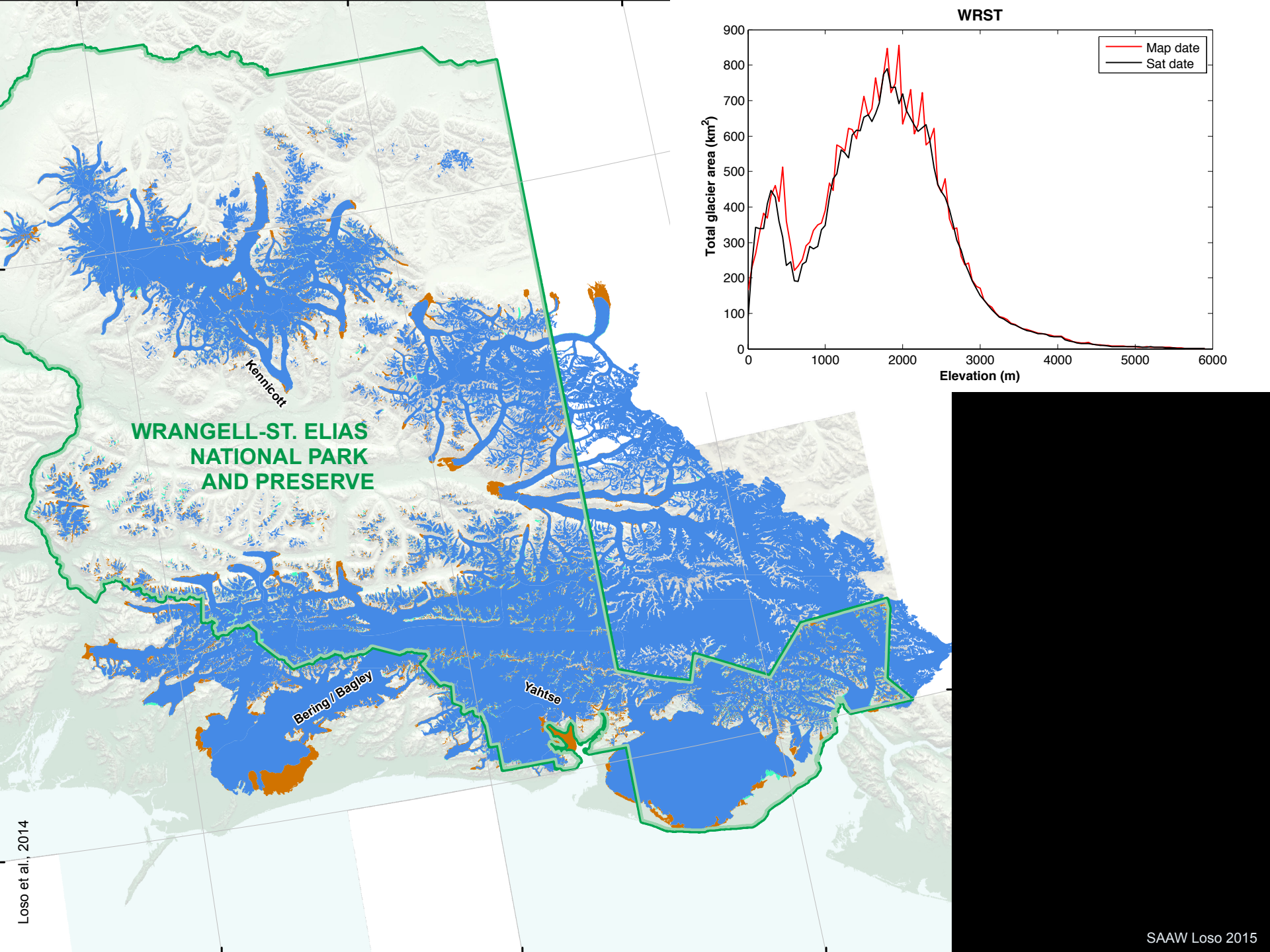
Climate change in Alaska

National Park Service
U.S. Department of the Interior

Wrangell-St. Elias National Park

How to think positive

Michael Loso
Wrangell-St. Elias National Park and Preserve


WRST
Map date
Sat date
Total glacier area (km^2)
Elevation (m)
0
100
200
300
400
500
600
700
800
900
0
1000
2000
3000
4000
5000
6000
WRANGELL-ST. ELIAS
NATIONAL PARK
AND PRESERVE
Kennicott
Bering / Bagley
Yahtse
Loso et al., 2014
SAAW Loso 2015

WRANGELL-ST. ELIAS
NATIONAL PARK
AND PRESERVE

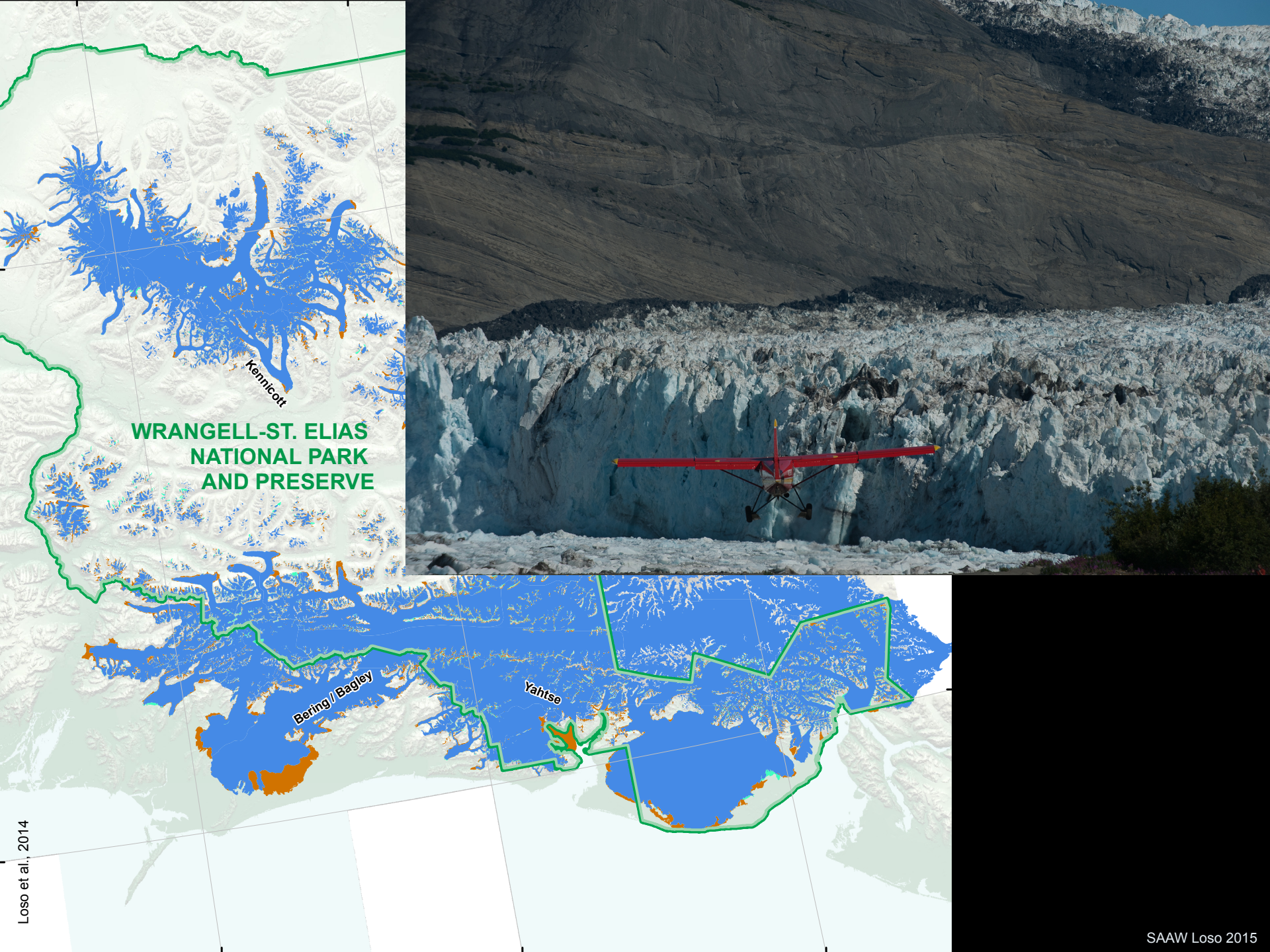
Kennicott

Bering / Bagley

Yahtse

Loso et al., 2014

SAAW Loso 2015


Kennicott
WRANGELL-ST. ELIAS
NATIONAL PARK
AND PRESERVE
Bering / Bagley
Yahtse
Loso et al., 2014
SAAW Loso 2015

Kennicott

WRANGELL-ST. EL
NATIONAL PA
AND PRESE

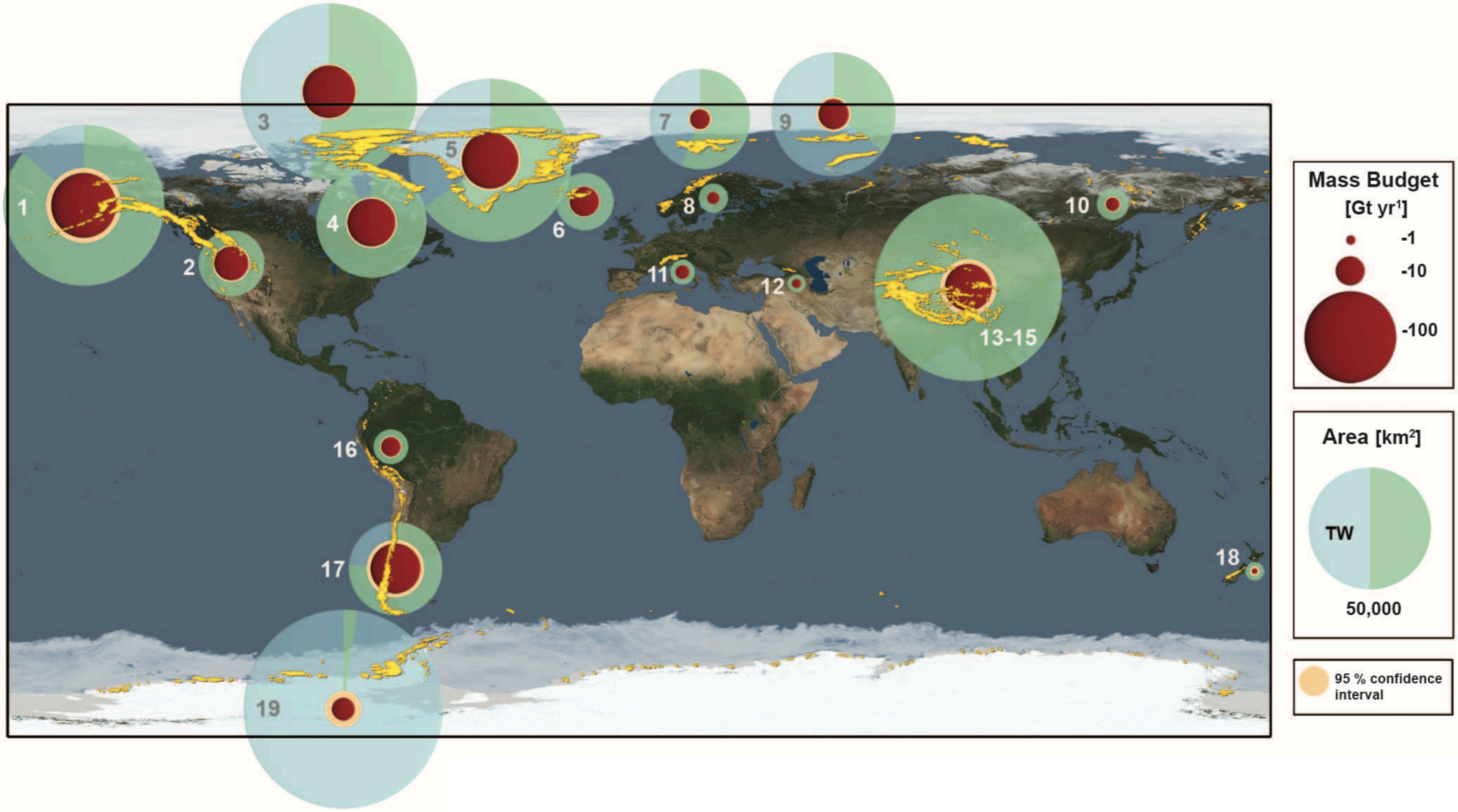
Bering / Bagley

Yahtse

Loso et al., 2014

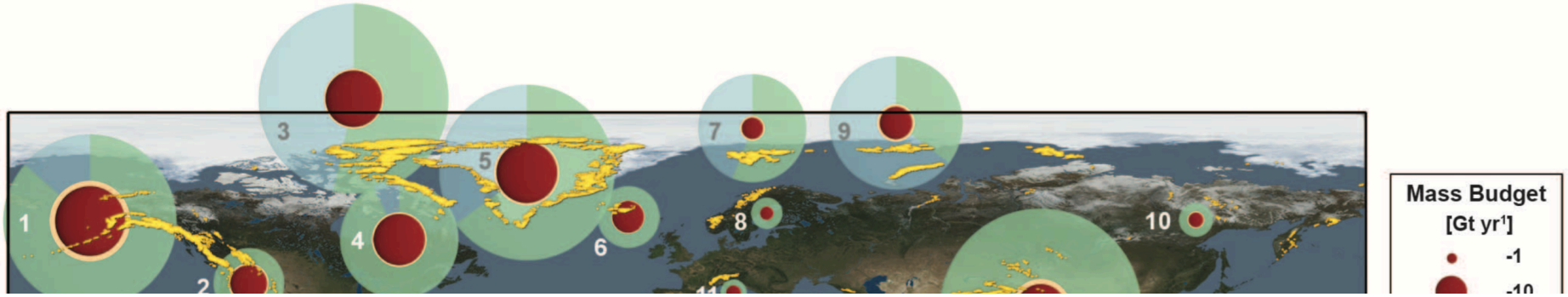
SAAW Loso 2015

Alaska's glaciers are melting really fast



Gardner et al. 2013

Alaska's glaciers are melting really fast



Geophysical Research Letters

RESEARCH LETTER
10.1002/2015GL064349

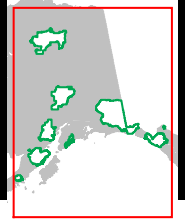
Surface melt dominates Alaska glacier mass balance

C. F. Larsen[1], E. Burgess[1,2], A. A. Arendt[3], S. O'Neel[2], A. J. Johnson[1], and C. Kienholz[1]

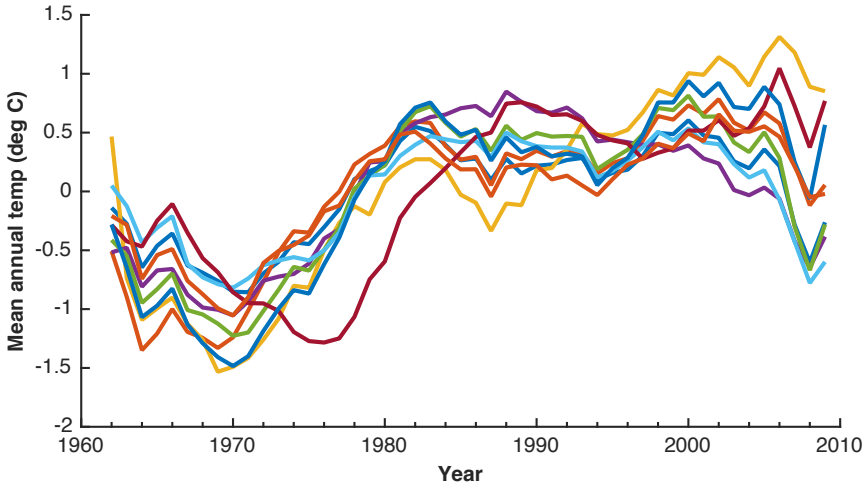
[1]Geophysical Institute, University of Alaska Fairbanks, Fairbanks, Alaska, USA, [2]Alaska Science Center, U.S. Geological Survey, Anchorage, Alaska, USA, [3]Polar Science Center, Applied Physics Laboratory, University of Washington, Seattle, Washington, USA

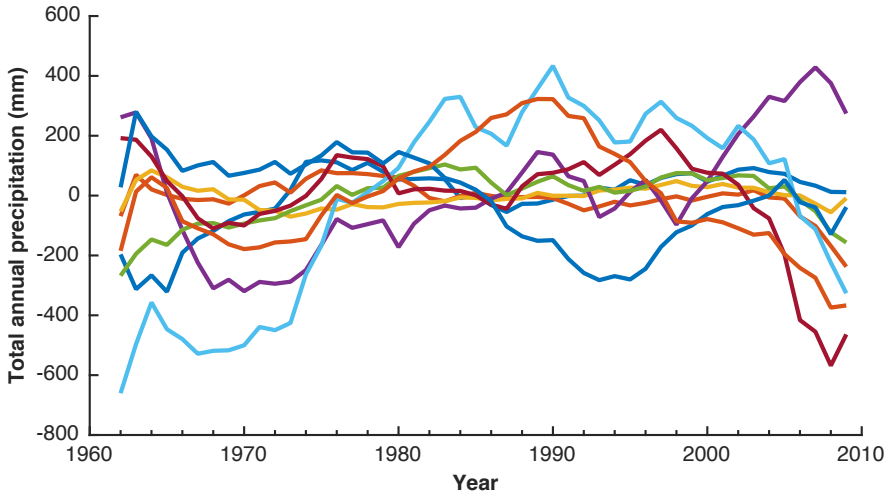
Abstract Mountain glaciers comprise a small and widely distributed fraction of the world's terrestrial ice, yet their rapid losses presently drive a large percentage of the cryosphere's contribution to sea level rise. Regional mass balance assessments are challenging over large glacier populations due to remote and rugged geography, variable response of individual glaciers to climate change, and episodic calving losses from tidewater glaciers. In Alaska, we use airborne altimetry from 116 glaciers to estimate a regional mass balance of -75 ± 11 Gt yr^{-1} (1994–2013). Our glacier sample is spatially well distributed, yet pervasive variability in mass balances obscures geospatial and climatic relationships. However, for the first time, these data allow the partitioning of regional mass balance by glacier type. We find that tidewater glaciers are losing mass at substantially slower rates than other glaciers in Alaska and collectively contribute to only 6% of the regional mass loss.

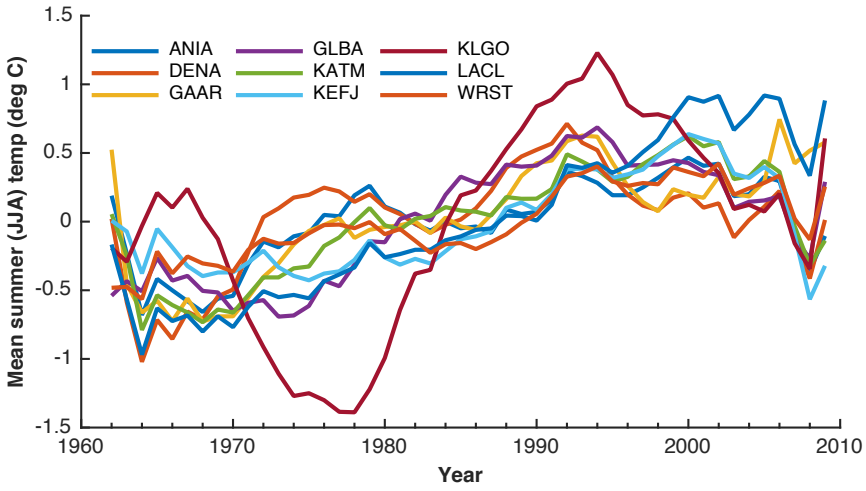
50 yrs warming

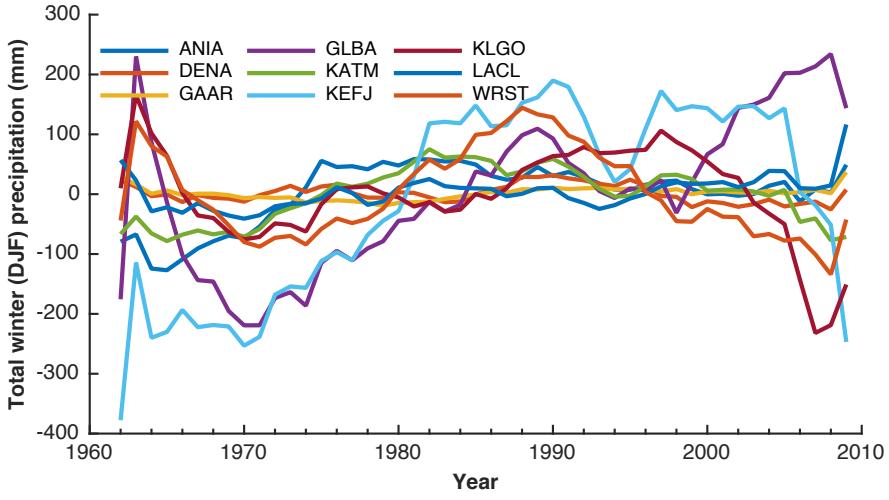


50 yrs precip?



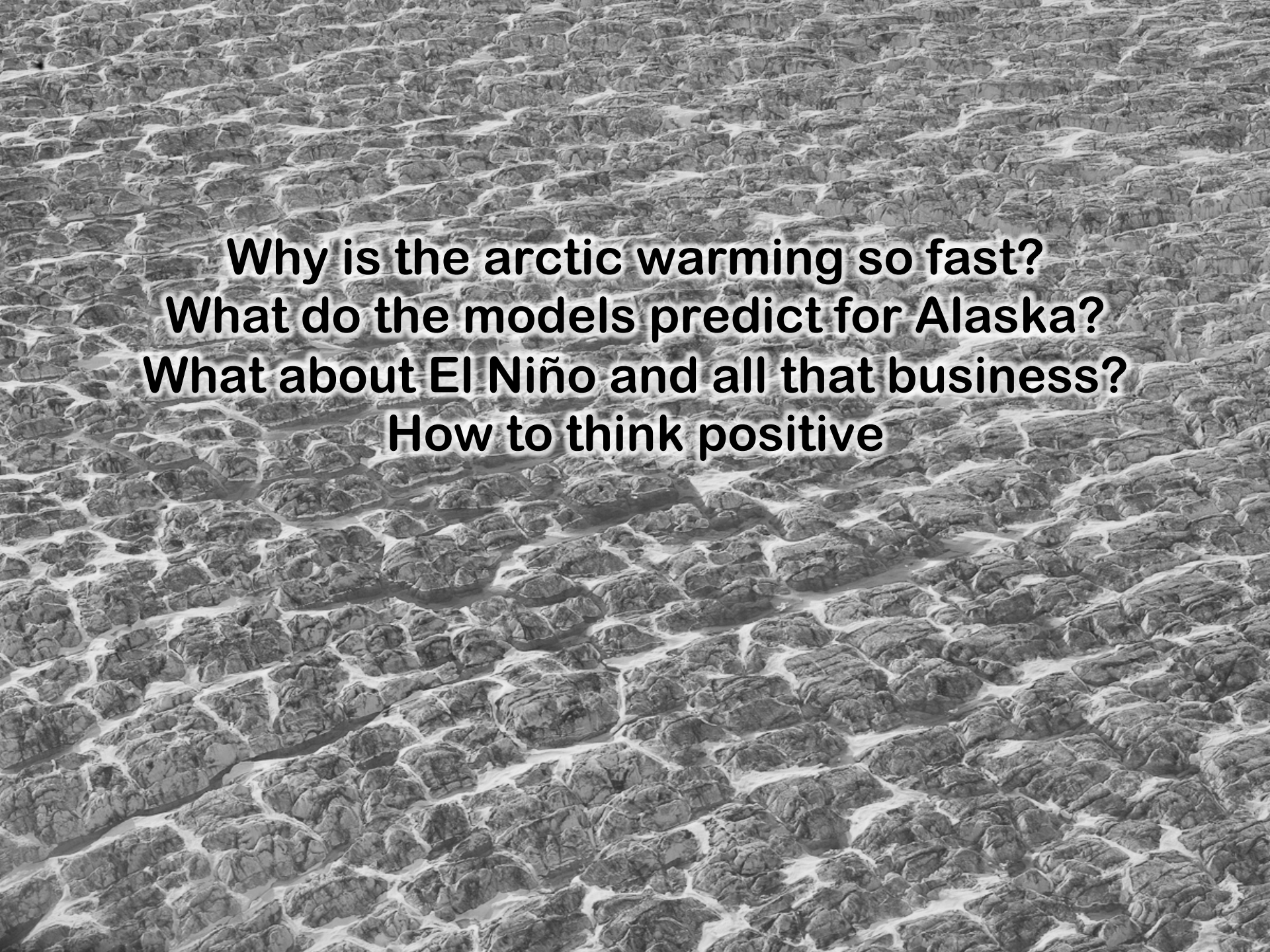






Loso et al., 2014

So.
Our glaciers are shrinking fast due to rising temps.
Exceptions have ~nothing to do with climate.


Why is the arctic warming so fast?
What do the models predict for Alaska?
What about El Niño and all that business?
How to think positive

Why is the arctic melting so fast?

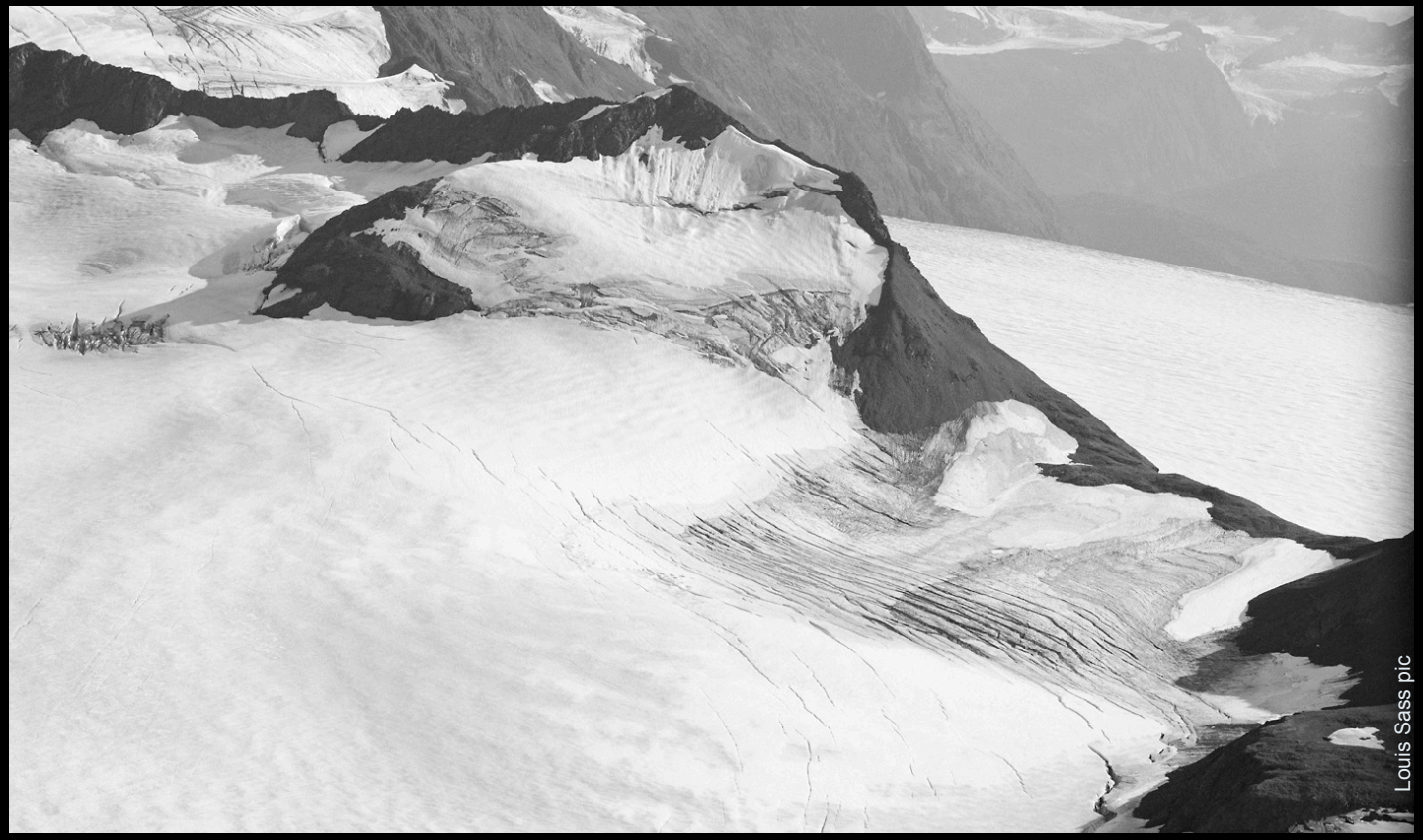
J.T. Thomas pic

Arctic Amplification: positive feedbacks

1) Sea ice
2) Terrestrial snow and ice
3) Vegetation and permafrost

Arctic Amplification: positive feedbacks

1) Sea ice
2) Terrestrial snow and ice
3) Vegetation and permafrost



Arctic Amplification: positive feedbacks

1) Sea ice
2) Terrestrial snow and ice
3) Vegetation and permafrost

So.

Greater warming is expected in the arctic.

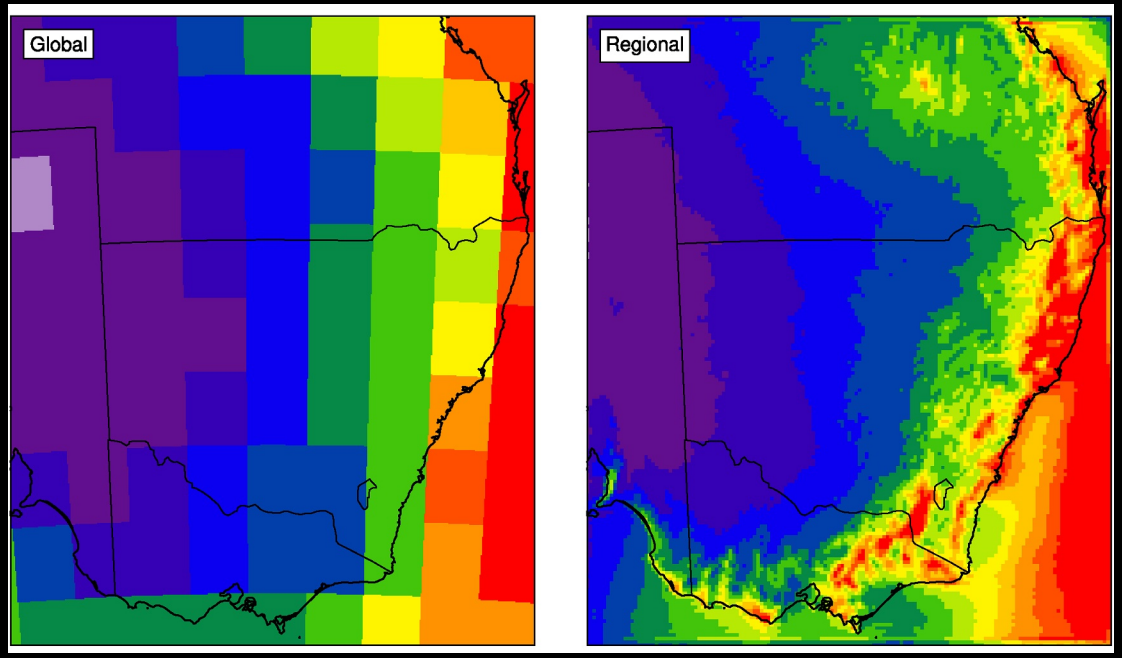
Especially the high arctic and near the ocean.

What do the models predict for Alaska?

What the models are: *downscaled* GCMs

Global Climate Model (GCM) → **Regional Climate Model (RCM)**

~125 km grid → **~2 km grid**



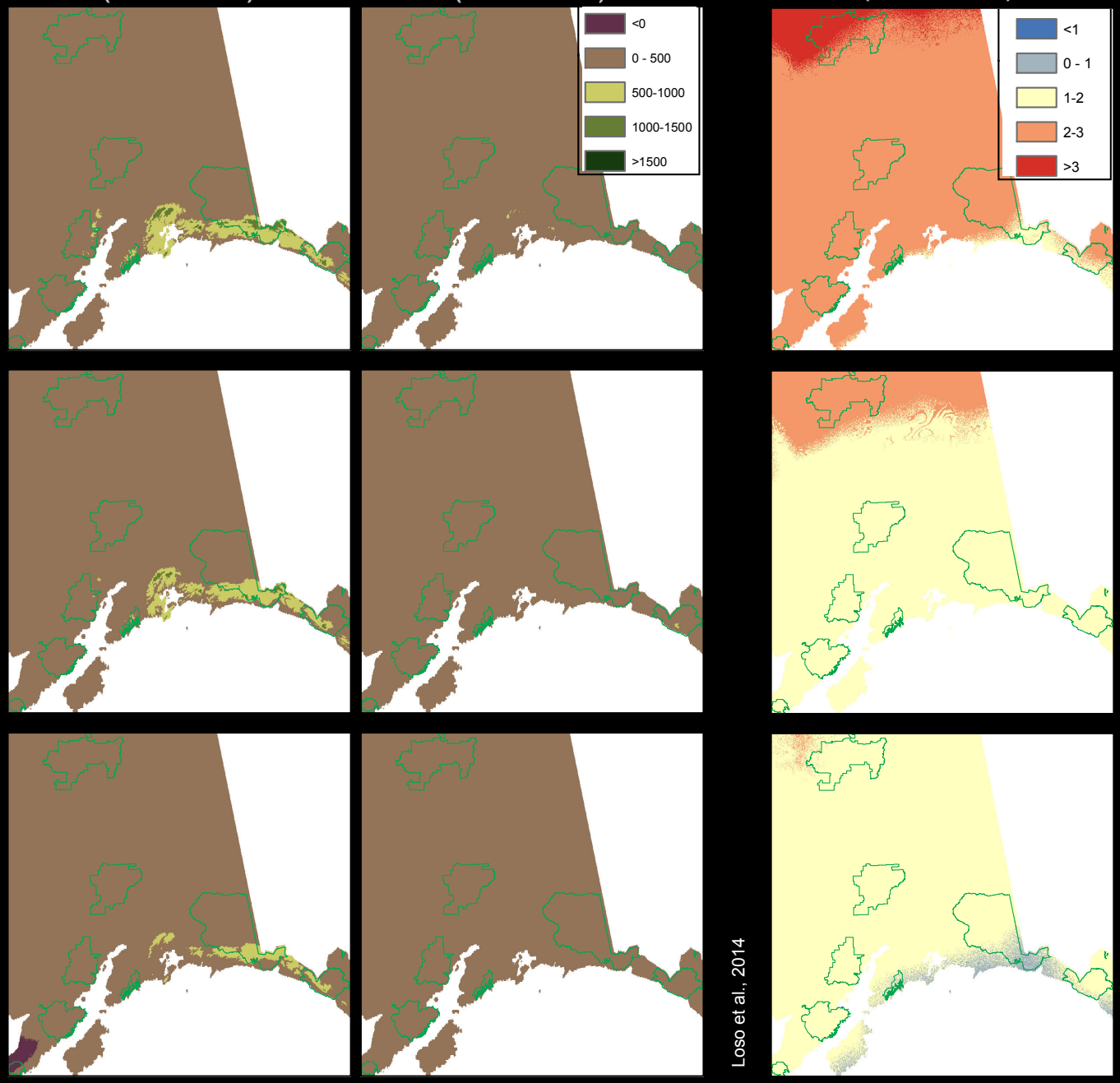
2 basic ways:

1) Dynamical (run a new climate model at smaller scale)
2) Statistical (use known relationships from modern climate)

I'm showing results of a 2 km statistically downscaled model:

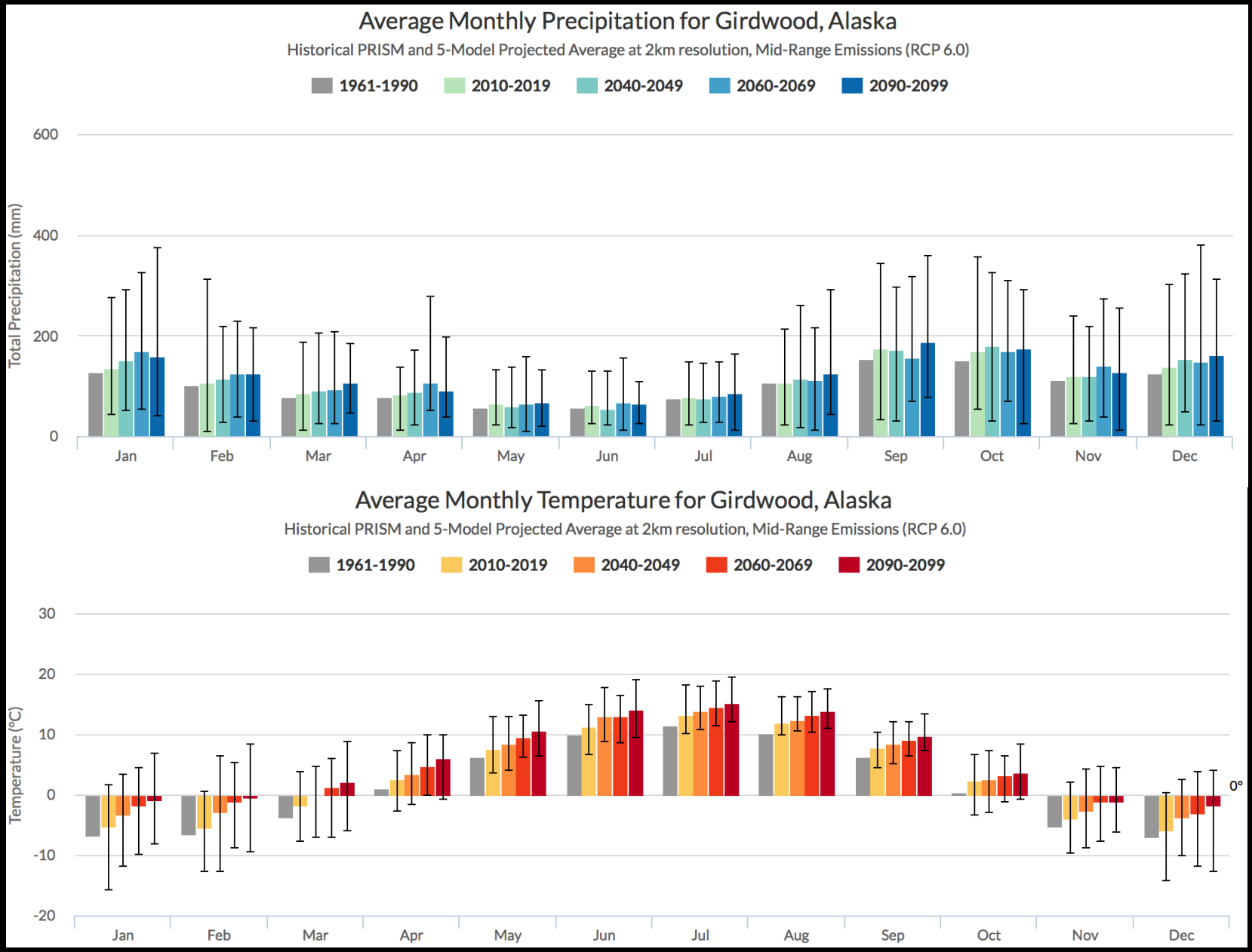
www.snap.uaf.edu

2015-2065 projected anomalies



SAAW Loso 2015

Girdwood, month by month



So.

Hotter statewide, especially far north.

Wetter everywhere, especially coast ranges.

Large uncertainty, especially in winter.

What about El Niño and all that business?

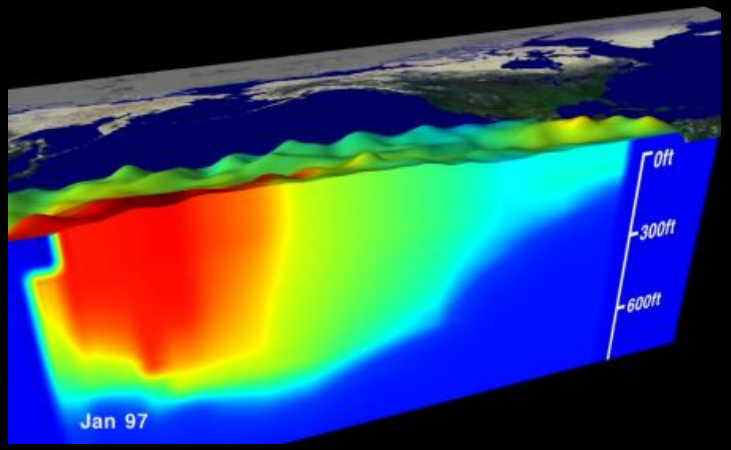
Why the buzz?

- Weather seems chaotic and random
- There are patterns that help us understand. Easy ones:
  1. Diurnal and seasonal cycles
  2. Continental / coastal
  3. Etc…
- And more subtle ones:
  1. ENSO
  2. PDO
  3. PNA
  4. Etc.
- What are they, what do they do, and what do they tell us?

El Niño / Southern Oscillation (ENSO)

La Niña

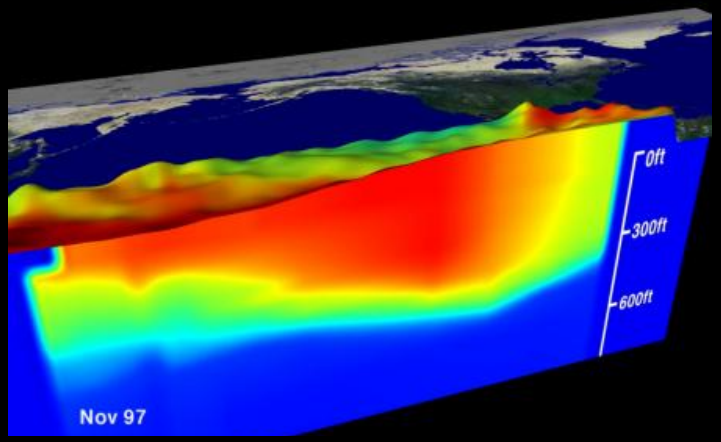
hot



cold

Normal

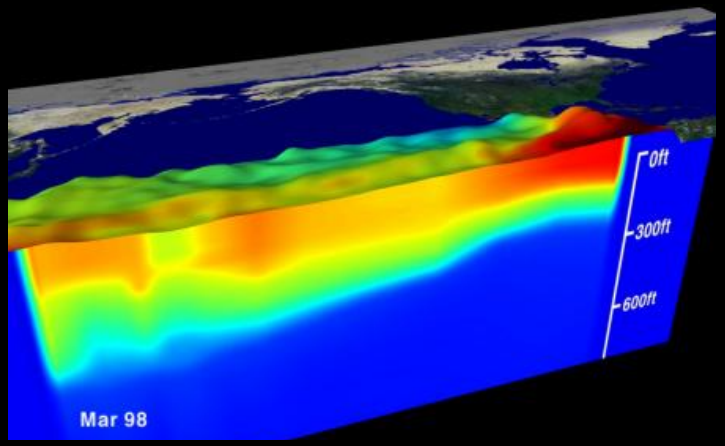
warm



cool

El Niño

warm

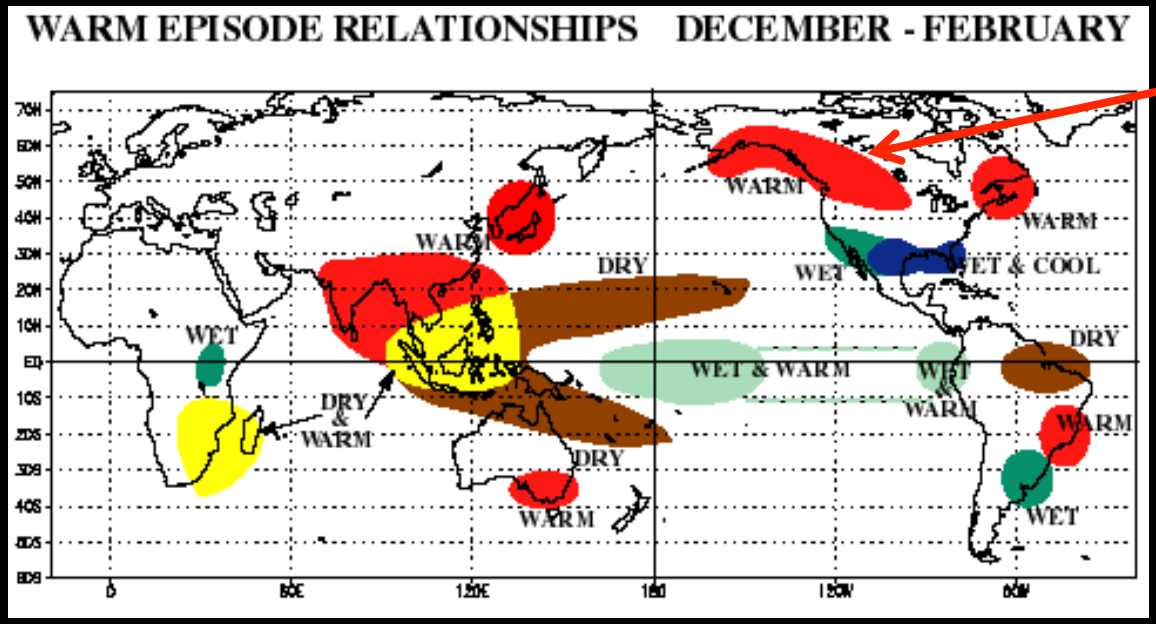


warm

Warm Phase

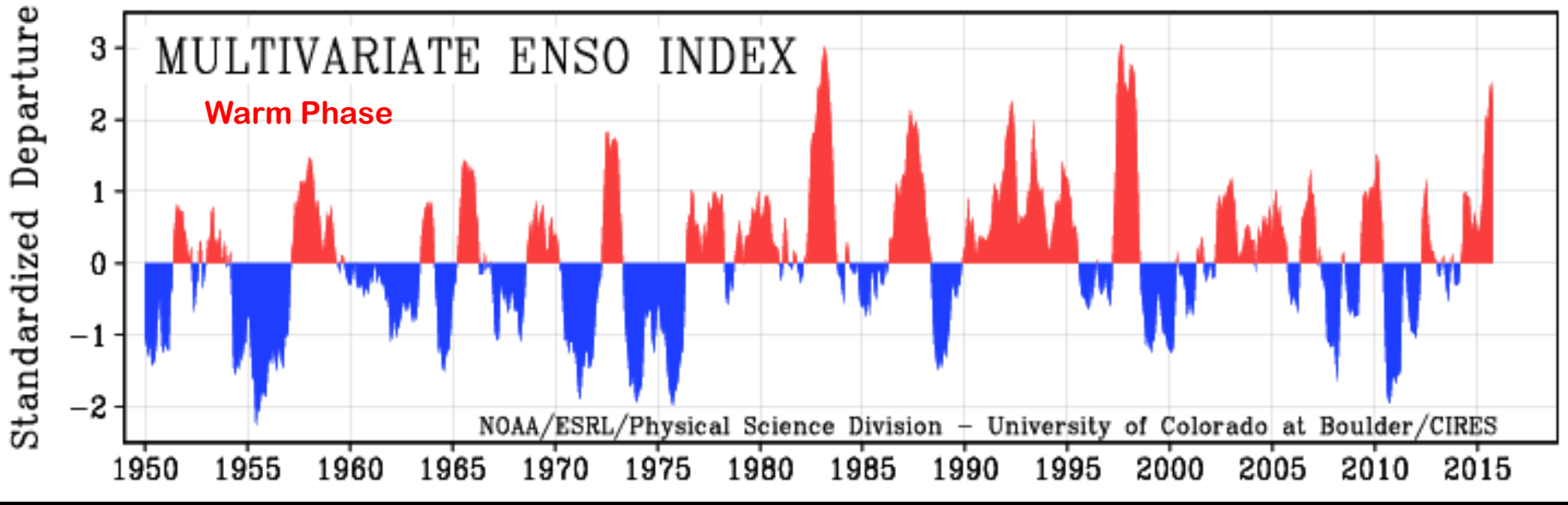
- weakened easterly trade winds
- warm SST off Ecuador/Peru
- high air pressure over Indonesia

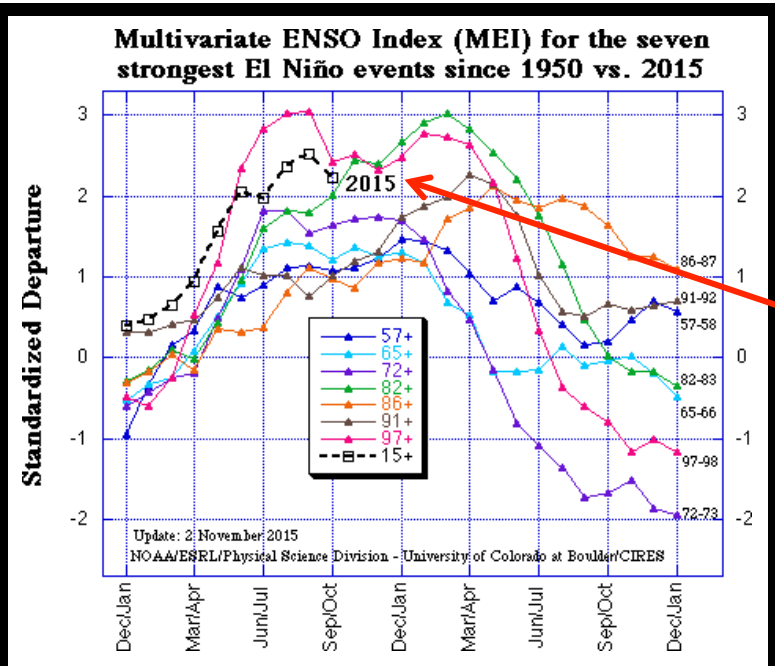
ENSO: teleconnections



The conventional wisdom (warmer winters)

ENSO: index





We're shaping up to have a big El Niño winter

ENSO: what it tells us

Table II. El Niño anomalies (°C) stratified by PDO mode[a]

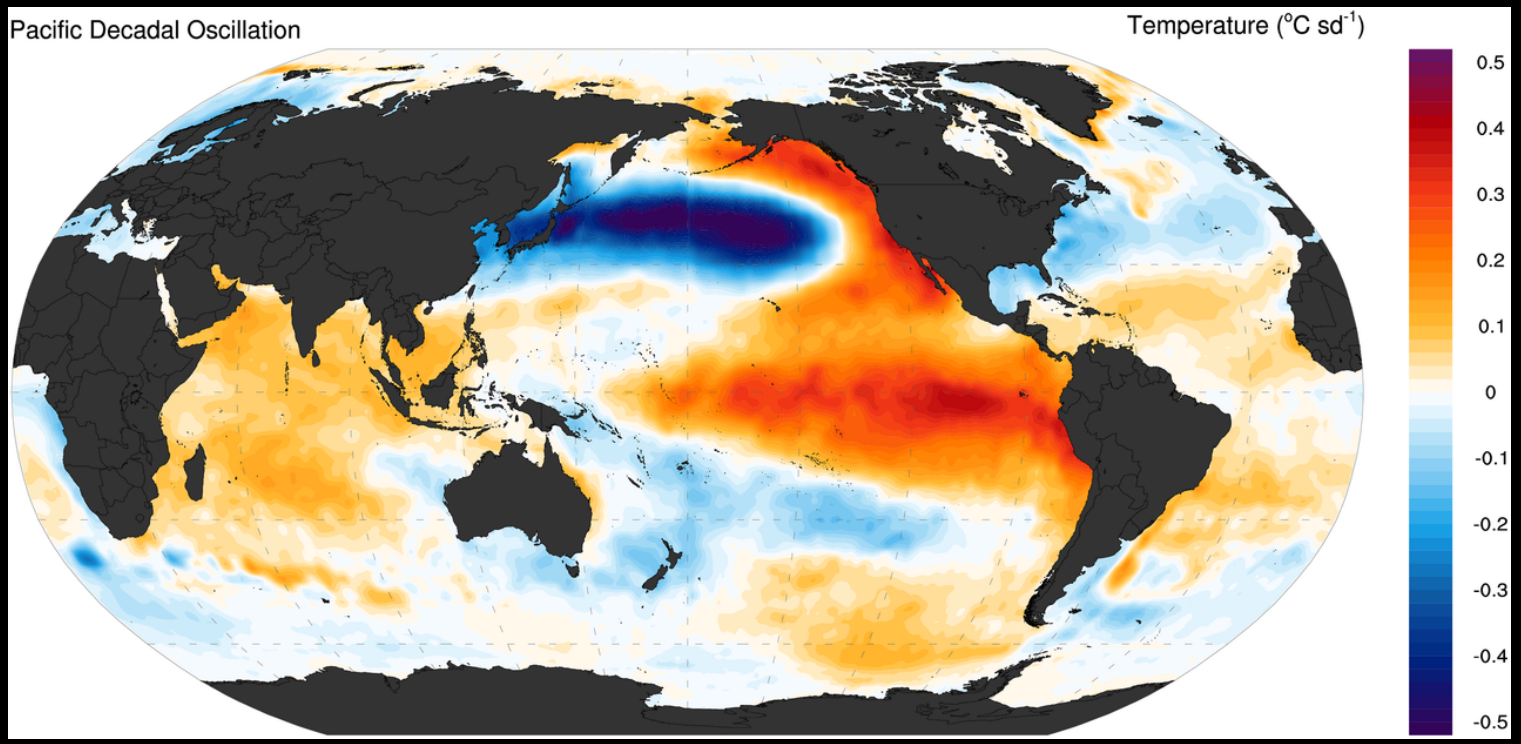
	+PDO (1925–1946)			−PDO (1947–1976)			+PDO (1977–1997*)		
	(°C)	Cold	Warm	(°C)	Cold	Warm	(°C)	Cold	Warm
Nome	+1.2	13	24	−0.4	19	14	+0.9	7	22
Bettles	NA	–	–	−0.2	20	10	+1.9	9	22
McGrath	NA	–	–	−1.4	21	11	+1.7	10	24
Fairbanks	+1.1	17	25	−0.8	26	12	+2.2	9	21
Bethel	NA	–	–	−0.7	23	8	+0.9	8	22
Anchorage	+1.6	13	20	−1.1	30	8	+1.7	11	23
Yakutat	NA	–	–	−0.5	26	9	+1.3	12	22
Annette	NA	–	–	+0.1	25	10	+1.0	11	23

[a] Cold and warm columns indicate the number of monthly anomalies that occurred during the given time period.
* Note: a possible shift in the PDO occurred in 1997.

Papineau, 2001

John's conclusion: El Nino winters are often warmer than is typical, but it is dependent on the state of the PDO and the PNA

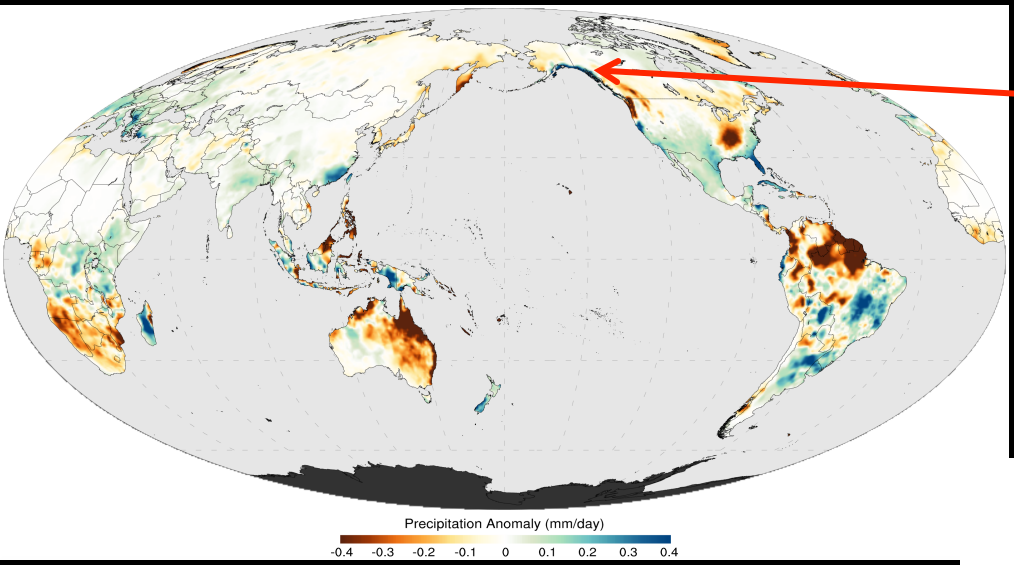
Pacific Decadal Oscillation (PDO)



Warm Phase

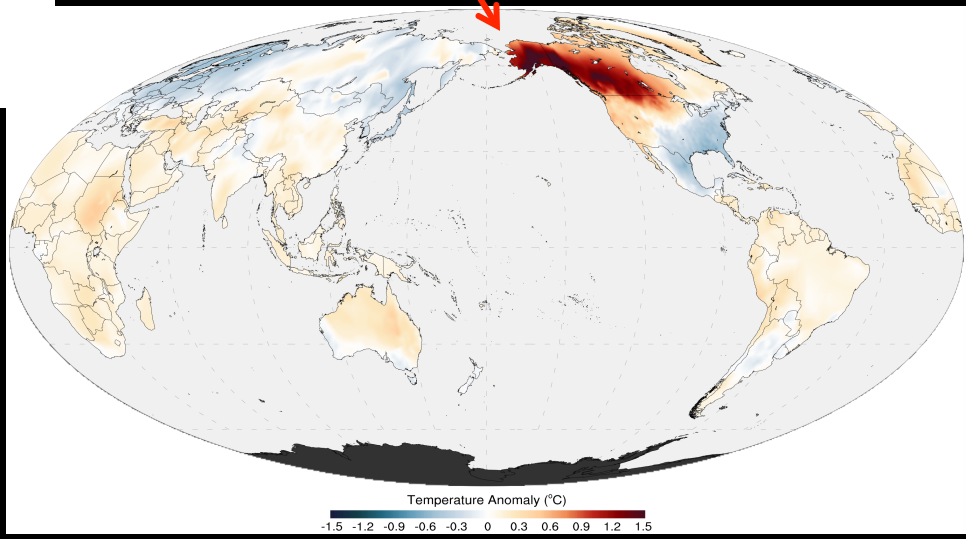
- Warm SST in eastern North Pacific
- Cooler to west
- Deeper (stronger) Aleutian Low

PDO: teleconnections



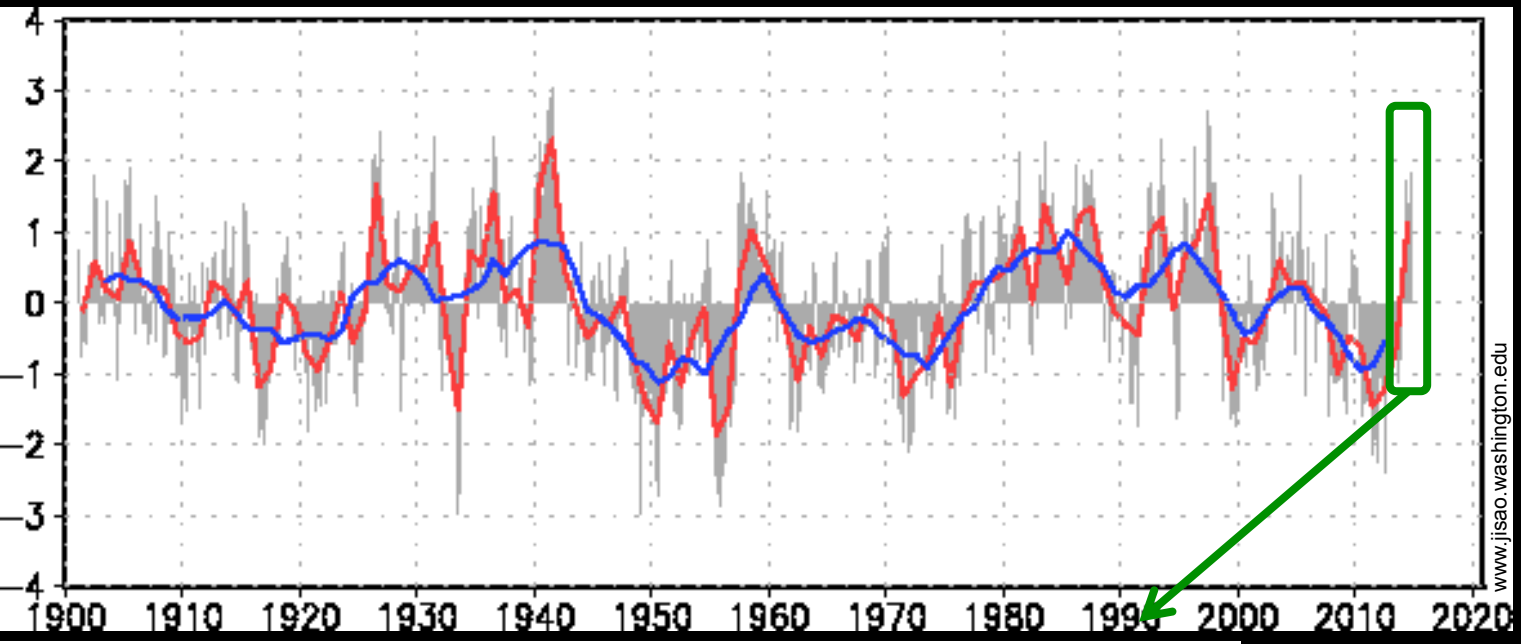
Winter precipitation anomaly

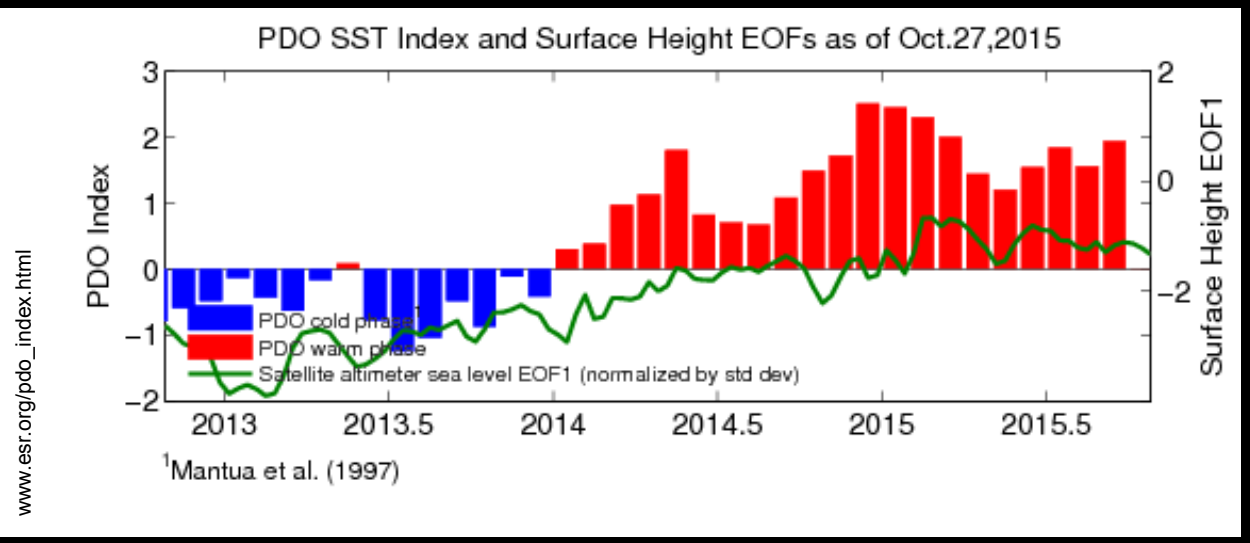
The conventional wisdom
(warmer & wetter)



Winter temperature anomaly

PDO: index





We're in an unstable, weakly warm PDO

PDO: what it tells us

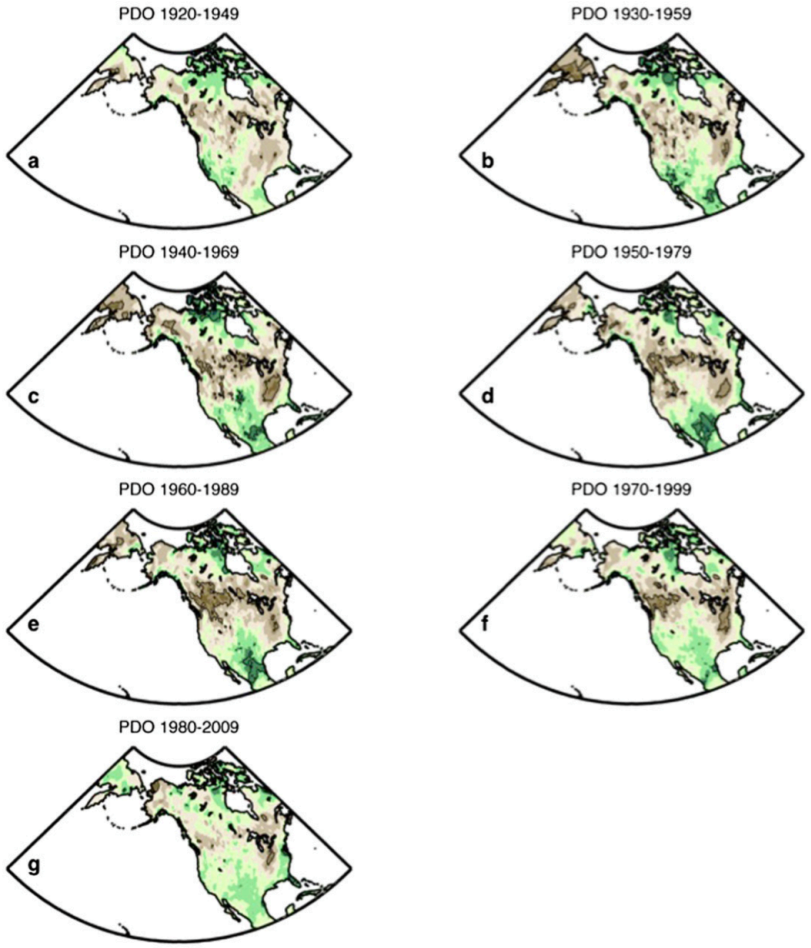


FIG. 13. Correlation between the PDO and standardized precipitation anomalies from the GPCC v. 6 data. Black outlining indicates regions where grid cell level differences are significant ($p \leq 0.01$).

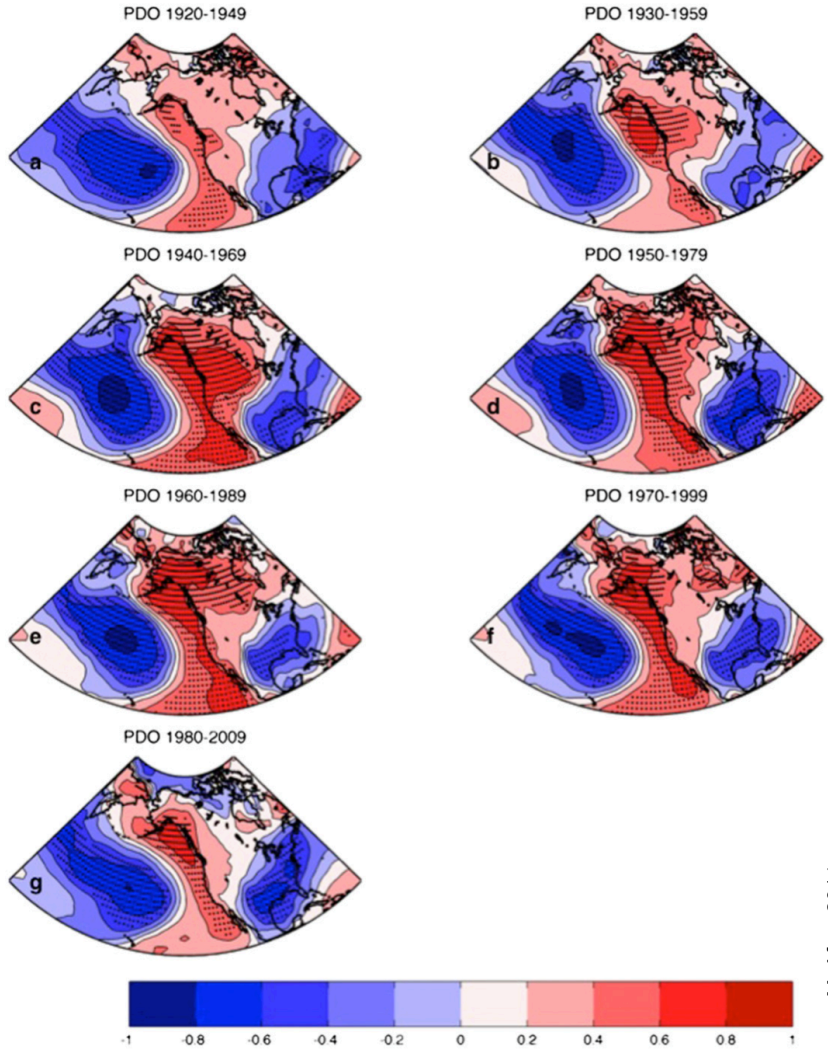
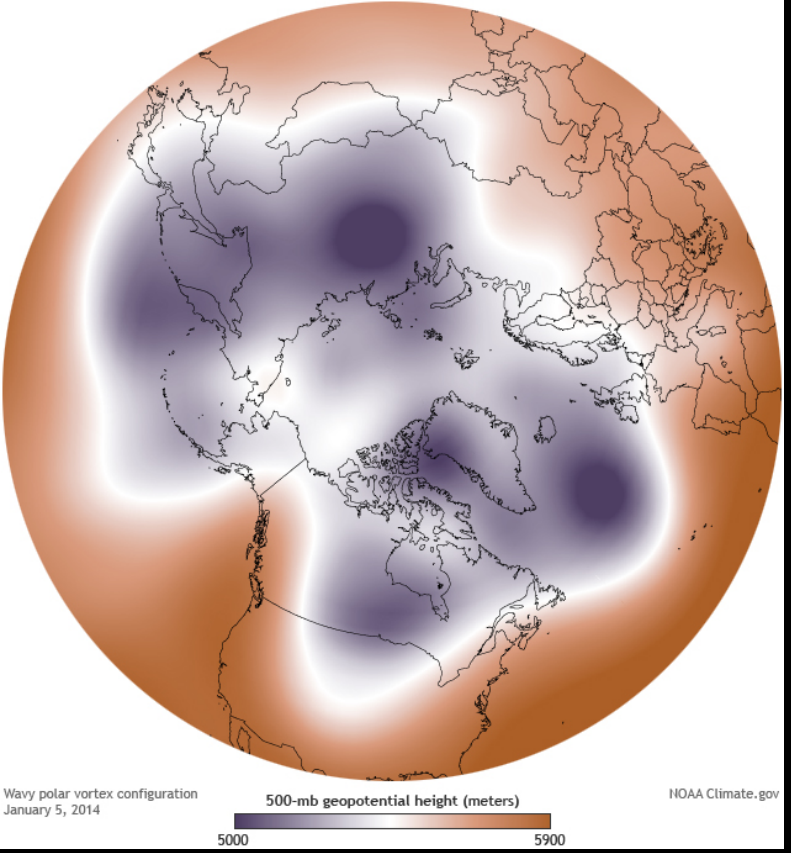


FIG. 10. 30-yr correlations between the PDO and temperature in the 20CR. Stippling indicates regions where the estimated p value is ≤ 0.01.

McAfee, 2014

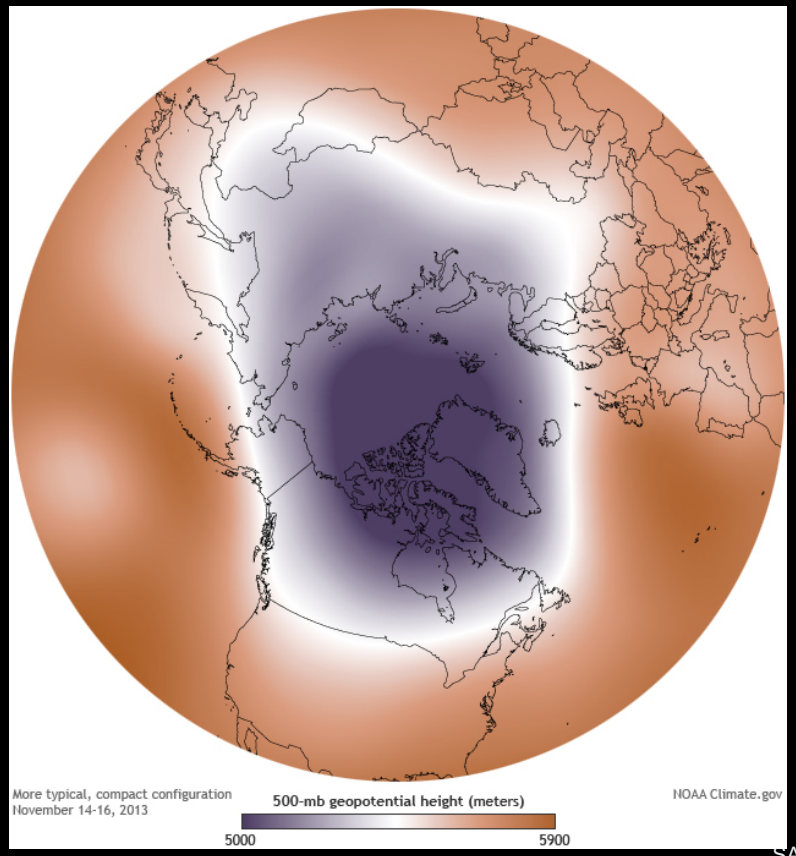
McAfee's conclusion: There are striking differences between climate responses during PDO's of the same sign over the last 100 years. Be cautious about drawing conclusions from recent patterns.

Pacific/North American pattern (PNA)



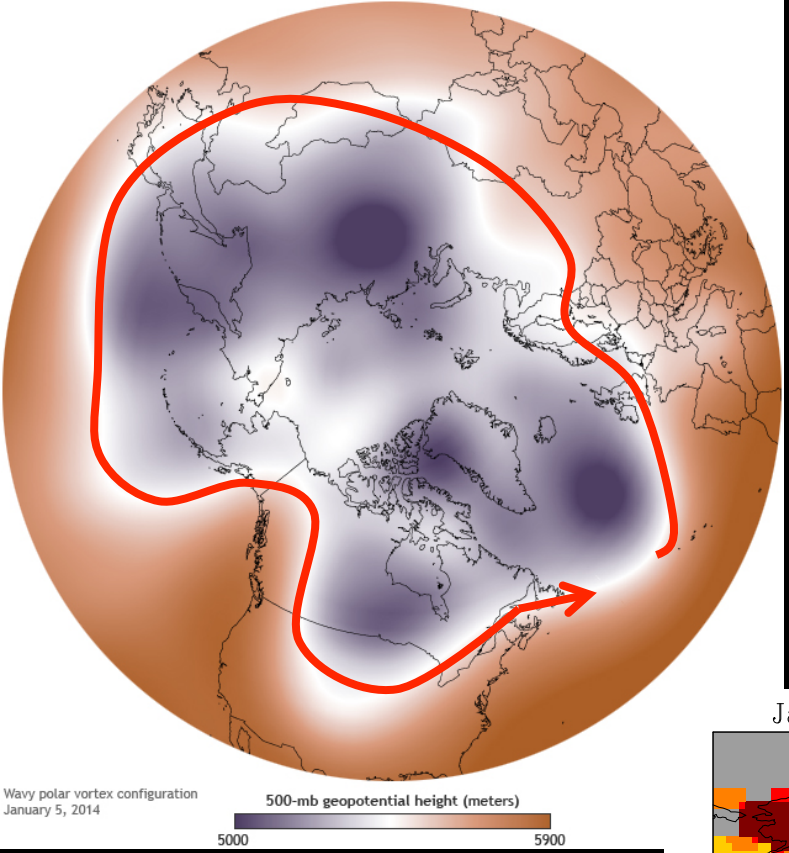
Positive phase

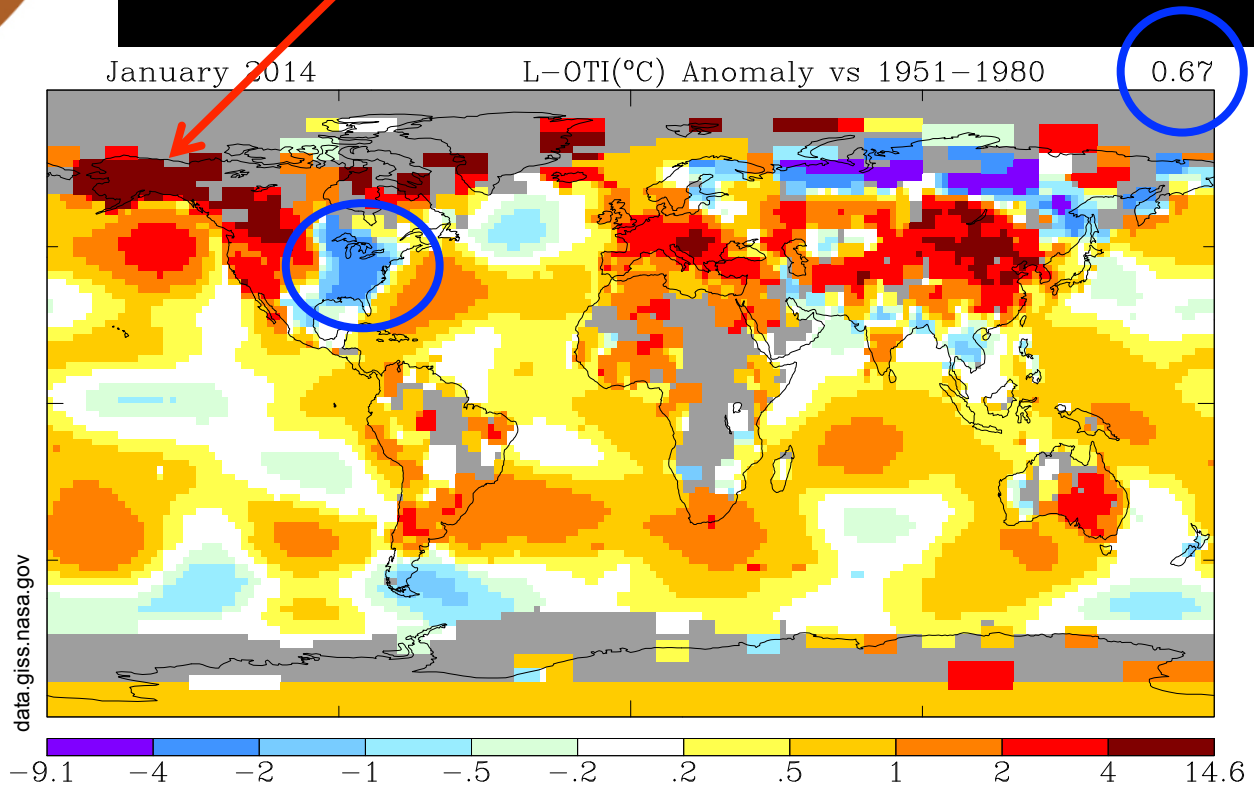
- Deep trough over Aleutians/north Pacific
- Strong ridging over western US
- Deeper (stronger) Aleutian Low



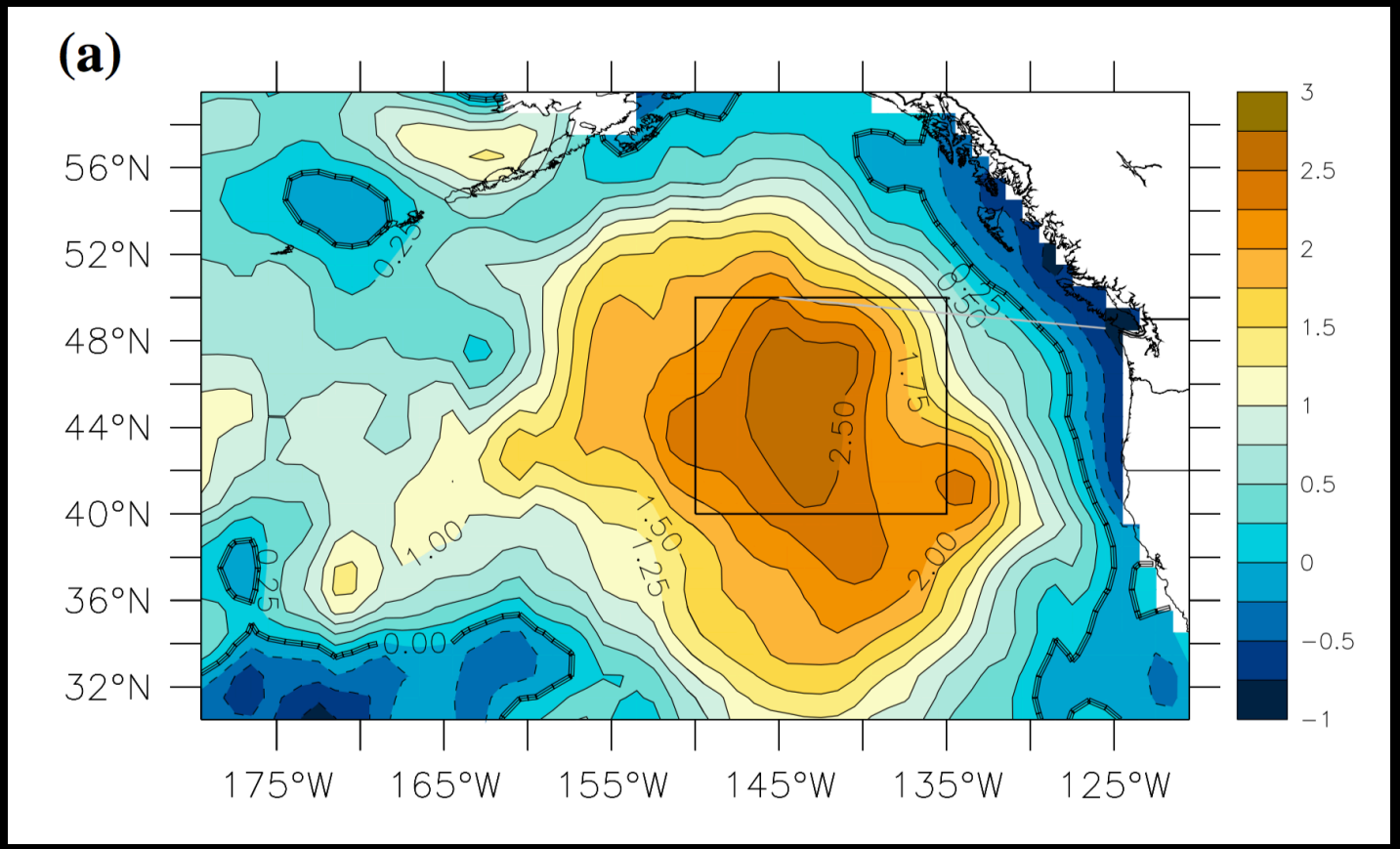
PNA: teleconnections

The conventional wisdom
(warmer & wetter)

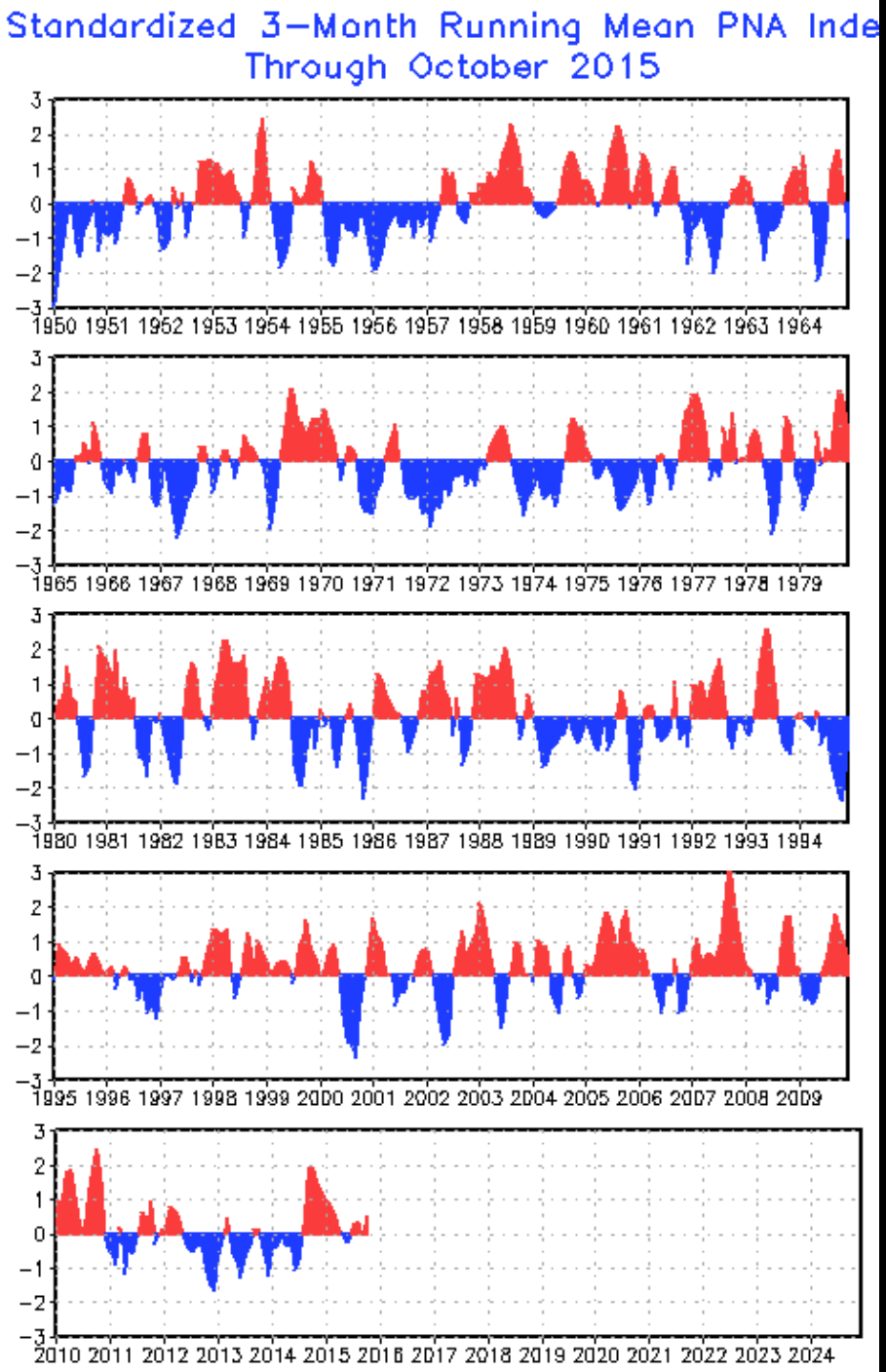


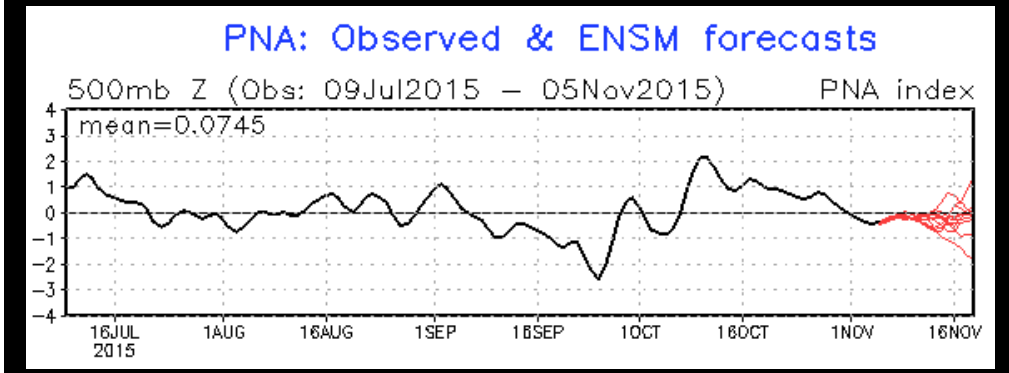


A digression... the blob



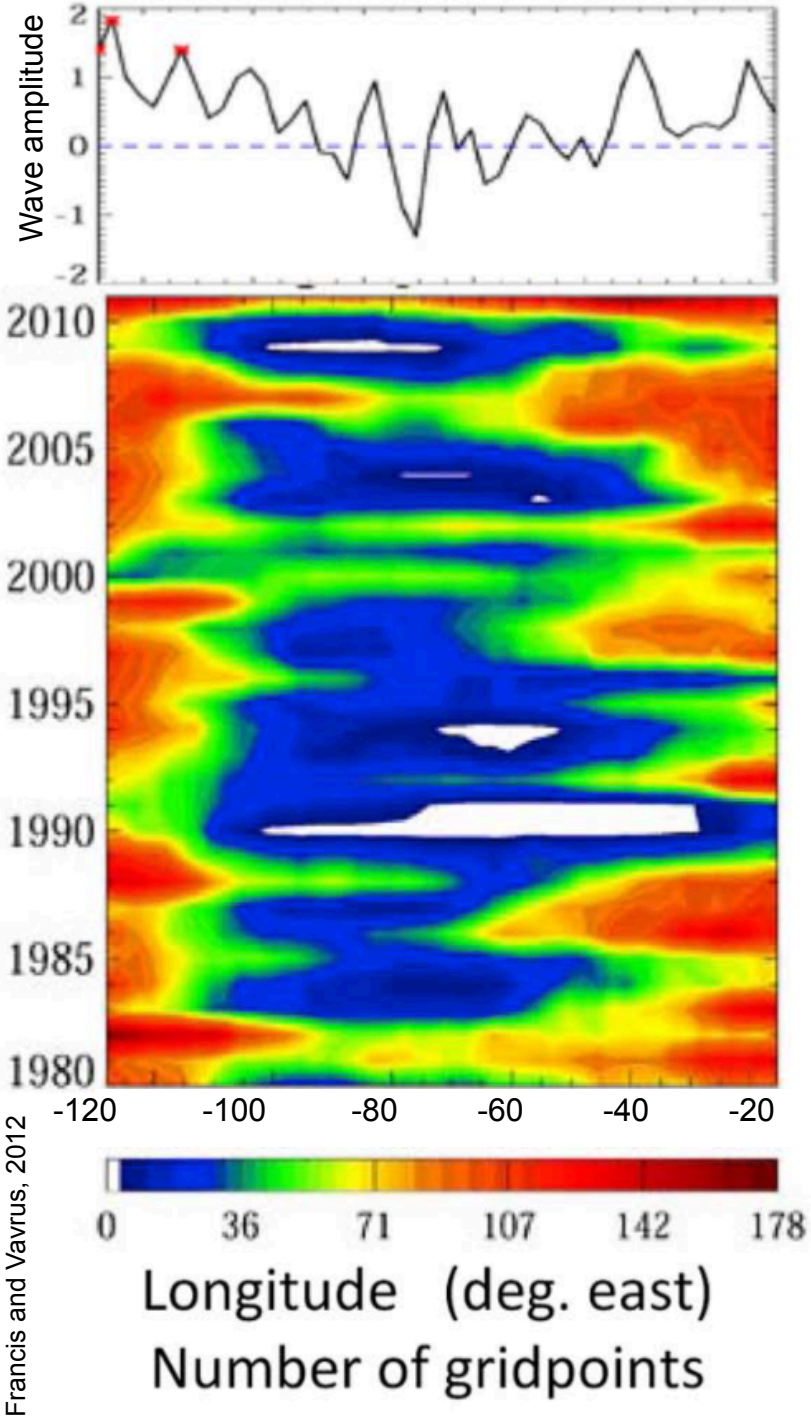
PNA: index



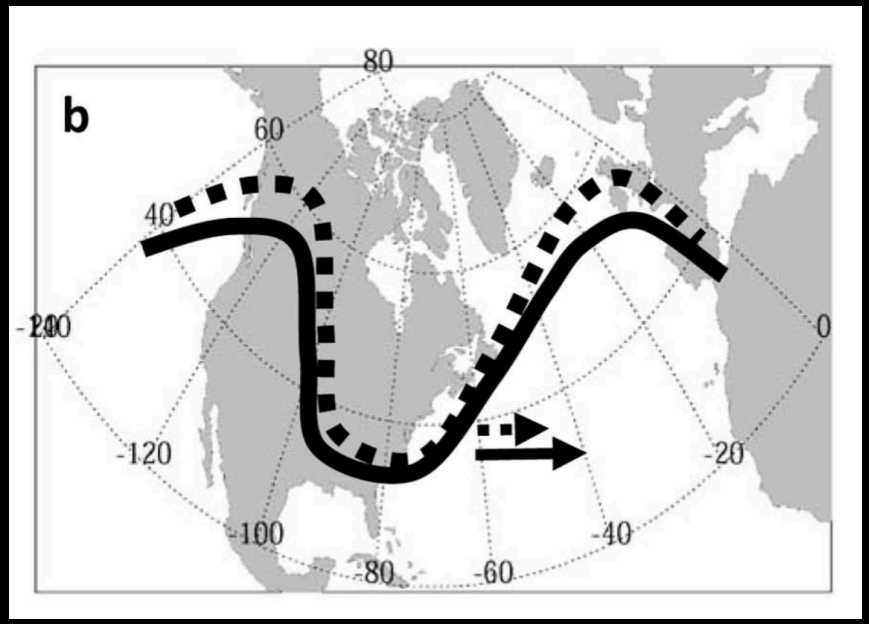


We're in a neutral phase PNA, but it can change fast

PNA: what it tells us



Francis and Vavrus, 2012



Francis's conclusion: We will see more intense, and more entrenched, occurrences of the positive phase of the PNA as the arctic warms.

So.

Trends in ENSO, the PDO, and the PNA: warmer winter, likely with more overall precip.

But none, by themselves, are good predictive tools.