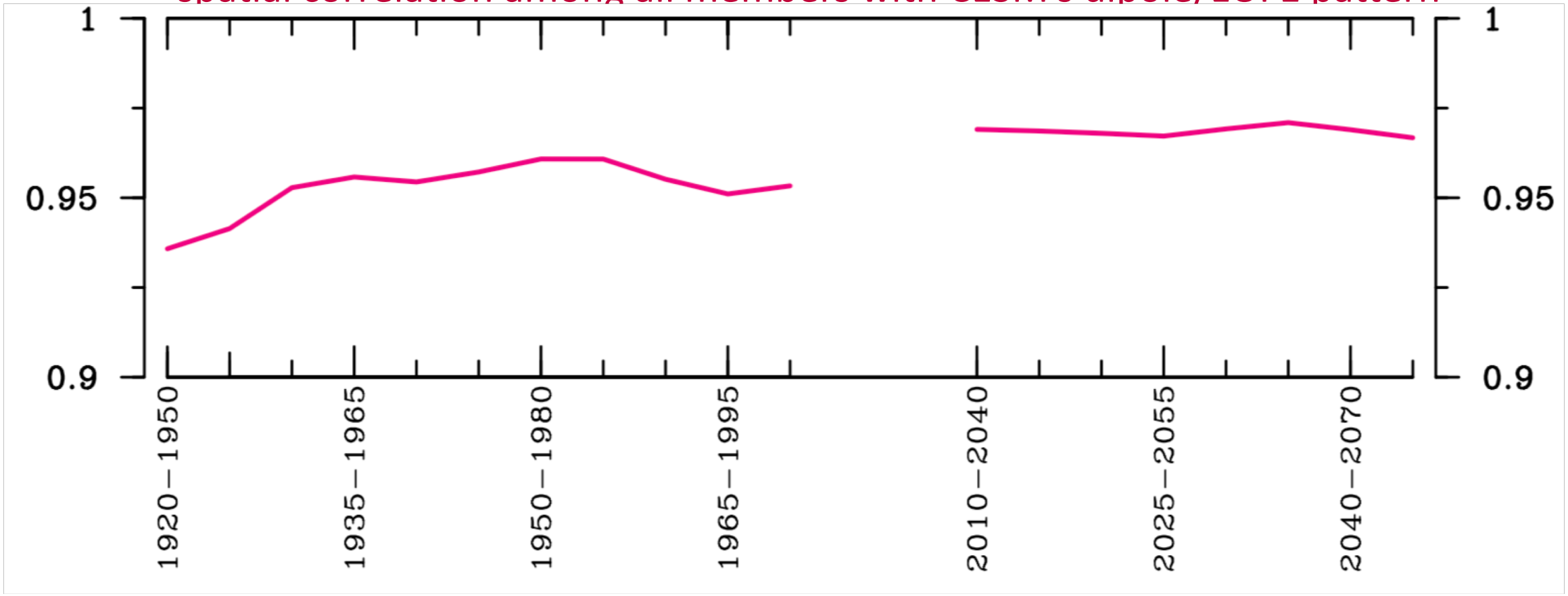




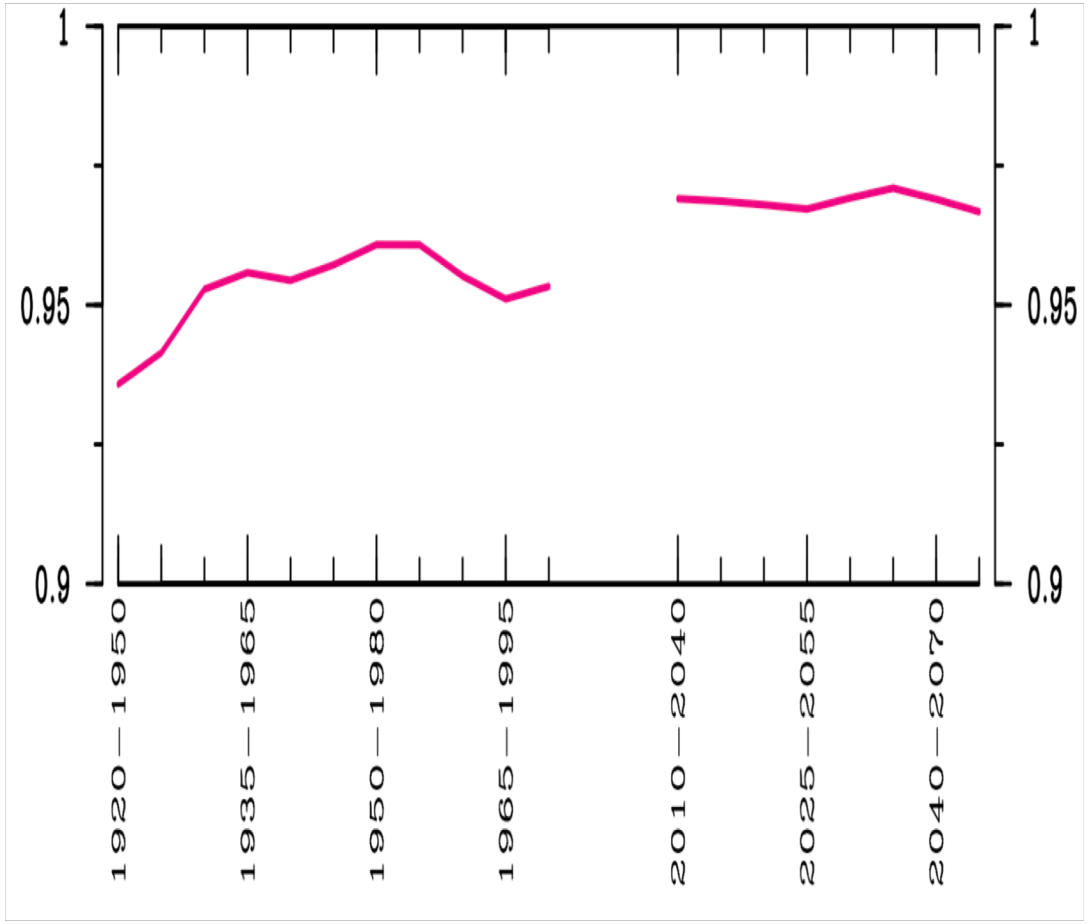
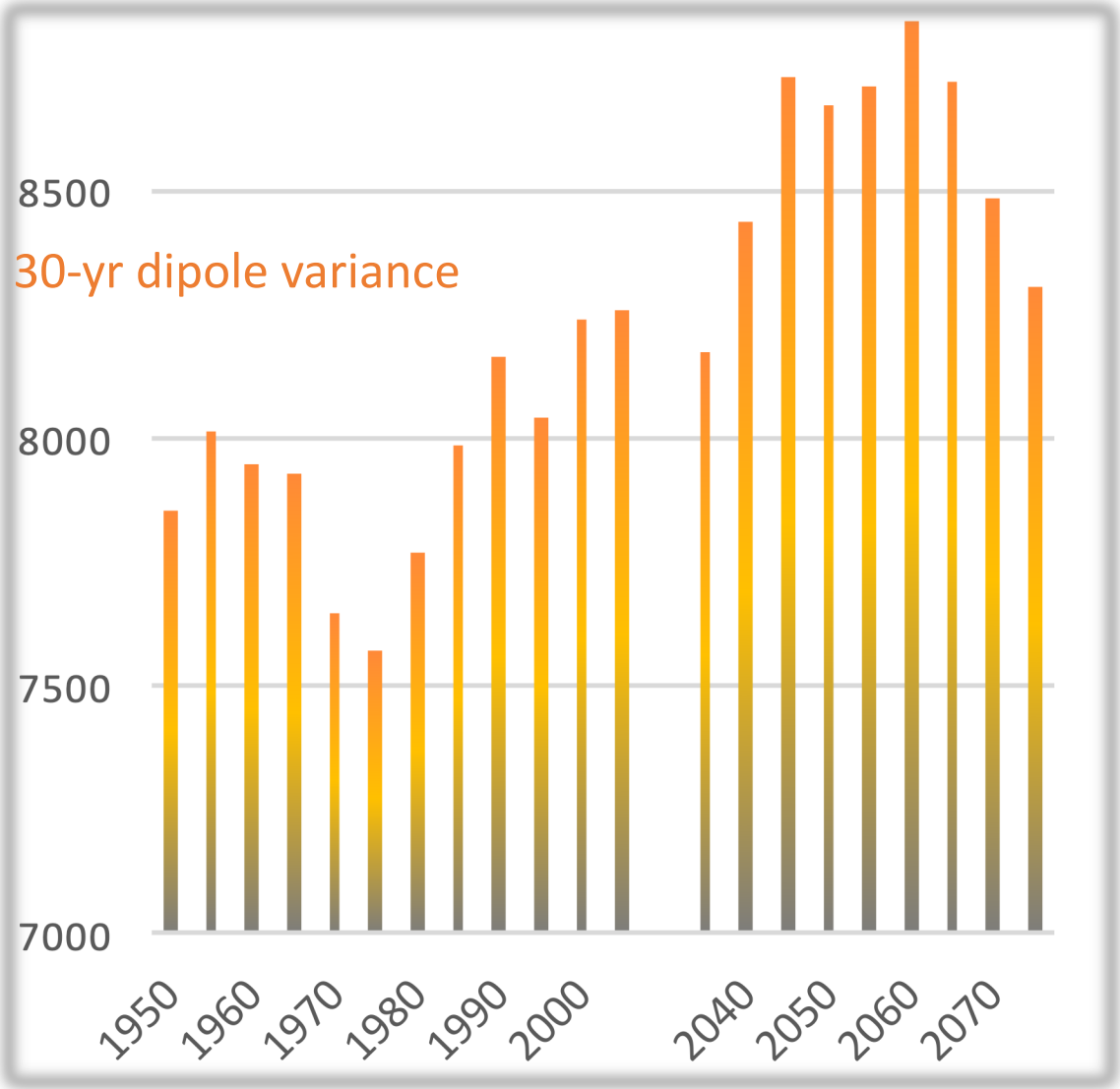
e26

CESM LE: dipole pattern may not change

spatial correlation among all members with CESM's dipole/EOF1 pattern



CESM LE: dipole pattern may not change



CESM: but dipole amplitude will increase