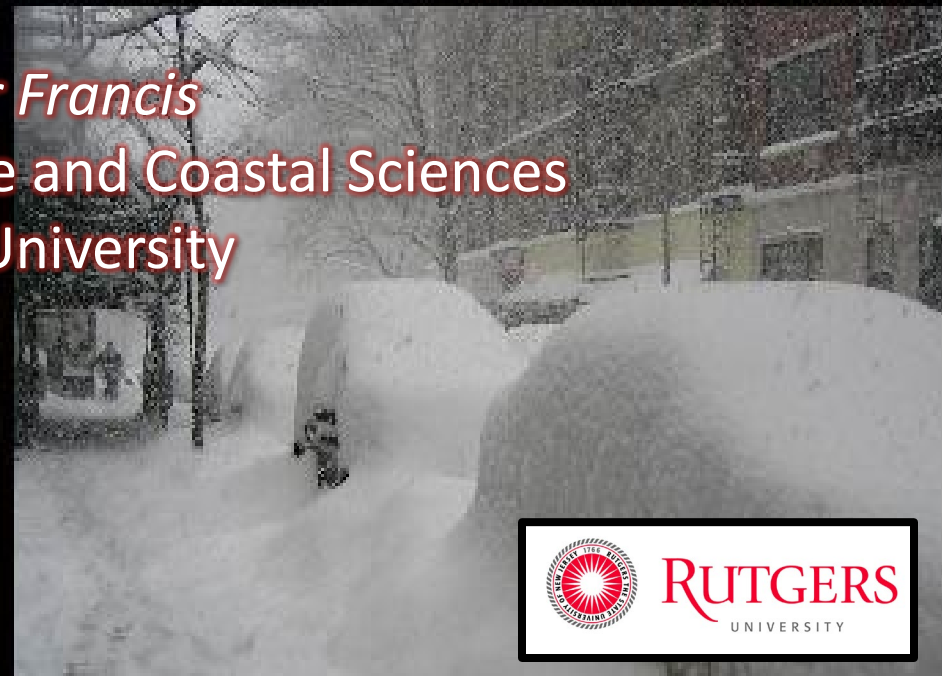
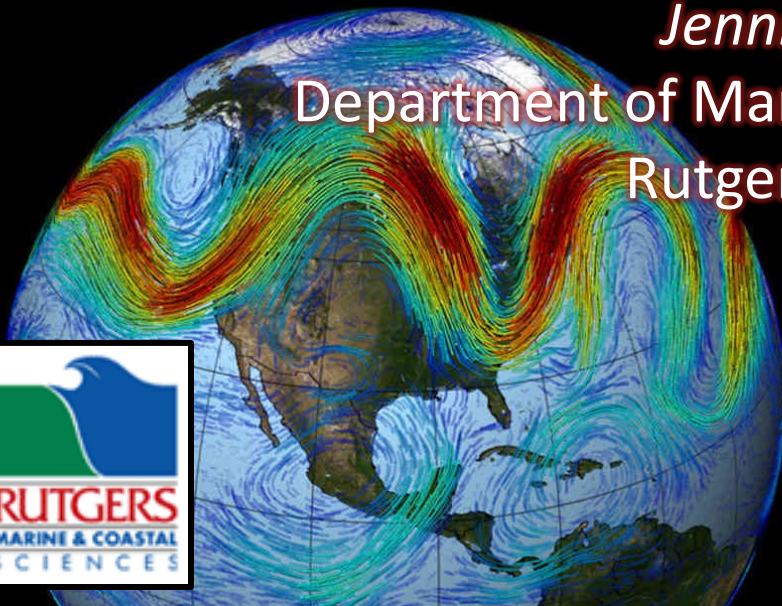


Crazy Weather and the Arctic Meltdown: Are They Connected?



Jennifer Francis
Department of Marine and Coastal Sciences
Rutgers University



© Cartoonbank.com

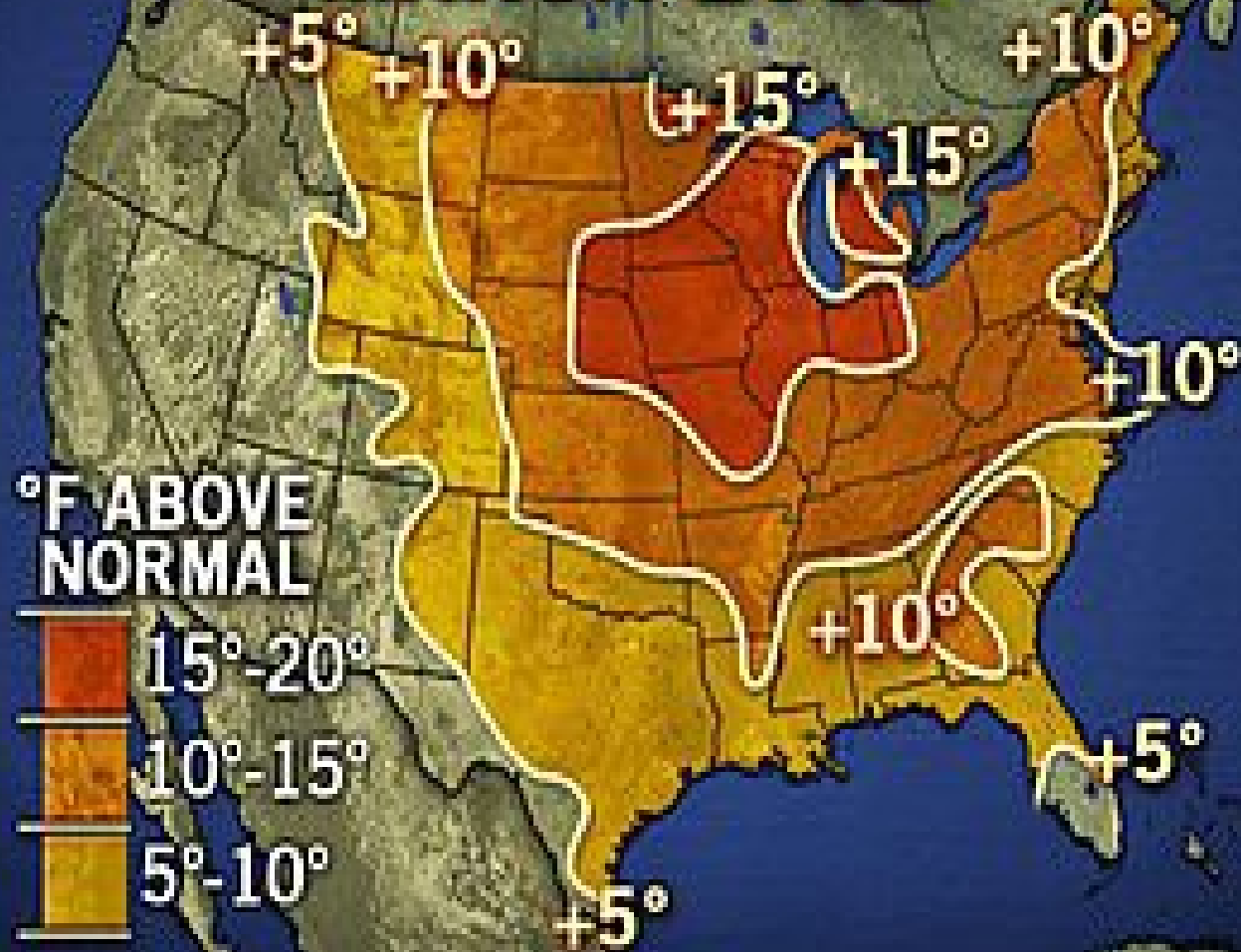


*"Long term I'm worried about global warming...
Short term, about freezing my ass off."*

The New Yorker

One of Boston's many snowstorms during winter 2015

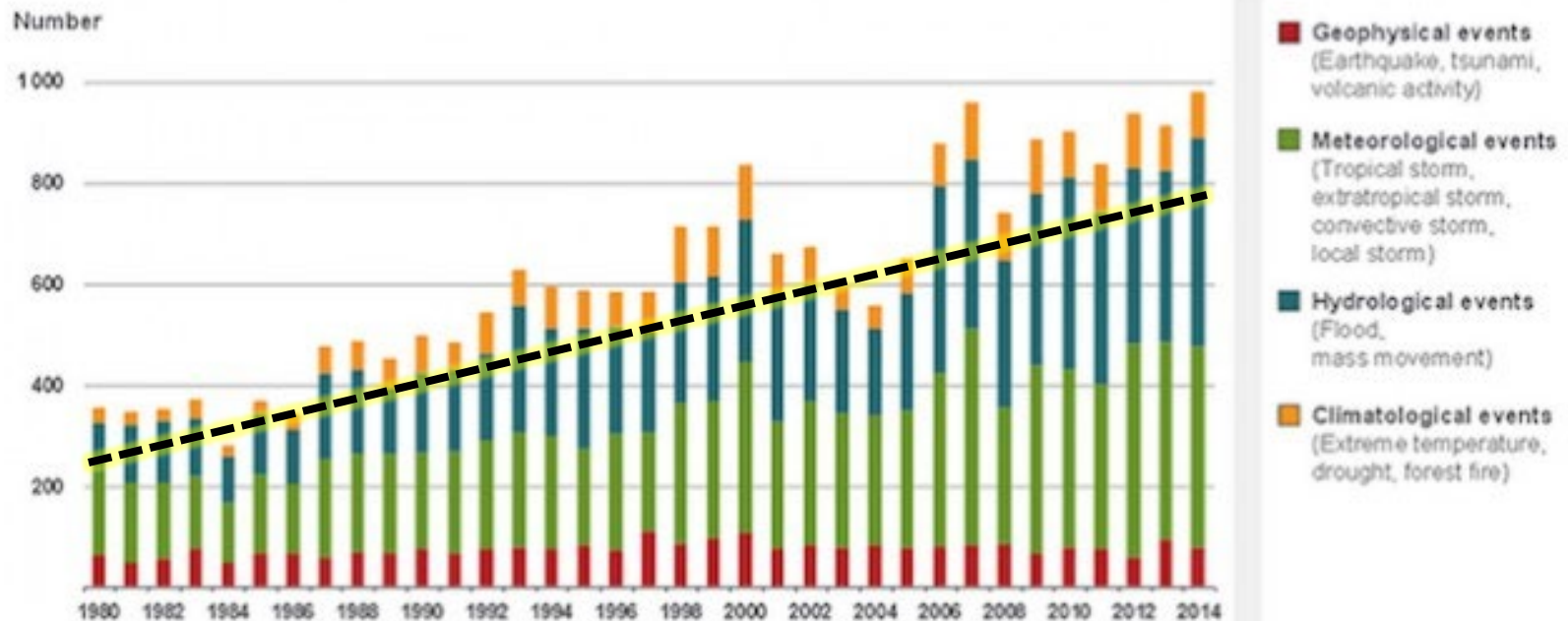
RECORD WARMTH OF MARCH 2012



Extreme weather events are on the rise...

WORLD NATURAL CATASTROPHES, 1980–2014

(Number of events)



Source: © 2015 Munich Re, Geo Risks Research, NatCatSERVICE. As of January 2015.

Munich Re

U.K. Winters 2014, 2015

What do these extreme events
have in common?

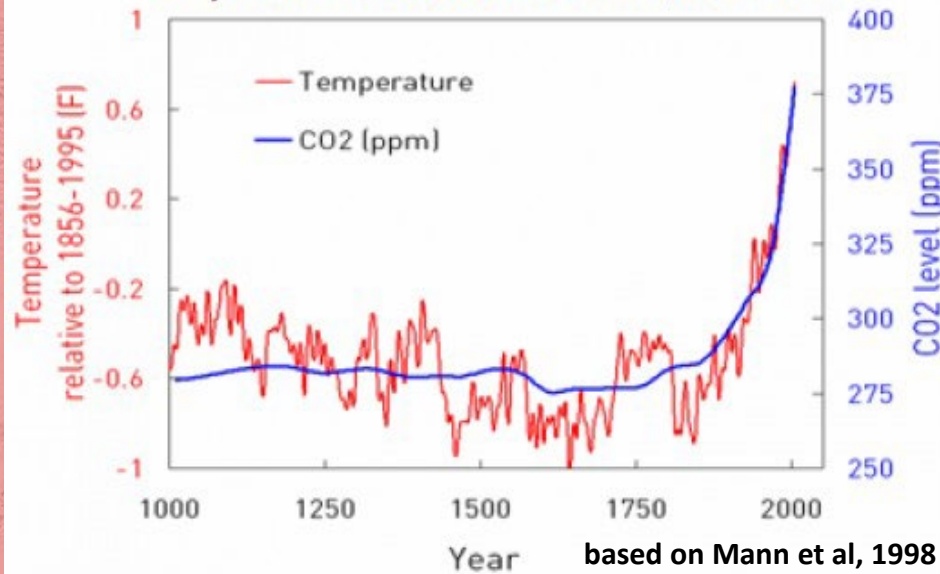
They're caused by "stuck"
weather patterns.

Is human-caused climate change
So, what the heck is going on??
playing a role?

YES!

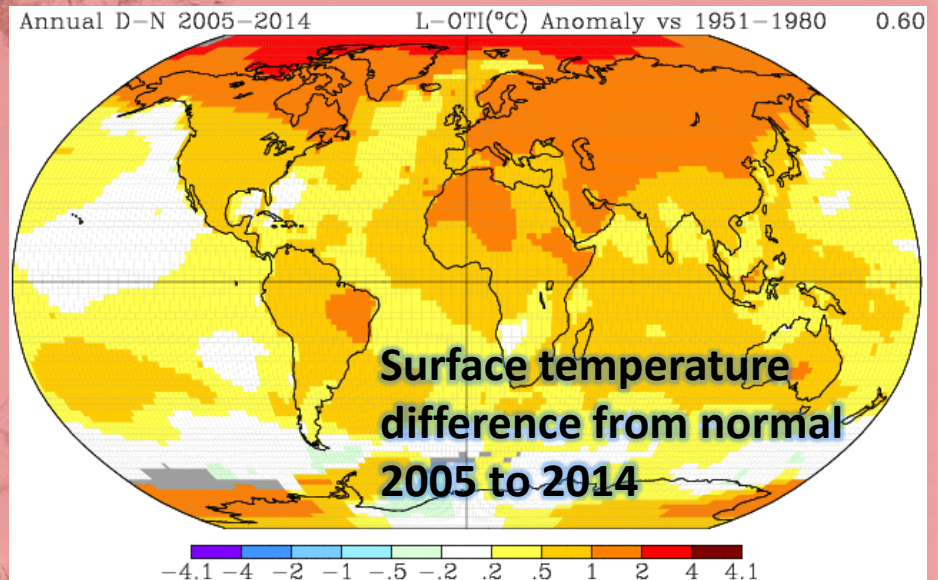


Temperature and CO2 for Last 1,000 Years



CO₂ levels are highest in at least 800,000 years, and Earth's temperature is responding...

...but the warming is not occurring evenly around the globe.



From NASA/GISS

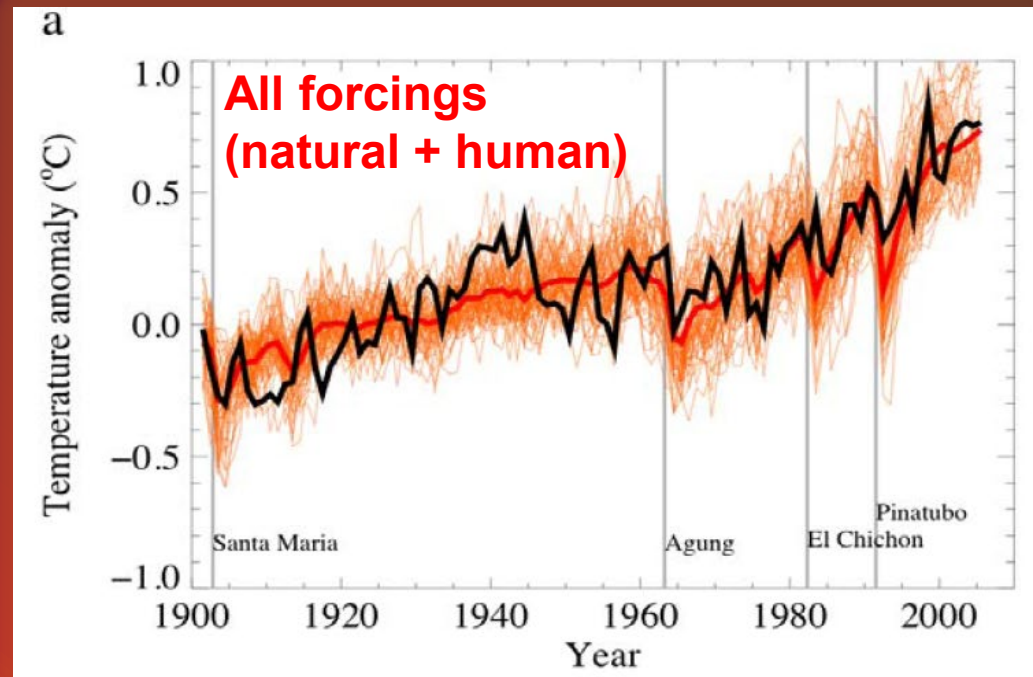
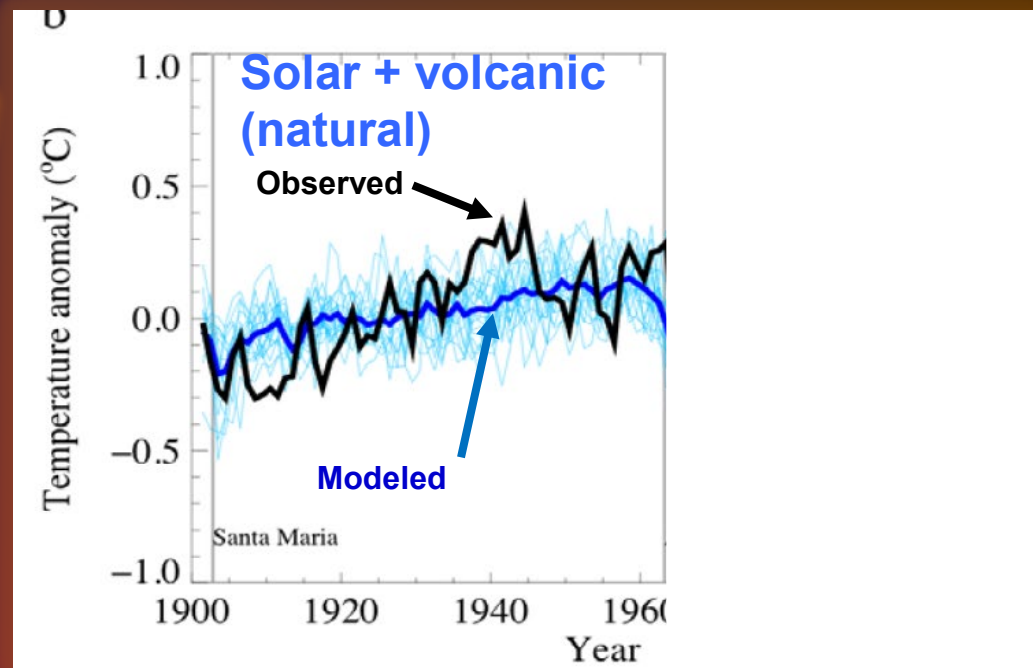
A large industrial facility, possibly a power plant or refinery, is shown at night or in low light. Several tall, dark smokestacks are visible, each emitting thick, dark plumes of smoke that rise into the sky. Intense orange and yellow flames are visible within the smoke, suggesting a fire or a controlled combustion process. The overall scene is dramatic and somewhat ominous, with the dark silhouettes of the industrial structures contrasting sharply with the bright, fiery light of the smoke and flames.

How do we know that
humans are responsible?

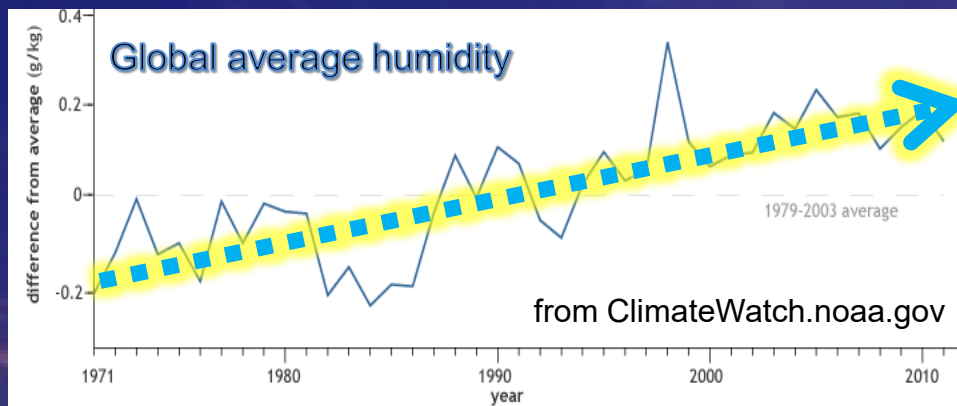
Evidence implicating humans

One of our best tools: computer programs

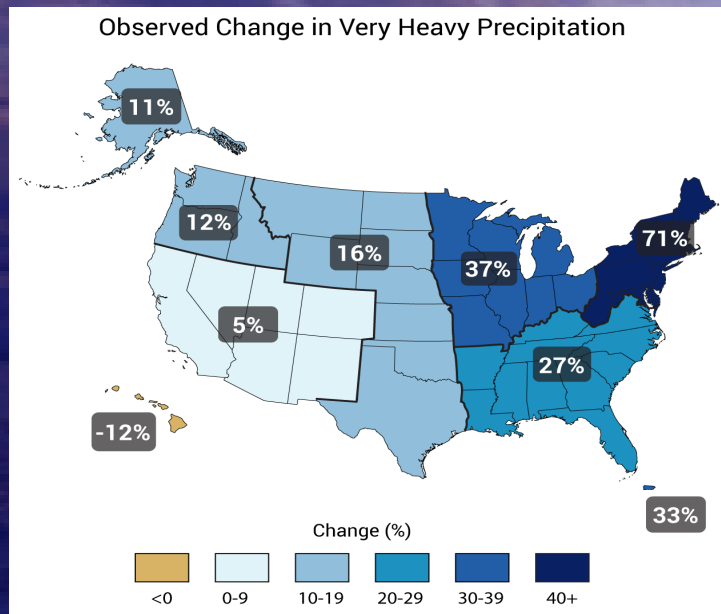
- climate models - that simulate the complex physics of the atmosphere, ocean, snow, ice, and land and all the forces acting on them.



And the atmosphere is gaining moisture...



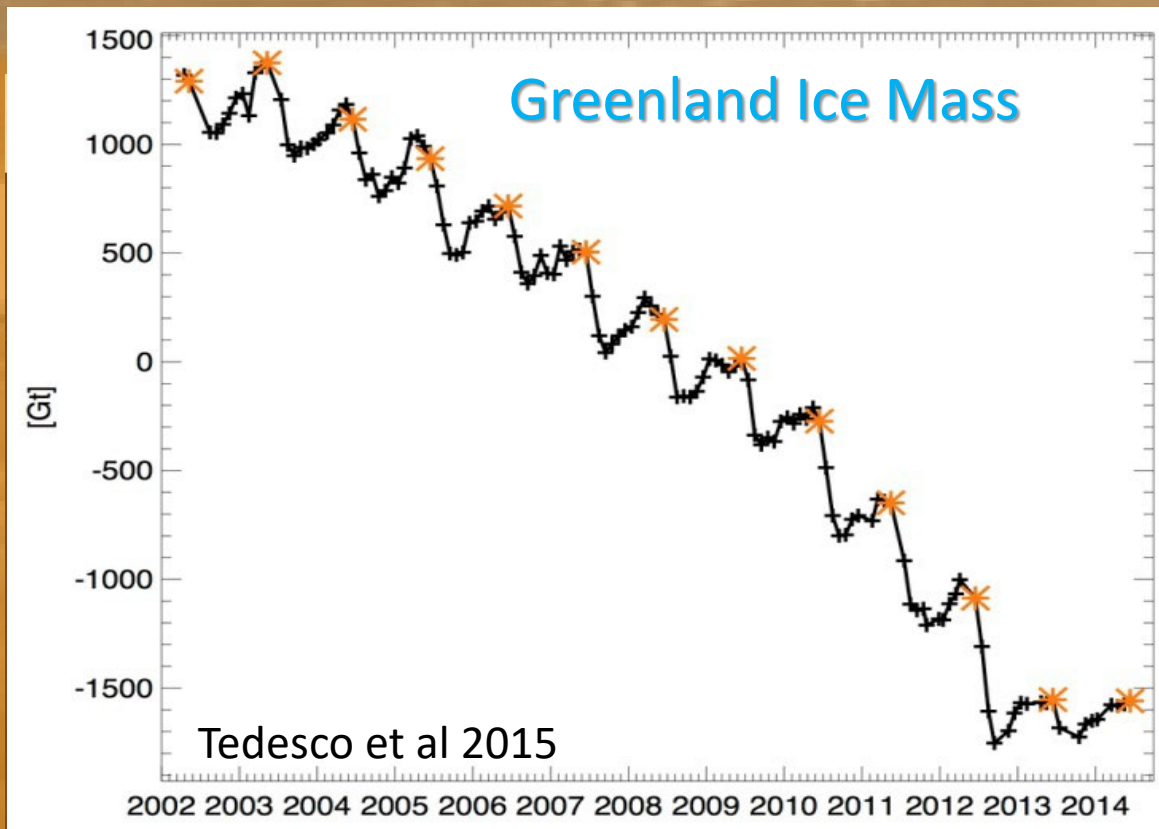
...providing more fuel to energize storms, a stronger greenhouse effect...



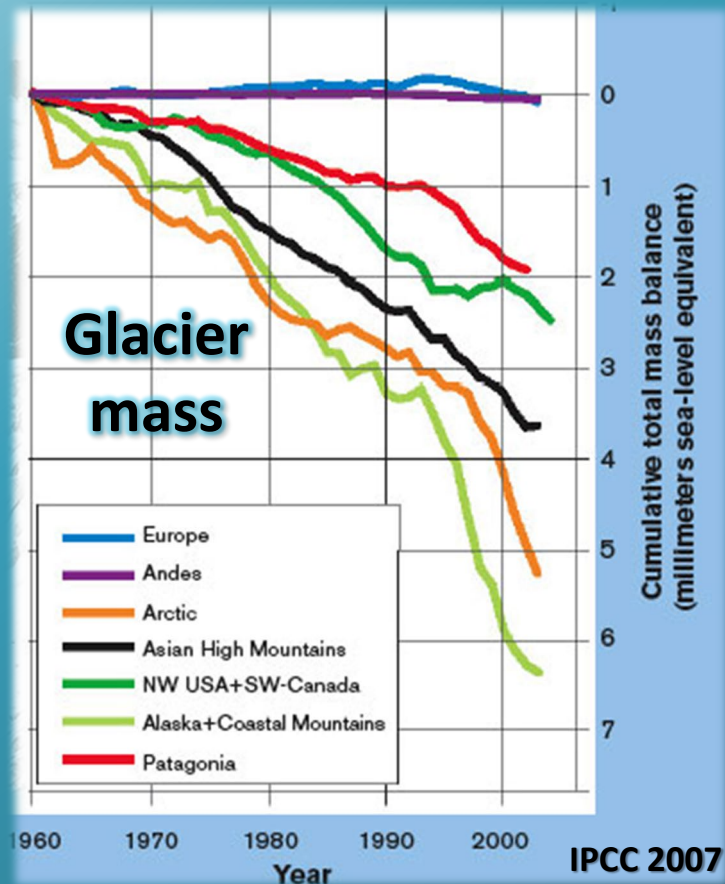
...and more frequent heavy precipitation events

Focus on the Arctic...

Nearly the entire surface of Greenland melted for the first time in at least 150 years

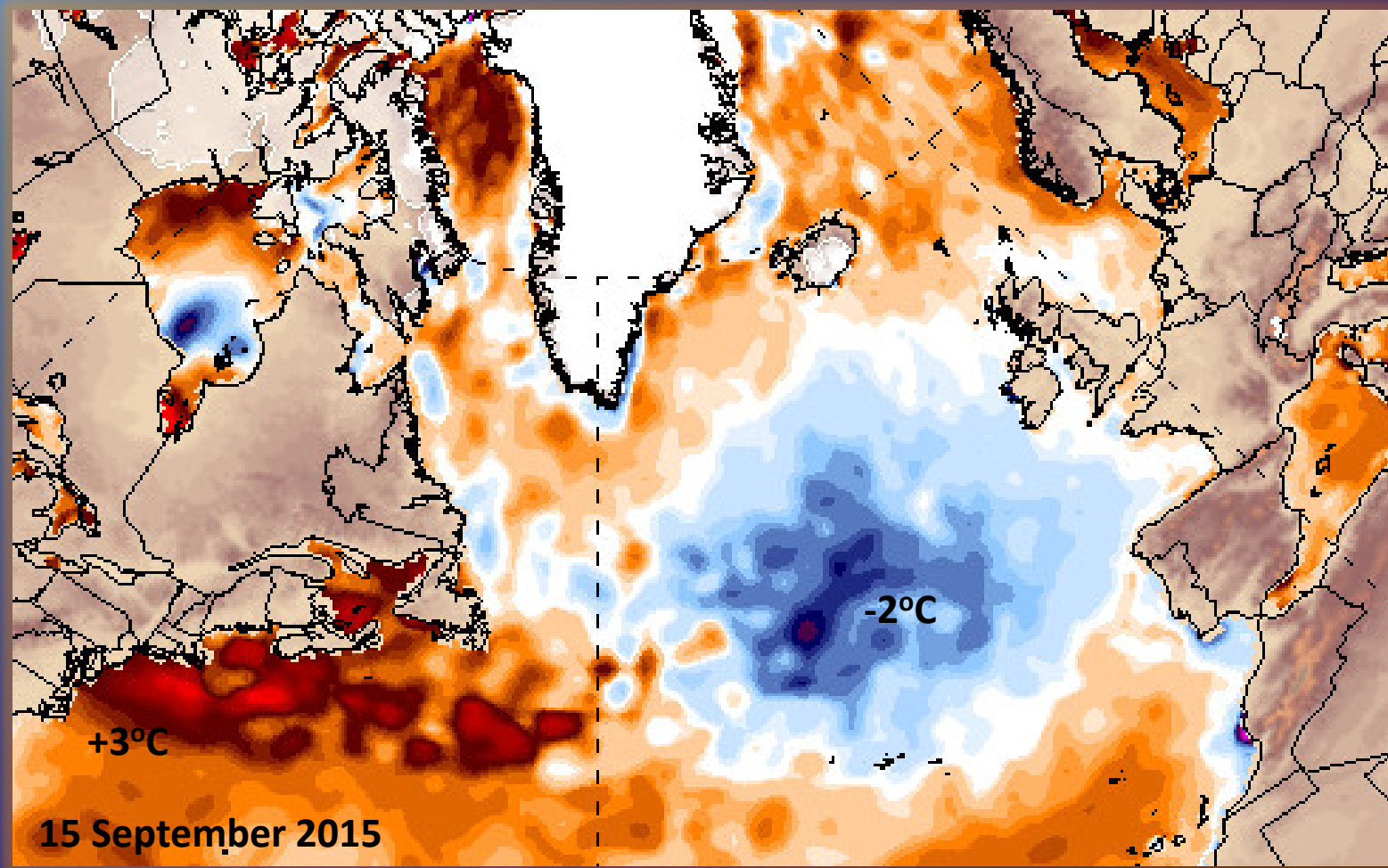


Most of the worlds glaciers are melting...

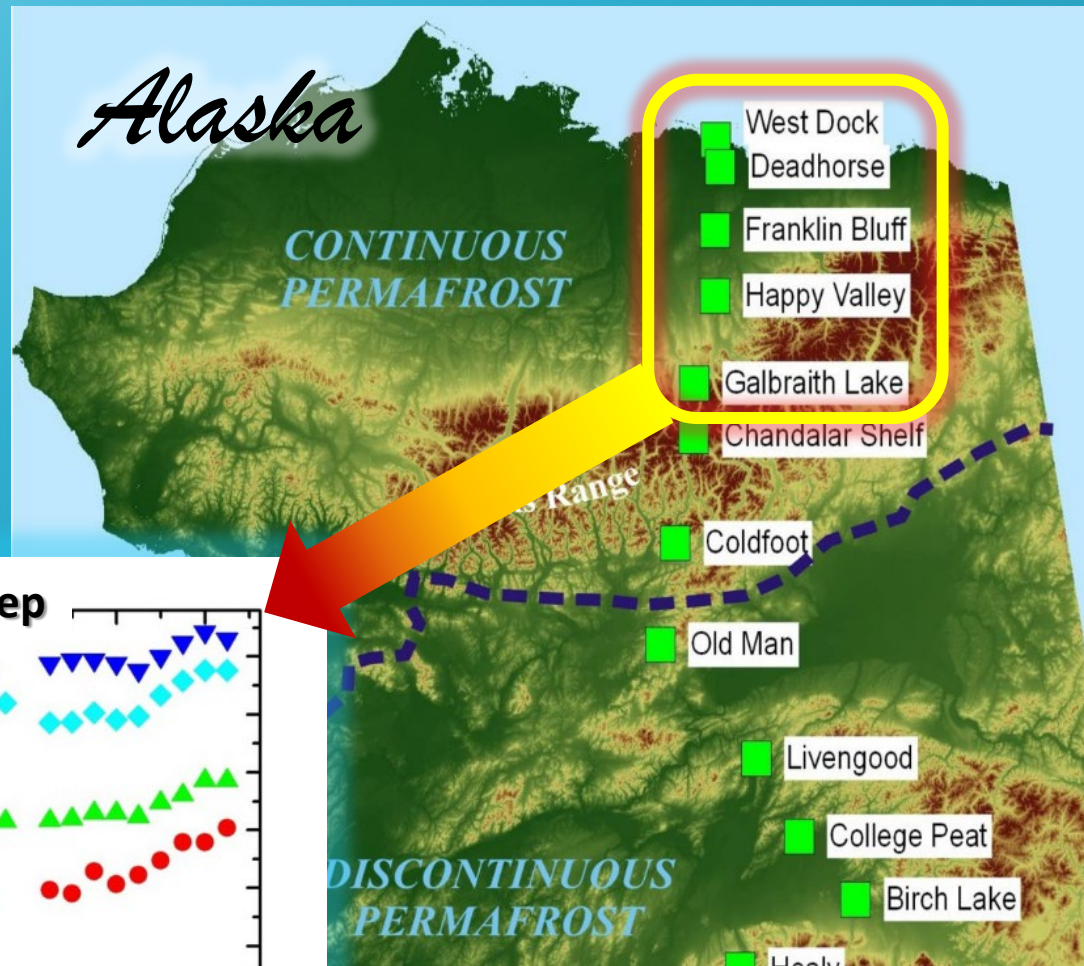


2003

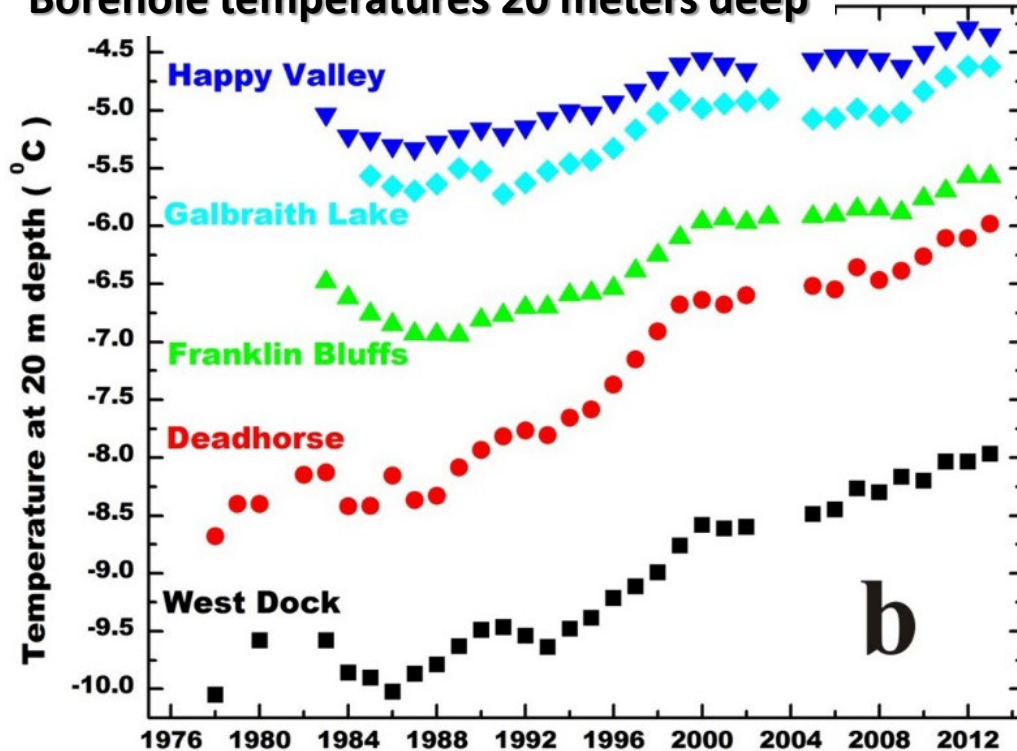
Is Arctic Ice Loss Affecting Ocean Currents?



...and permafrost is becoming less "perma"

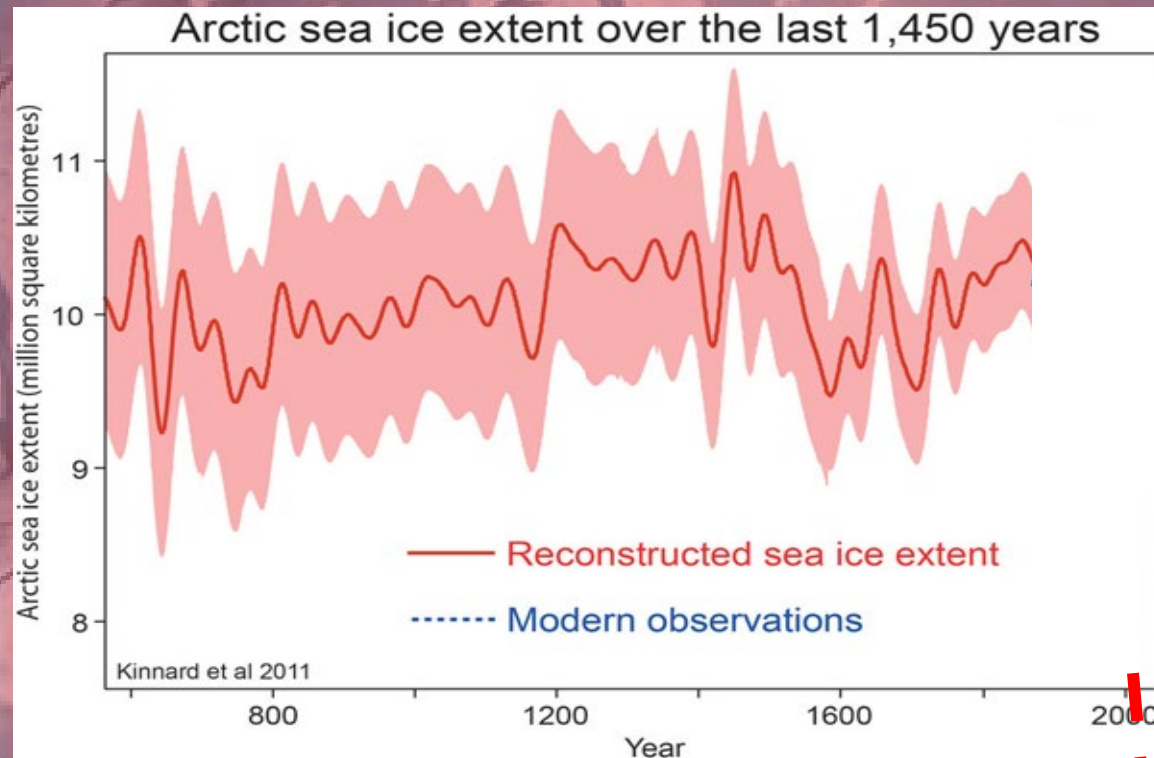


Borehole temperatures 20 meters deep



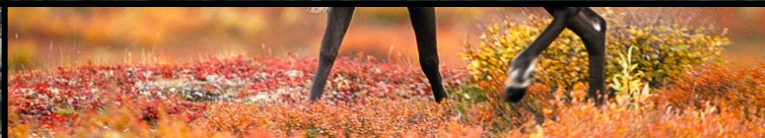
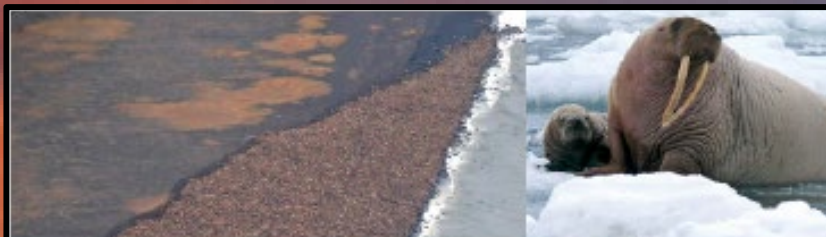
As permafrost thaws, it releases CO₂ and methane

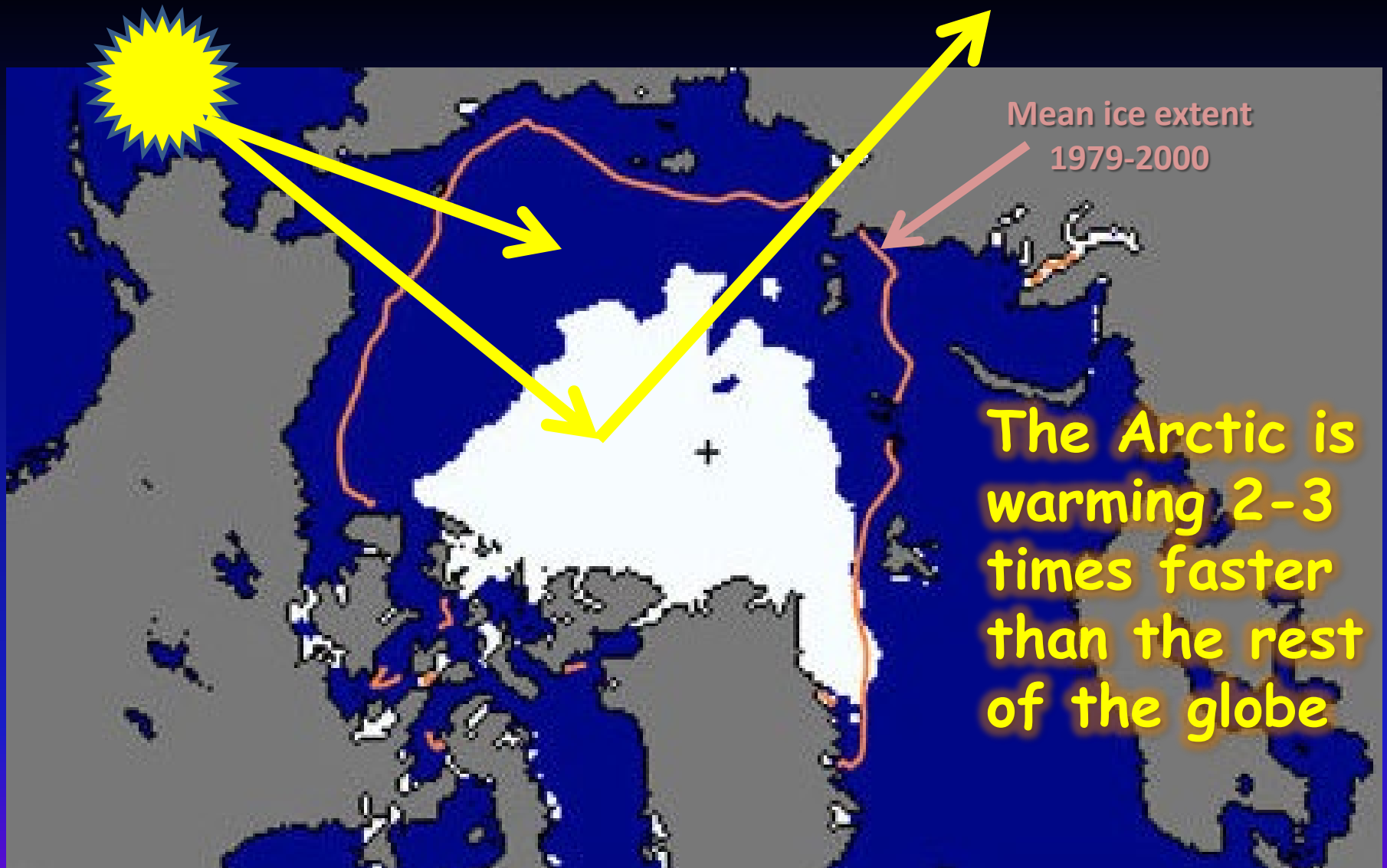
Arctic sea ice is disappearing...



NASA Ice Age
Animation

* 2013, 2014
* 2015
★ 2012

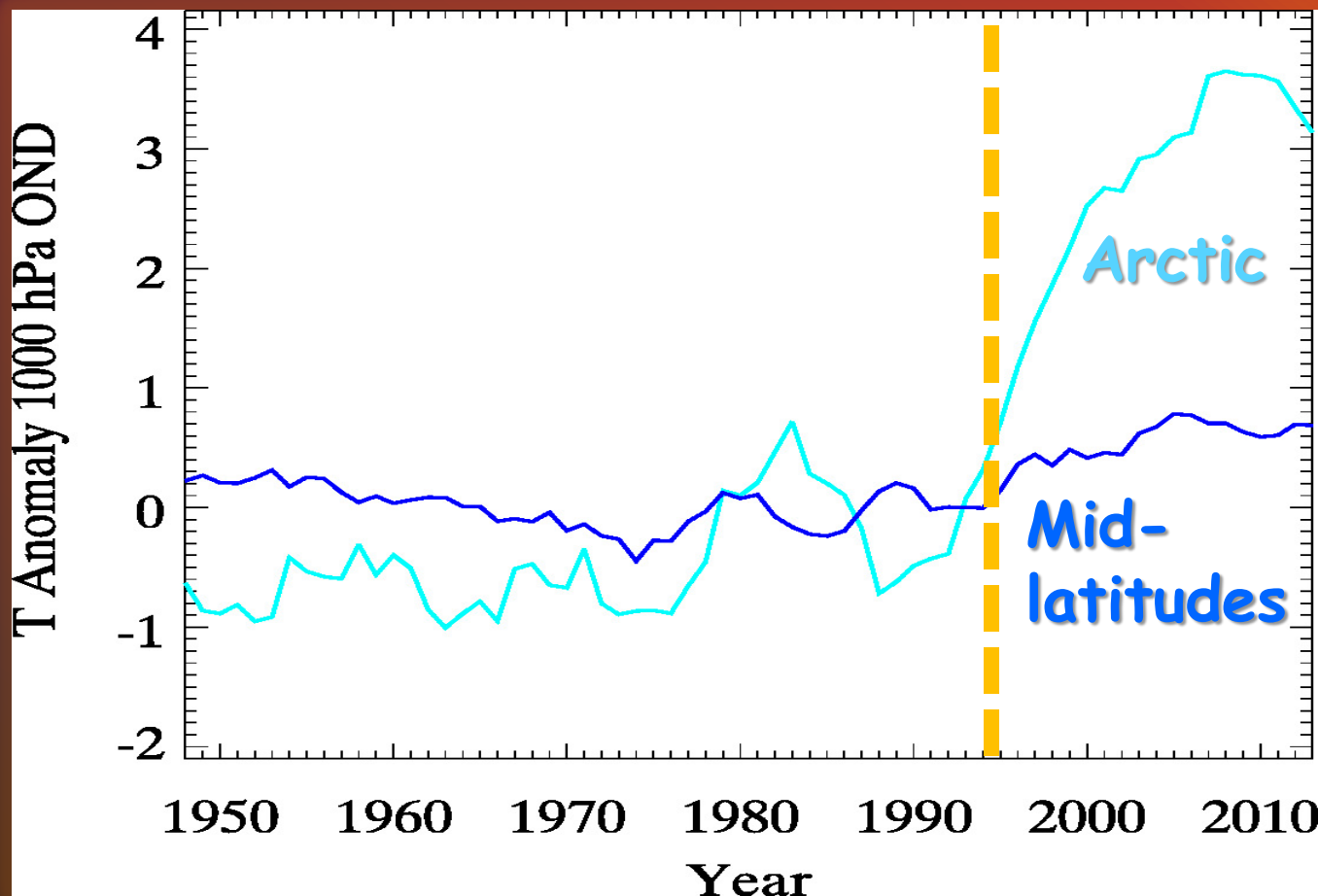




Ice extent September 2012

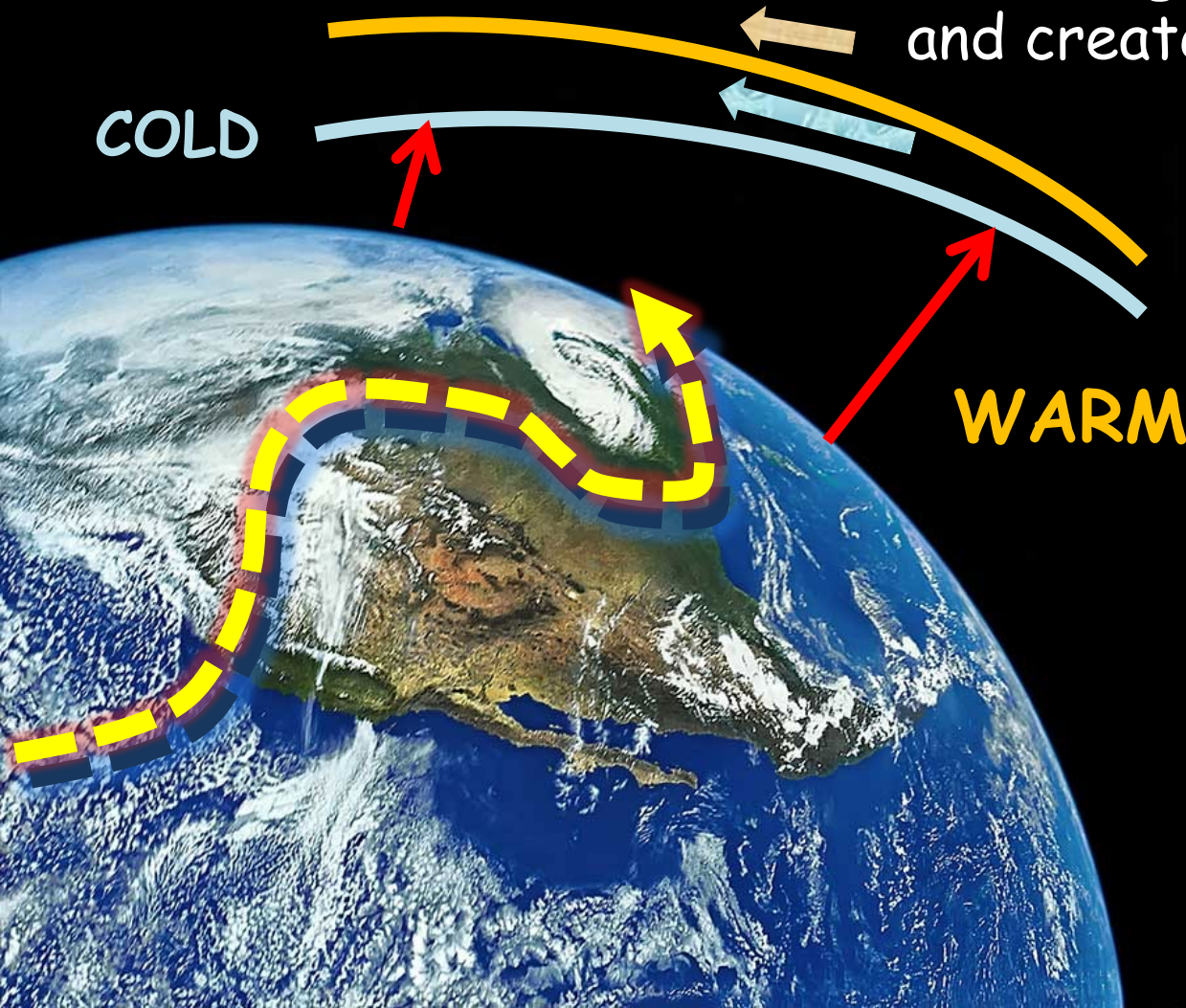
"Arctic Amplification"

Near-surface air temperature (Fall)



Because warm air expands, the layer will be thinner (warmer) than the Arctic (colder).

Air flows down this "hill", turns to the right as the Earth spins, and creates the Jet Stream



As the Arctic warms faster, the hill flattens, and the jet stream weakens.

A weaker jet is a wavier jet.



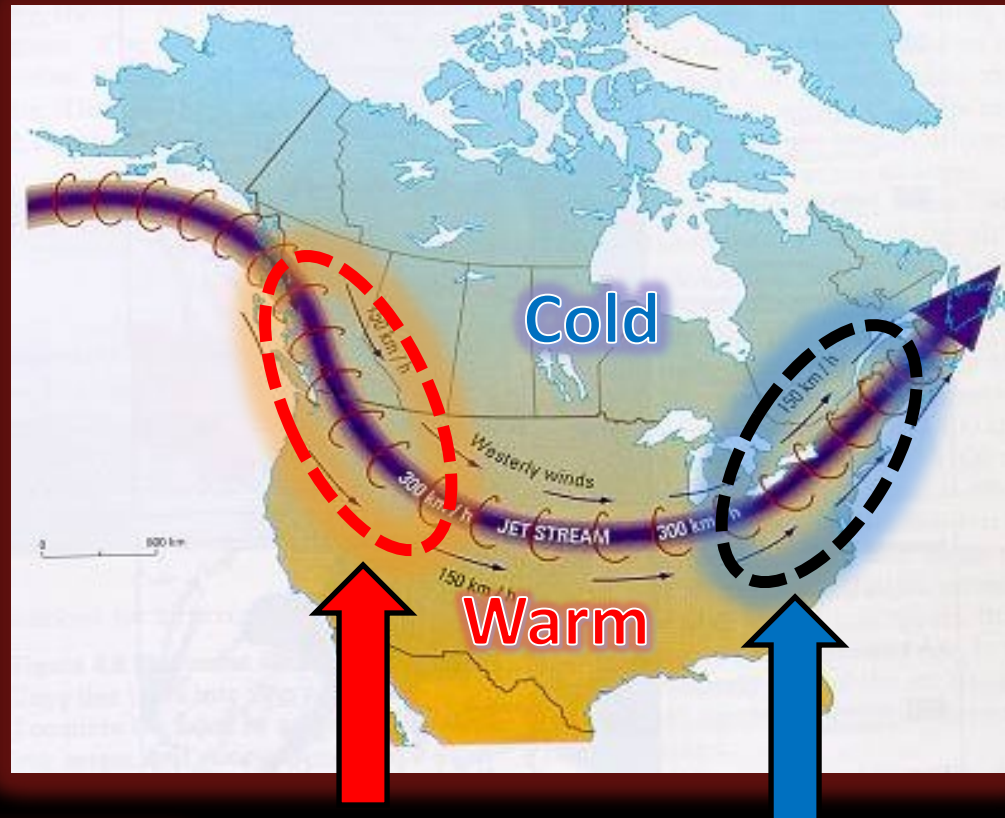
When the waves are small, they move eastward quickly.

When the waves are large, they shift eastward more slowly.



Why do we care about these waves?

The Jet Stream makes our weather

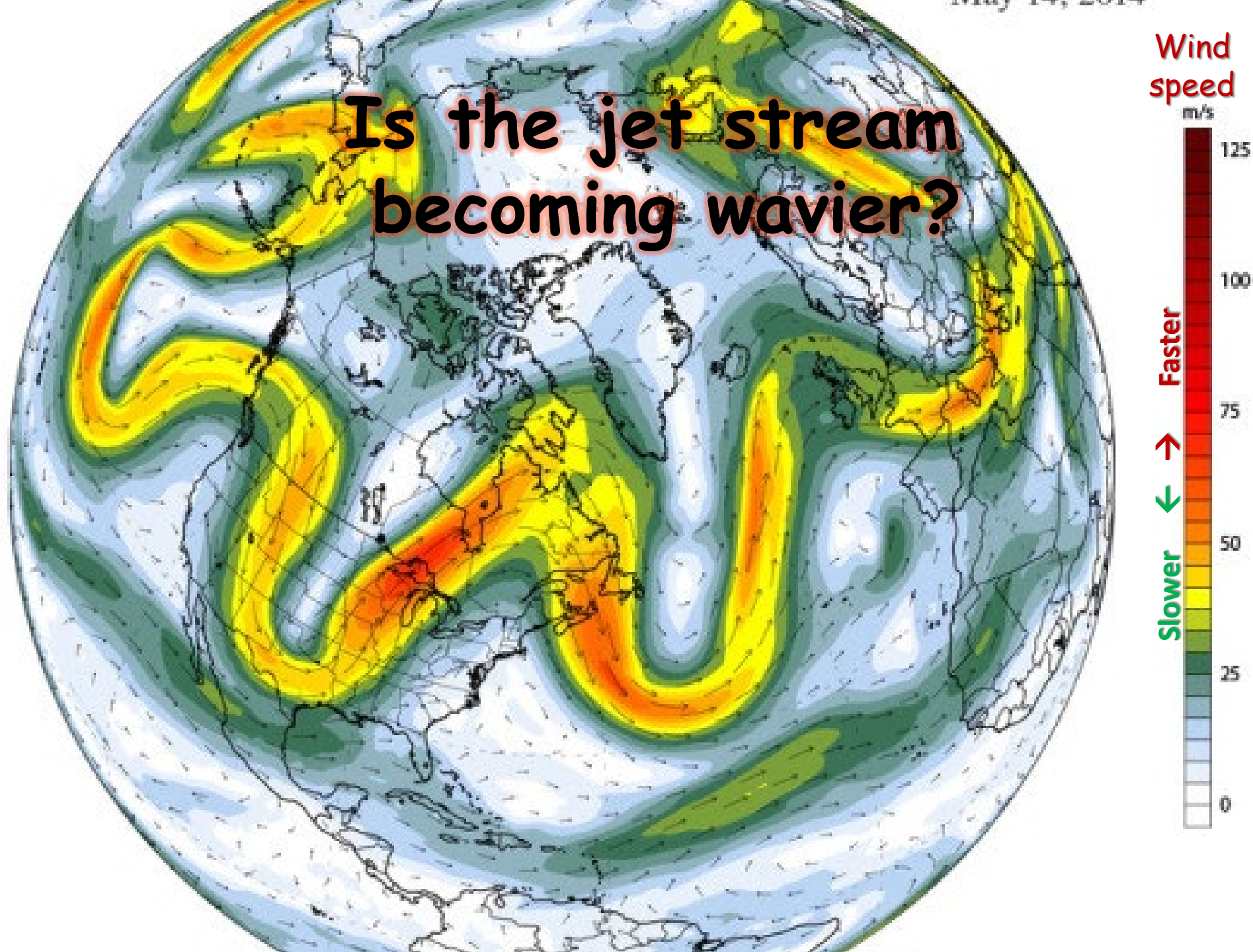


NASA Jet Stream

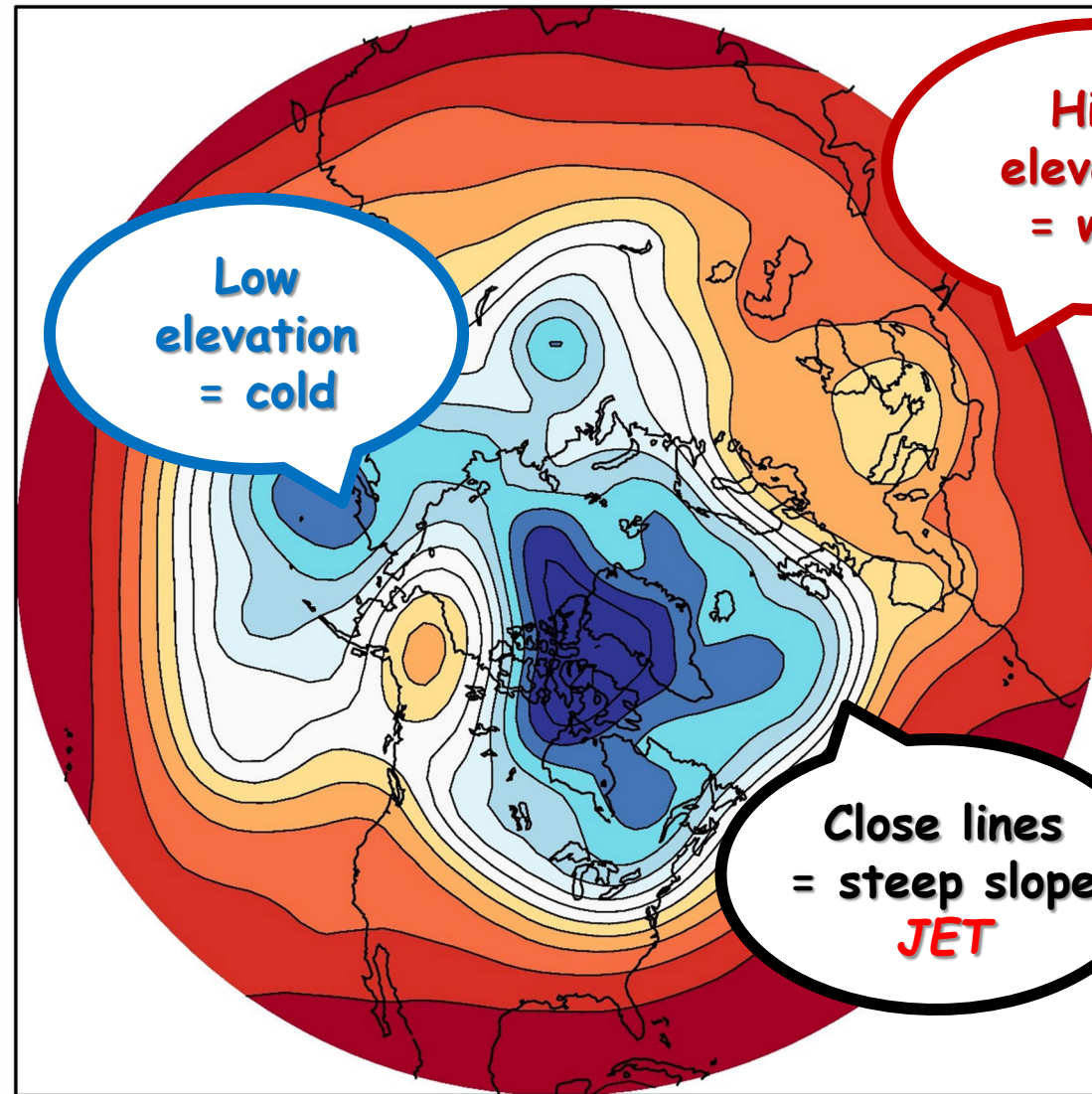
Dry and
settled

Wet and
stormy

Is the jet stream becoming wavier?



A "topographic map" of a layer in the atmosphere

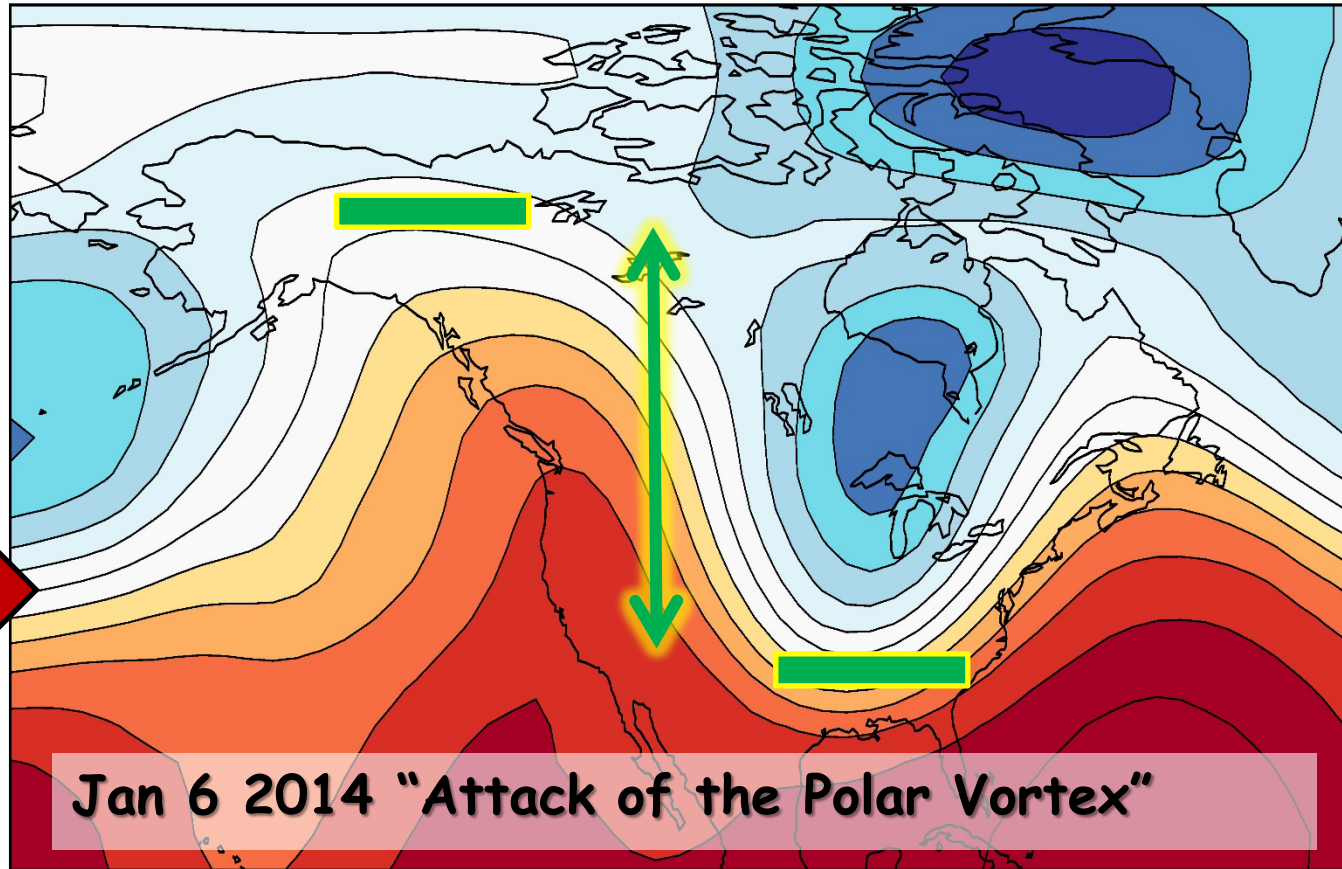


Low
elevation
= cold

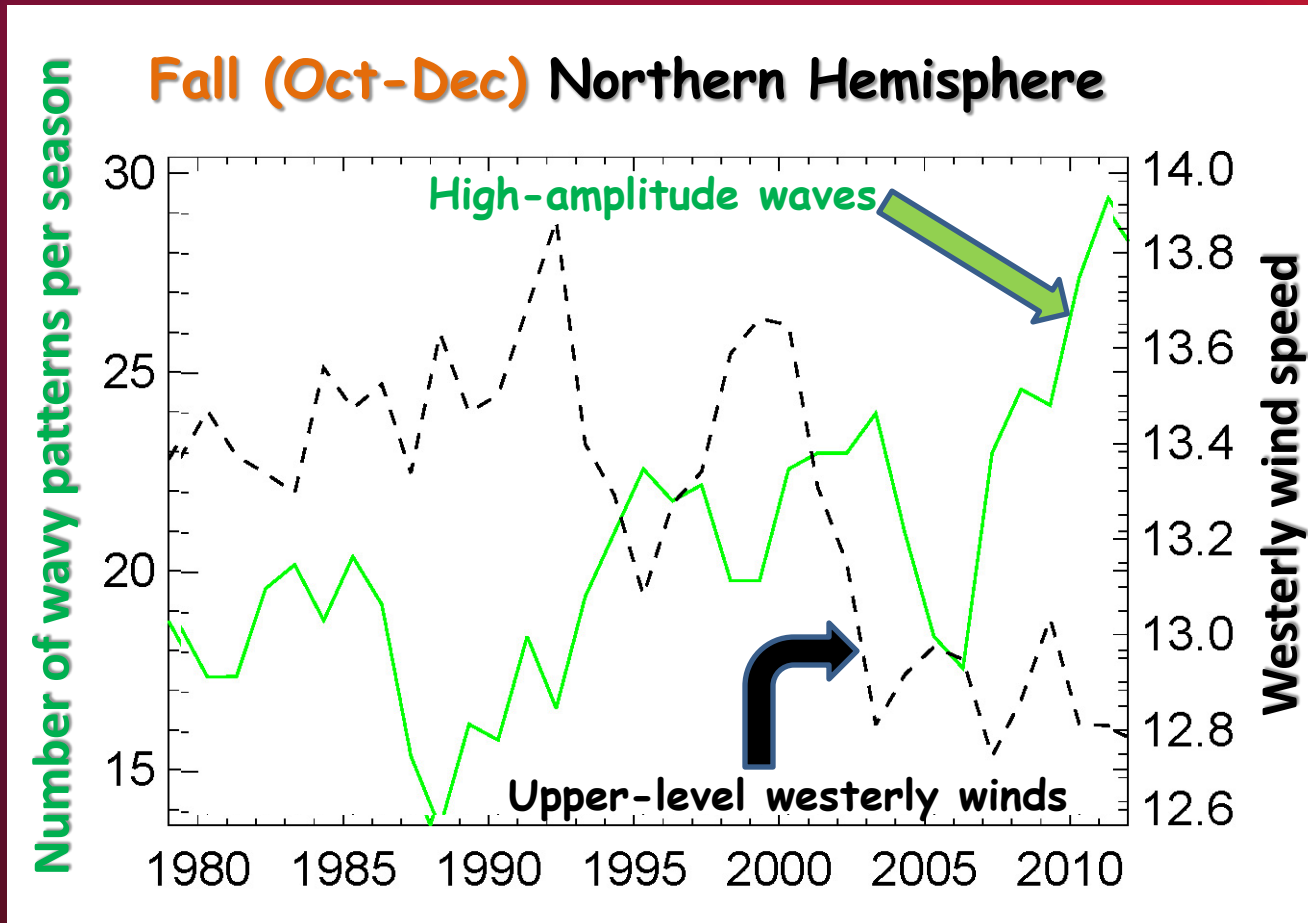
High
elevation
= warm

Close lines
= steep slope
JET

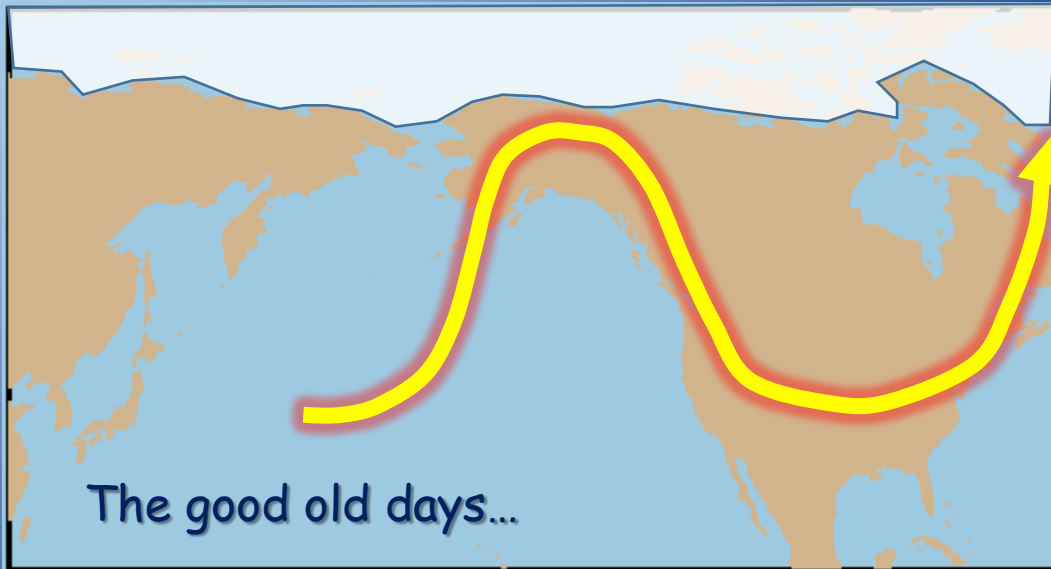
Count days with big waves



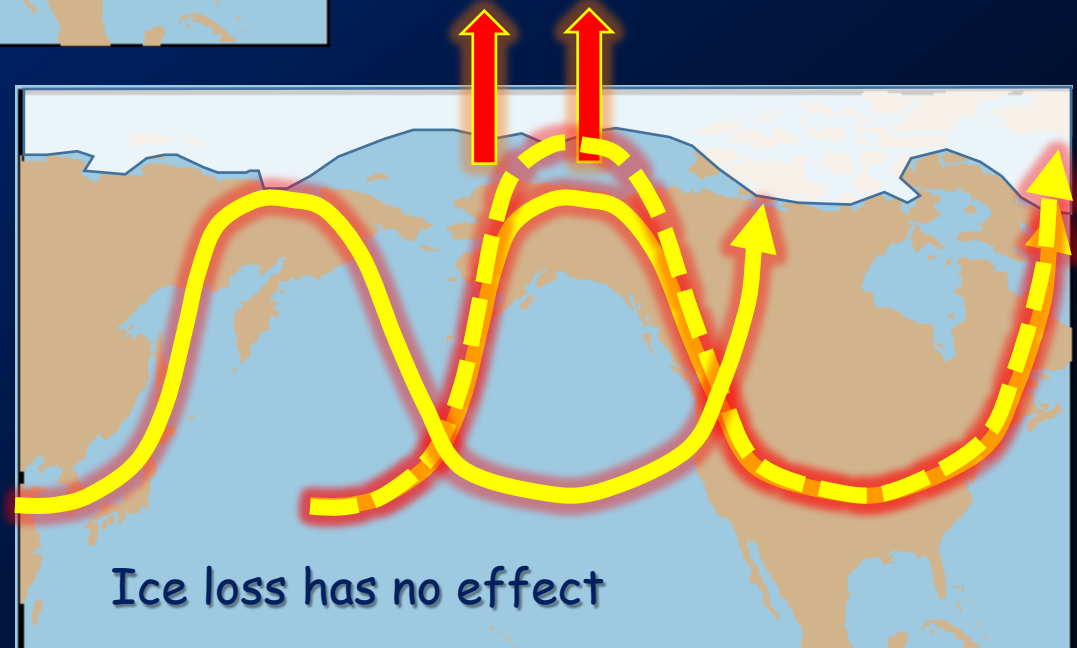
Are very wavy jet-stream patterns really happening more often?



The
"It Takes
Two to
Tango"
Hypothesis



Extra heating
elongates
wave, making
it more
persistent.

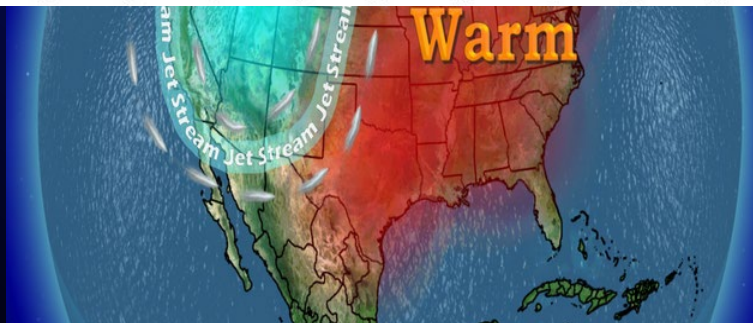
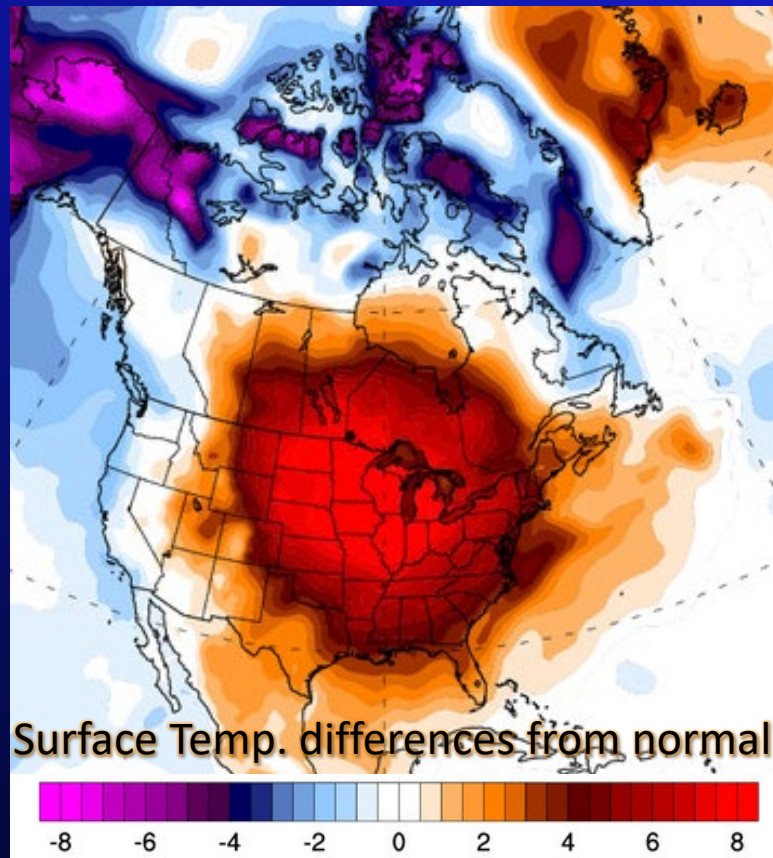




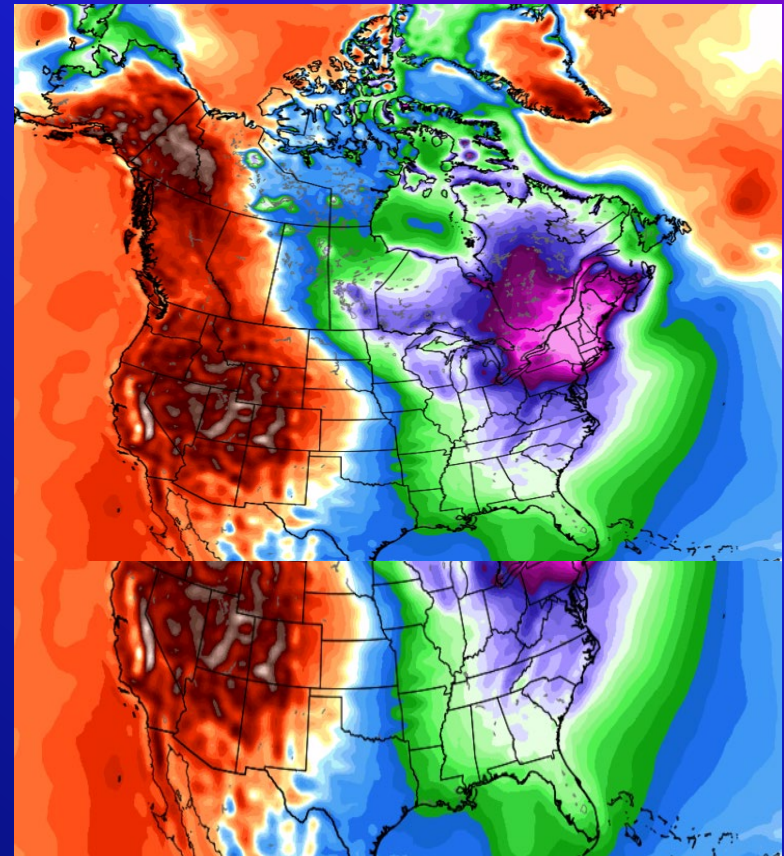
**Do recent extreme weather events
patterns fit this story?**

Boston – early February 2015

March 2012

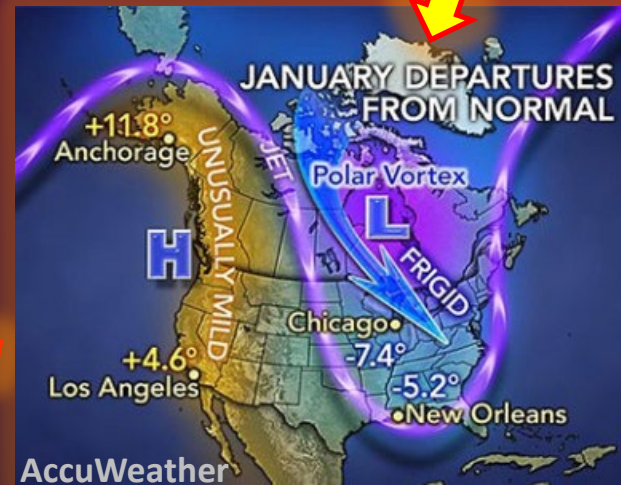
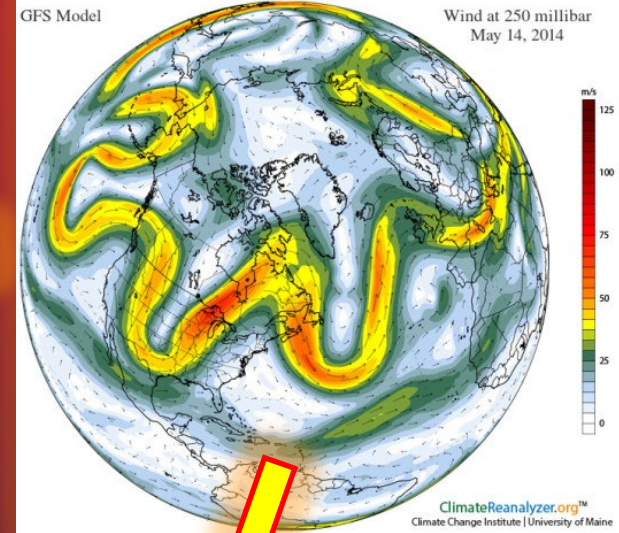
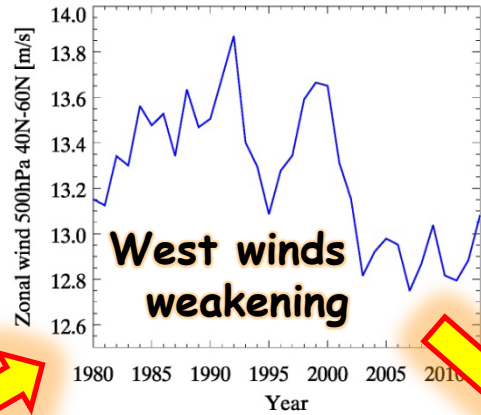
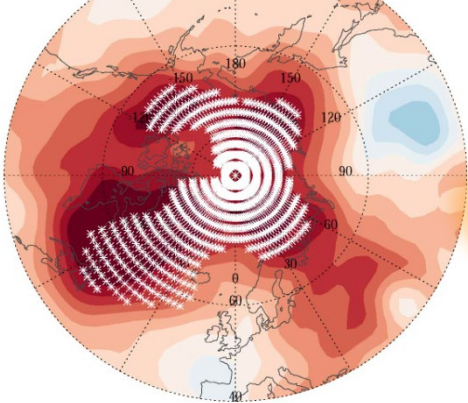


Feb. 1-14 2015

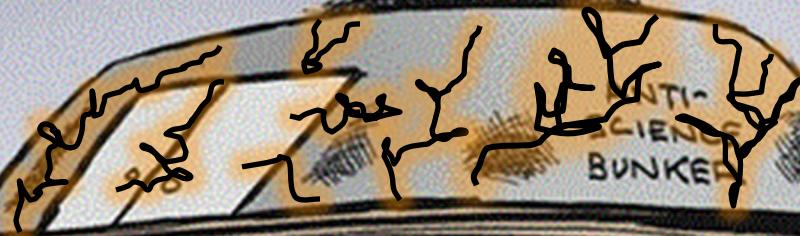


Summary

Arctic warming



EVIDENCE IS THAT
INCREASED EXTREME
WEATHER IS DUE
TO CLIMATE
CHANGE



ANTI-
SCIENCE
BUNKER

TES

UNIVERSAL UCLICA
4 © 2012 THE WASHINGTON POST

UNSAFE,
UNSOUND - 147

THANK-YOU !!

Extras

Oh, what a total bummer!

What can we DO??

LOTS!

Many small things add up to big differences...



Greenhouse gases

- => Conserve energy
- => Be efficient
- => Use/promote renewables



Every step you take,
Every move you make!

Consolidate
errands



FULL
Washing machine
Dishwasher

Tele-meeting?

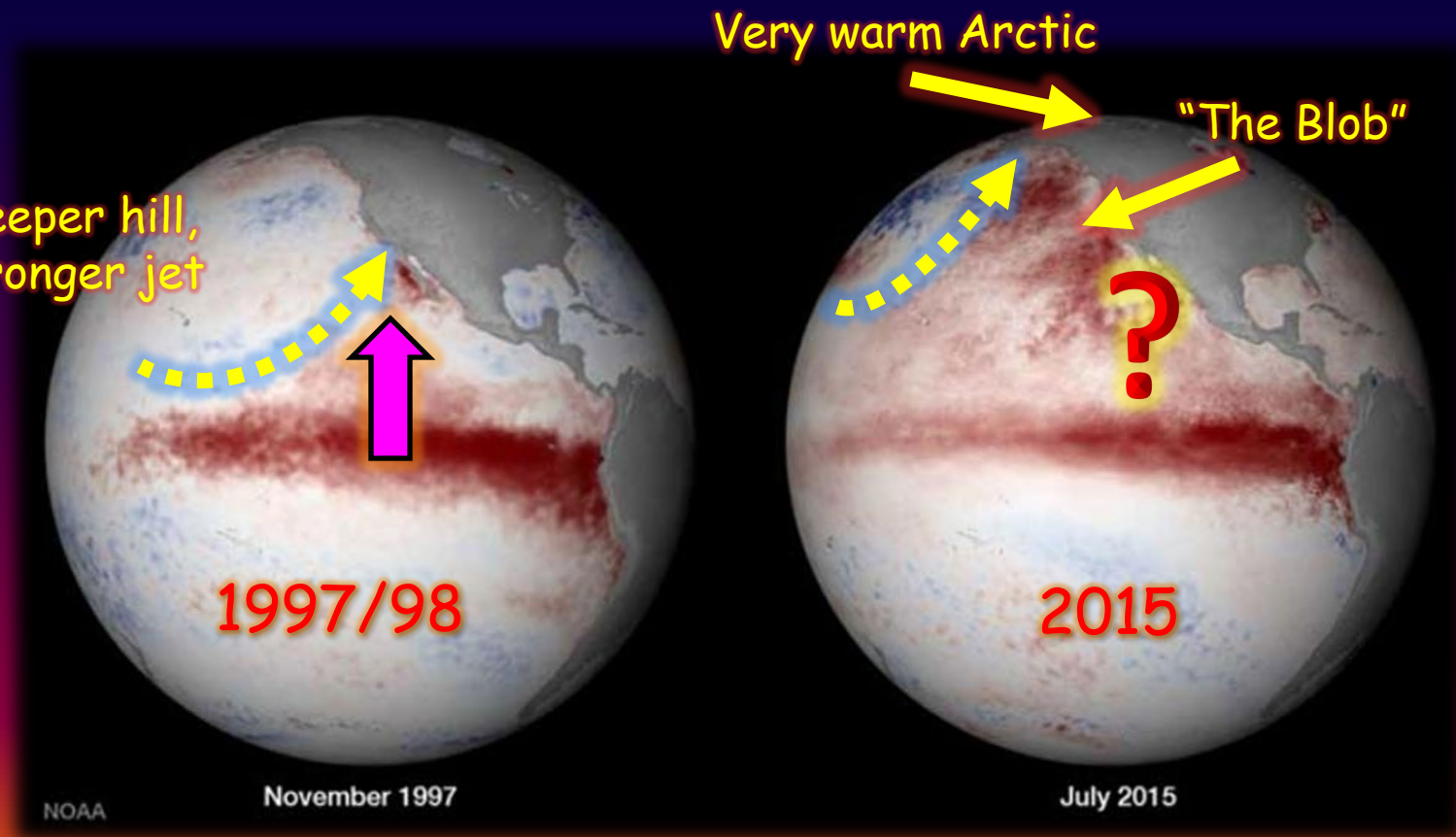
Done?
Turn it off!

VOTE !!

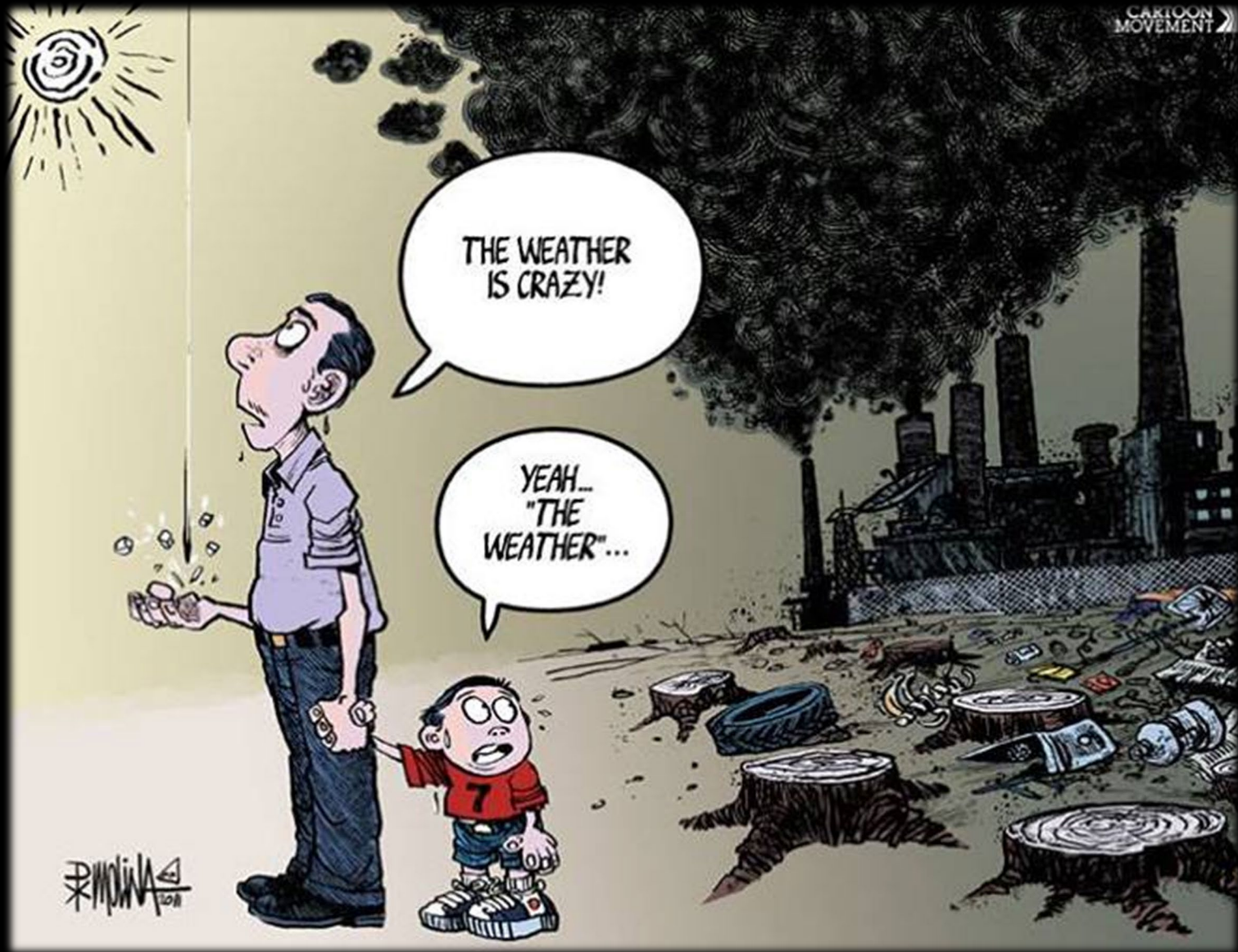
Bike/walk more,
Car less



How does all this relate to the big El Niño?



We are sailing in uncharted territory...
It will be an "interesting" winter!

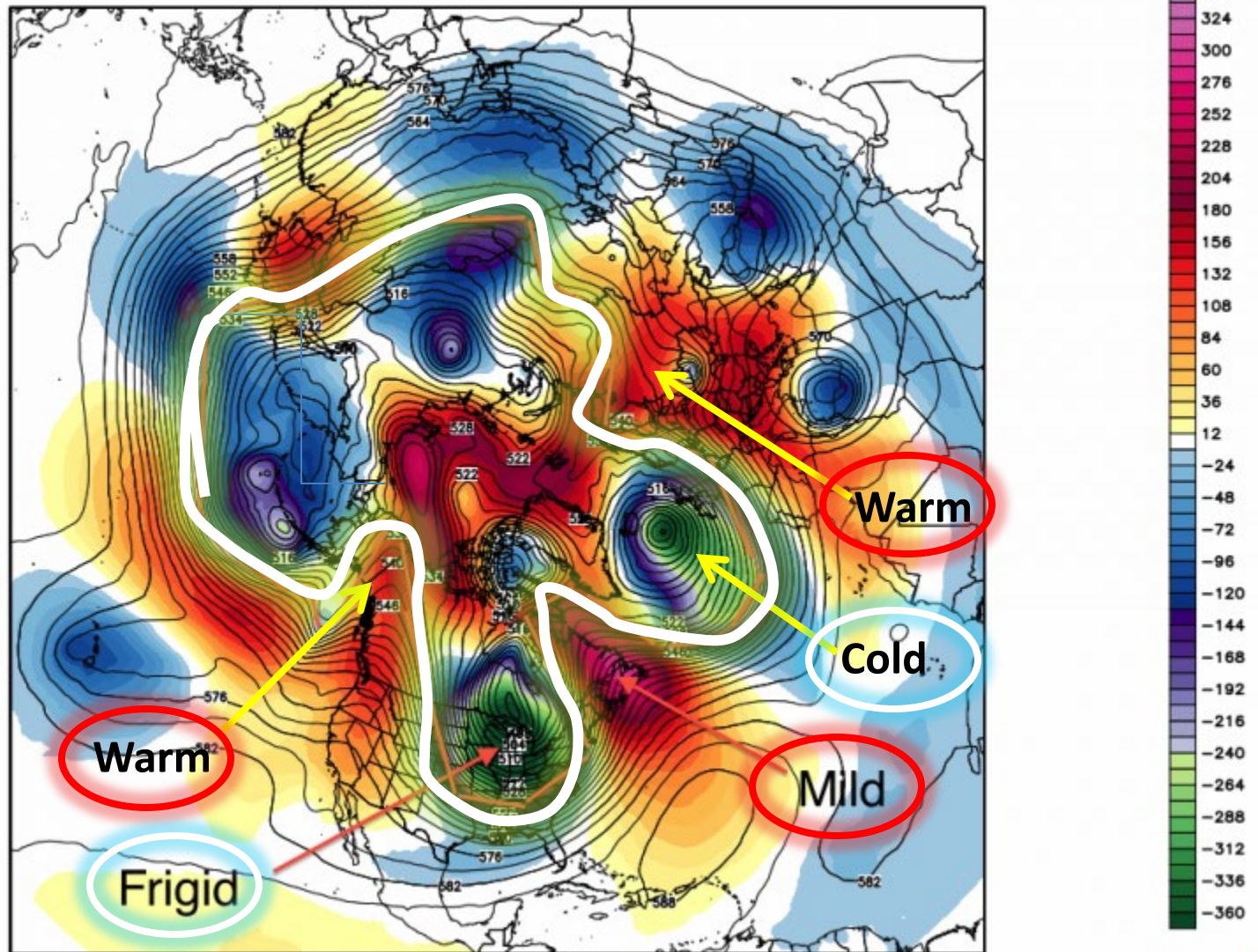


THANK-YOU !!

"Ridiculously Resistant Ridge/Trough:" Dec.'13-Feb.'14

ECMWF 500 hPa Geopotential Height [x10 gpm] & Anomaly [gpm]
INIT: 12Z02JAN2014 fx: [102] hr --> Mon 18Z06JAN2014

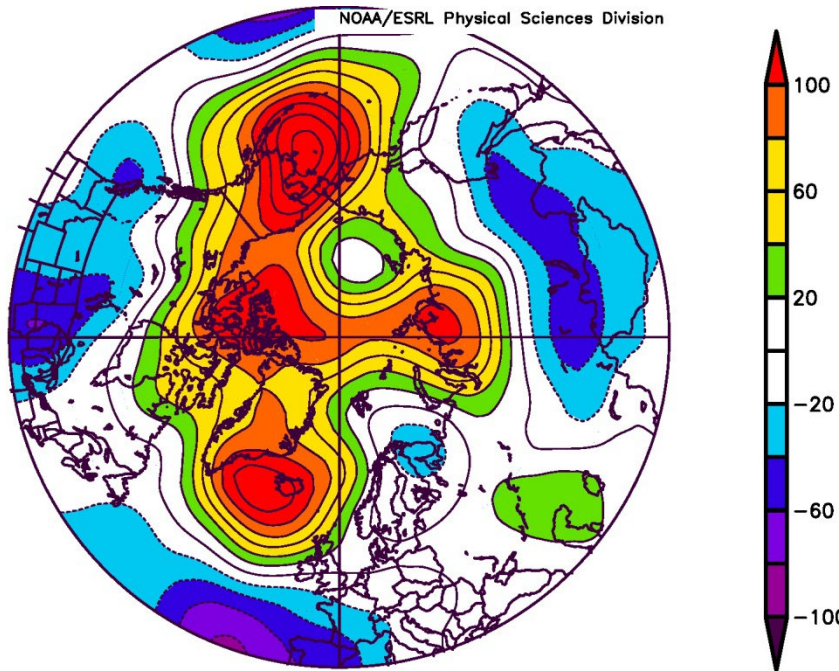
-413 : 293 gpm



Did Climate Change Contribute to Sandy?

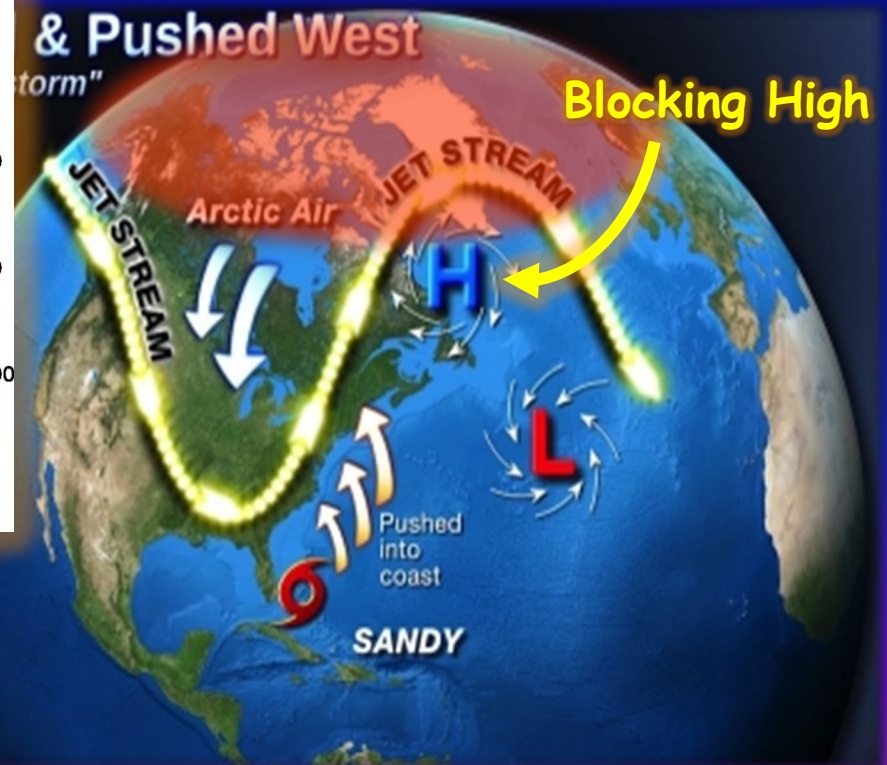
YES! – In At Least 5 Ways

The Arctic was MUCH warmer than normal



Was blocking high strengthened, extended northward, or prolonged by warm Arctic?

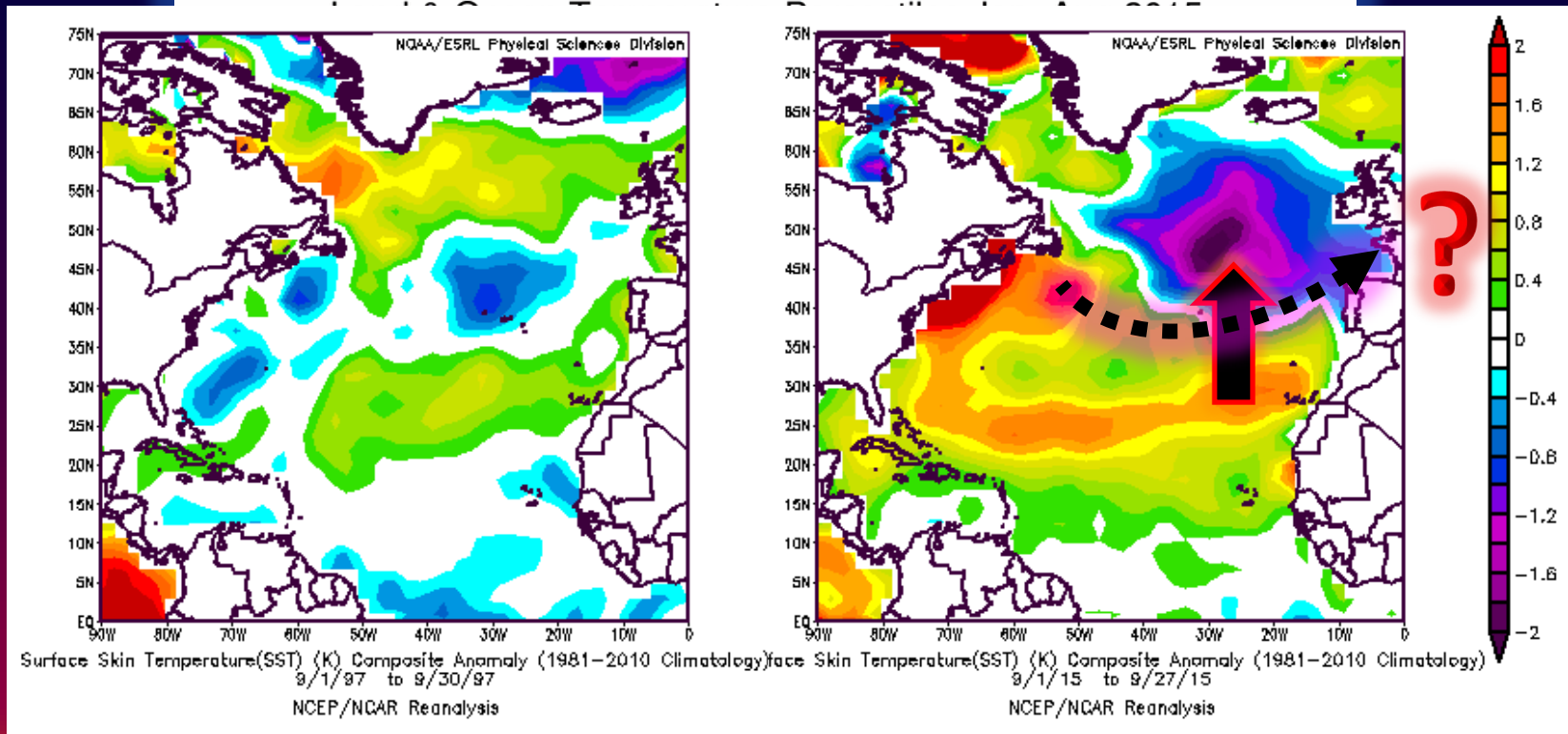
We think so.



But wait! What's going on in the Atlantic?

September 1997

September 2015



Record Coldest

Much Cooler than Average

Cooler than Average

Near Average

Warmer than Average

Much Warmer than Average

Record Warmest

We are sailing in uncharted territory...

It will be an "interesting" fall/winter!