Climate Change Through a Meteorological Perspective

Climate Change and Changing Weather

David Eichorn: Adjunct Assistant Professor
SUNY ESF dneichor@esf.edu

Arctic Warming Resulting in Mid-Latitude Weather Extremes

1) Warming in the Arctic

2) Relate the Arctic Warmth to Climate and Weather in Mid Latitudes

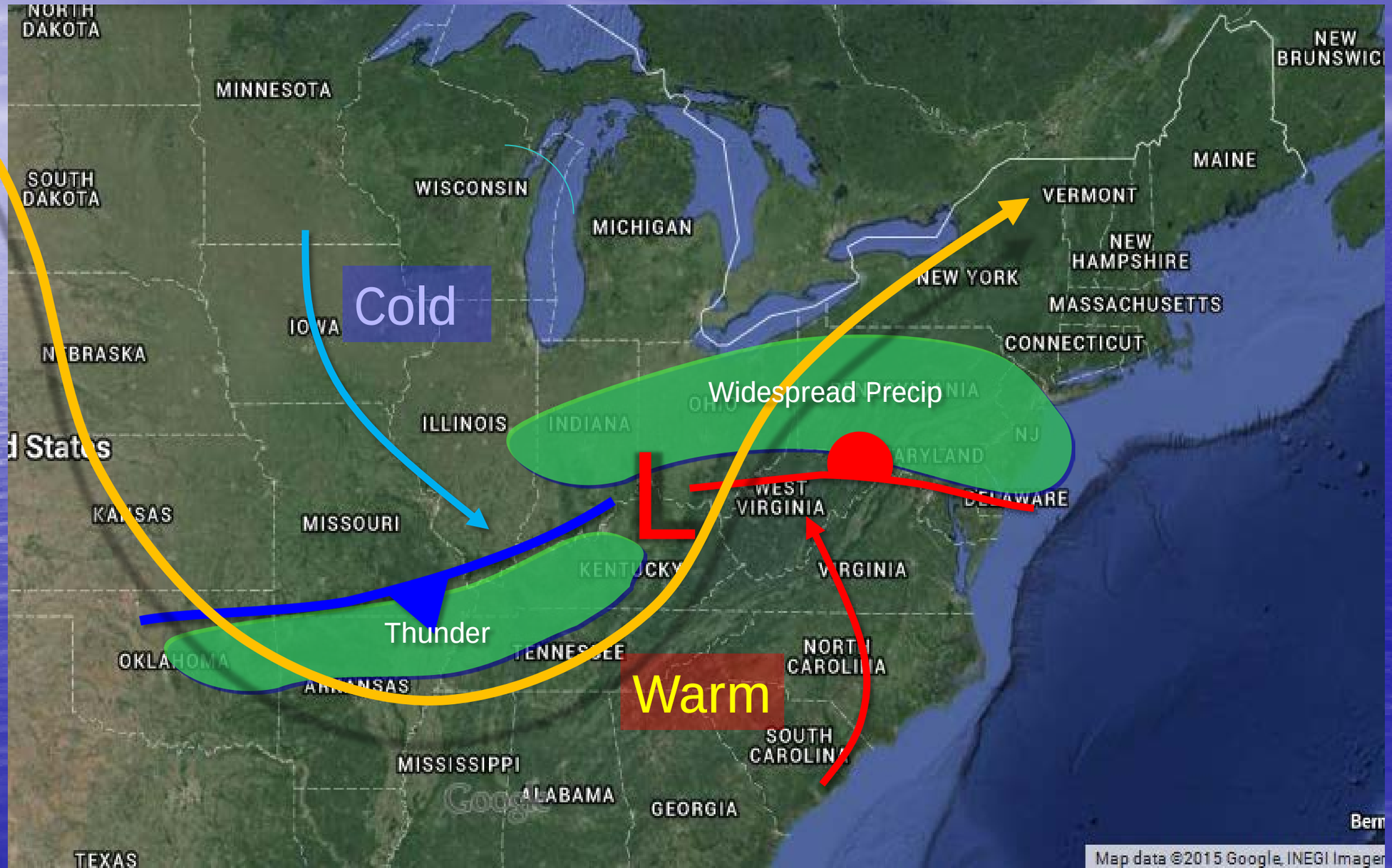
3) Some NE U.S. Regional and Local Impacts and Projections:

Part One

The connection between high altitude winds and mid latitude weather

Jet Stream winds aloft (40,000 feet up) generally reside above weather fronts down at the earth’s surface.

The Jet Stream (in yellow) steers storm systems (low pressure systems)



Part Two: The Arctic

A warmer Arctic, forces changes in the Jet Stream. We know that!

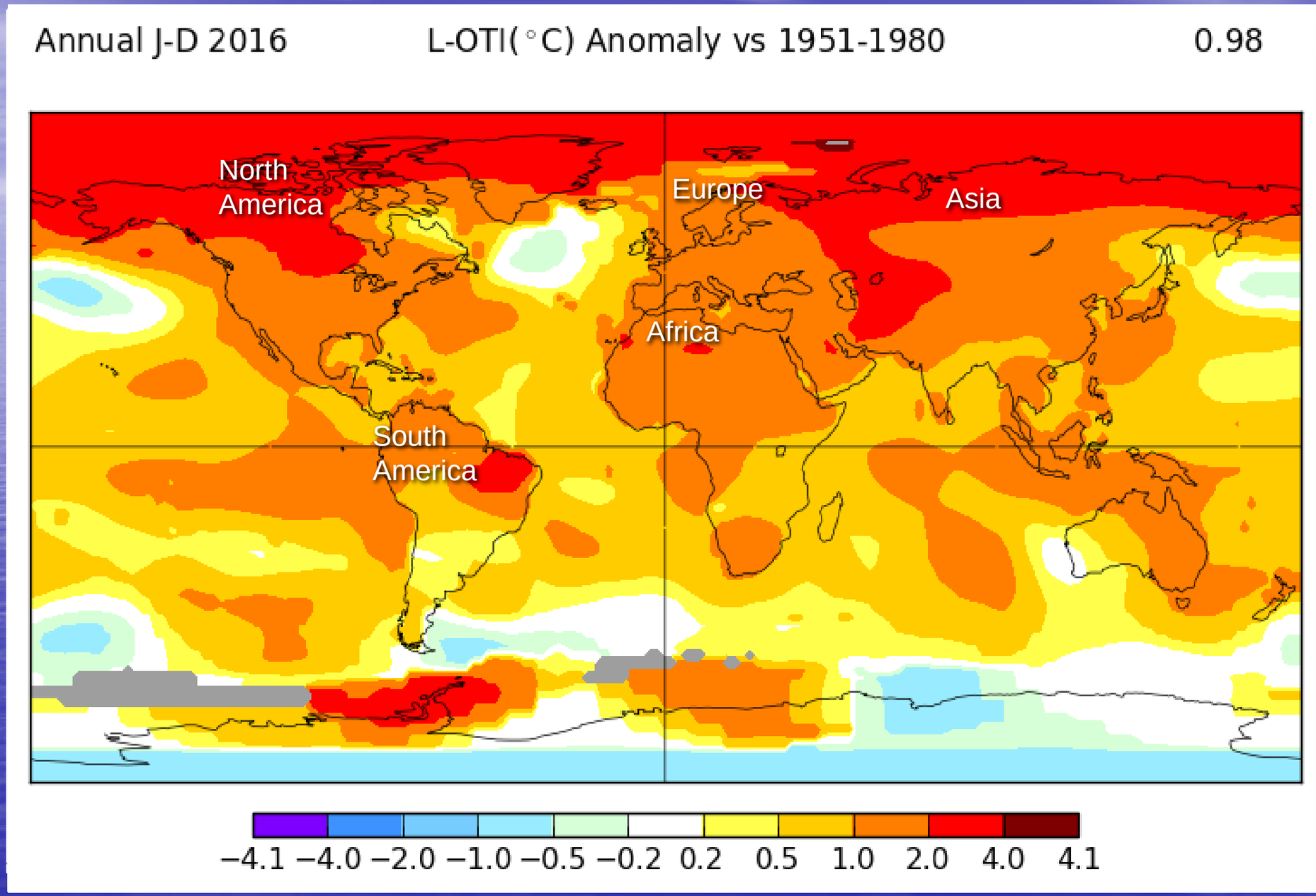
This affects mid-latitude weather, the big question/debate is…

How and Where?

Part Two cont…

Let’s start with the Arctic

Surface Temperature Anomaly



Data: NASA GISS

McCarty Fjords, Kenai Fjords National Park, Alaska.
McCarty Glacier July 30, 1909

National Snow and Ice Data Center/World Data Center for Glaciology, Boulder

McCarty Fjords, Kenai Fjords National Park, Alaska.
Aug 11, 2004

National Snow and Ice Data Center/World Data Center for Glaciology, Boulder

1941 by W.O. Field on White Thunder Ridge, Muir Inlet,
Glacier Bay National Park and Preserve, Alaska.

National Snow and Ice Data Center/World Data Center for Glaciology, Boulder

Muir Inlet, Glacier Bay National Park and Preserve, Alaska.
August 31, 2004

National Snow and Ice Data Center/World Data Center for Glaciology, Boulder

Reason's for the Arctic Warming:
There are many:

1: Changes in winds from the mid latitudes to the Poles
(Changes in Atmospheric, and Oceanic Circulation)

2: Increased CO2 and other GHGs

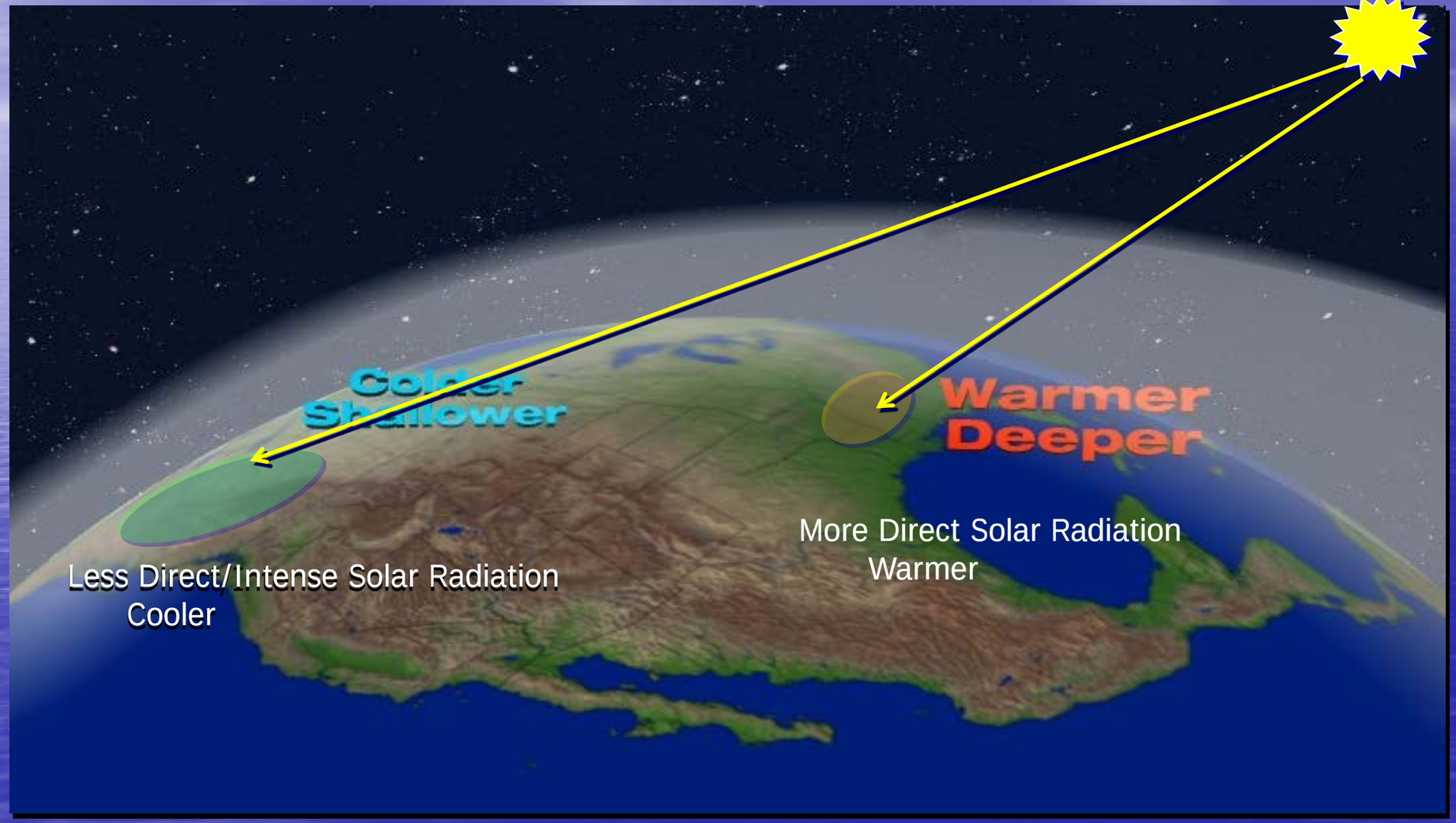
3: Changes in the stratospheric winds

4: Increased air Pollution, Cloud cover, Humidity

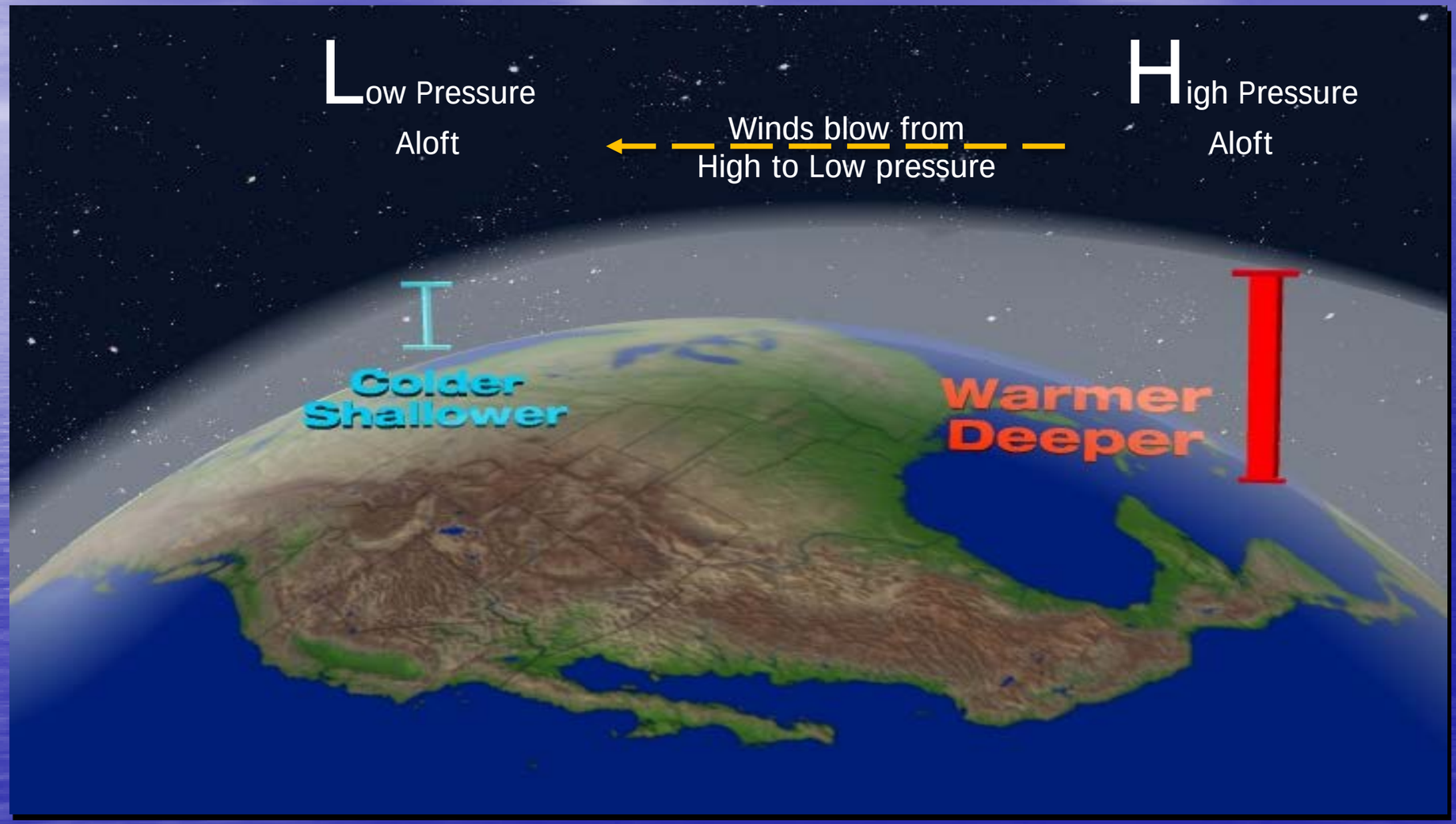
....And More: http://www.arctic.noaa.gov/reportcard/

How Does Arctic Warming affect high altitude winds over the mid-latitudes?

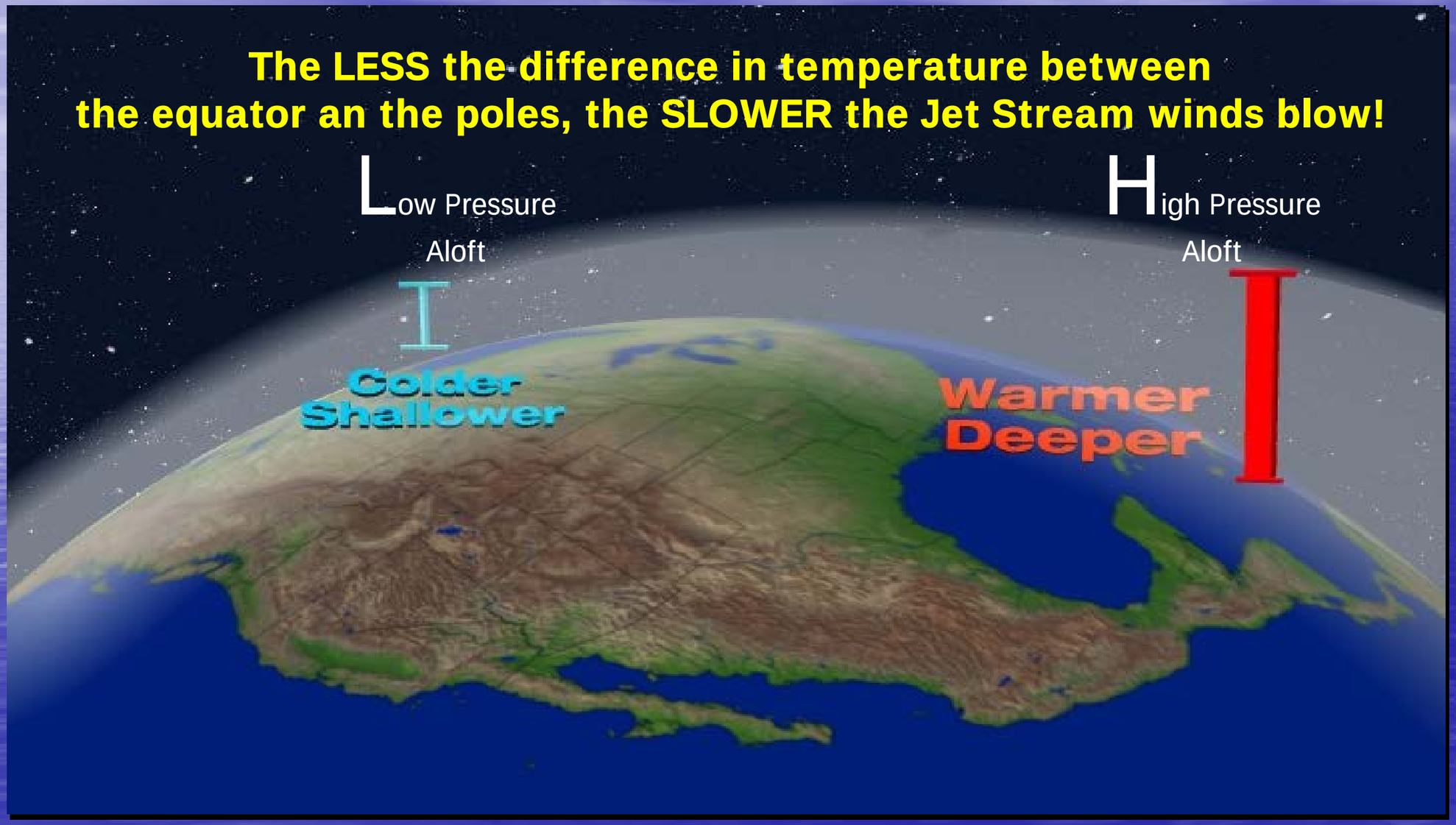
Angle of Incoming Solar Radiation



Tropospheric Depth Changes With Latitude



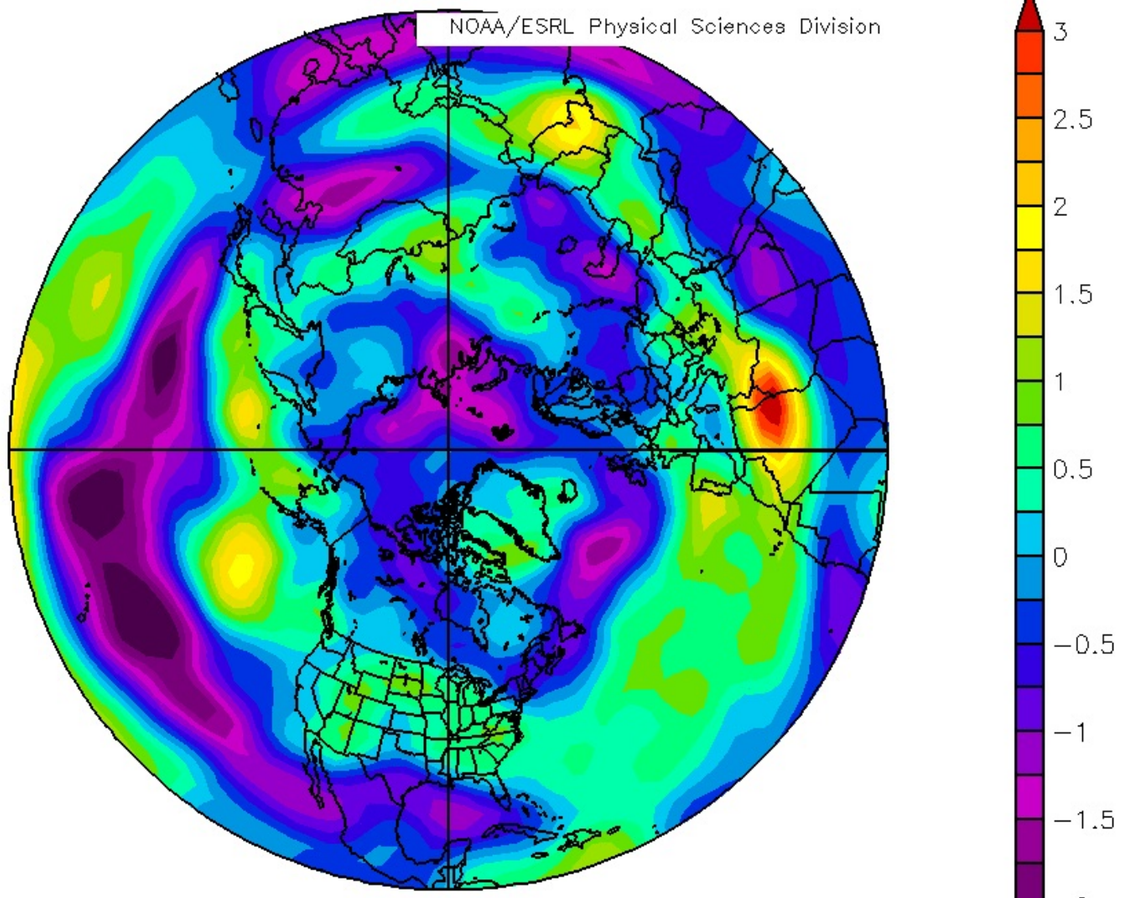
A warmer Arctic, weakens high Altitude winds



A Warmer Arctic
Weakens High Altitude Winds

It Must! And it is…

Annual Average Jet Stream Wind Changes from the last 20 years



Winds aloft are generally slowing down.

Over the mid-latitudes though they are actually increasing

(We'll get to that in a minute)

Slower Winds Aloft

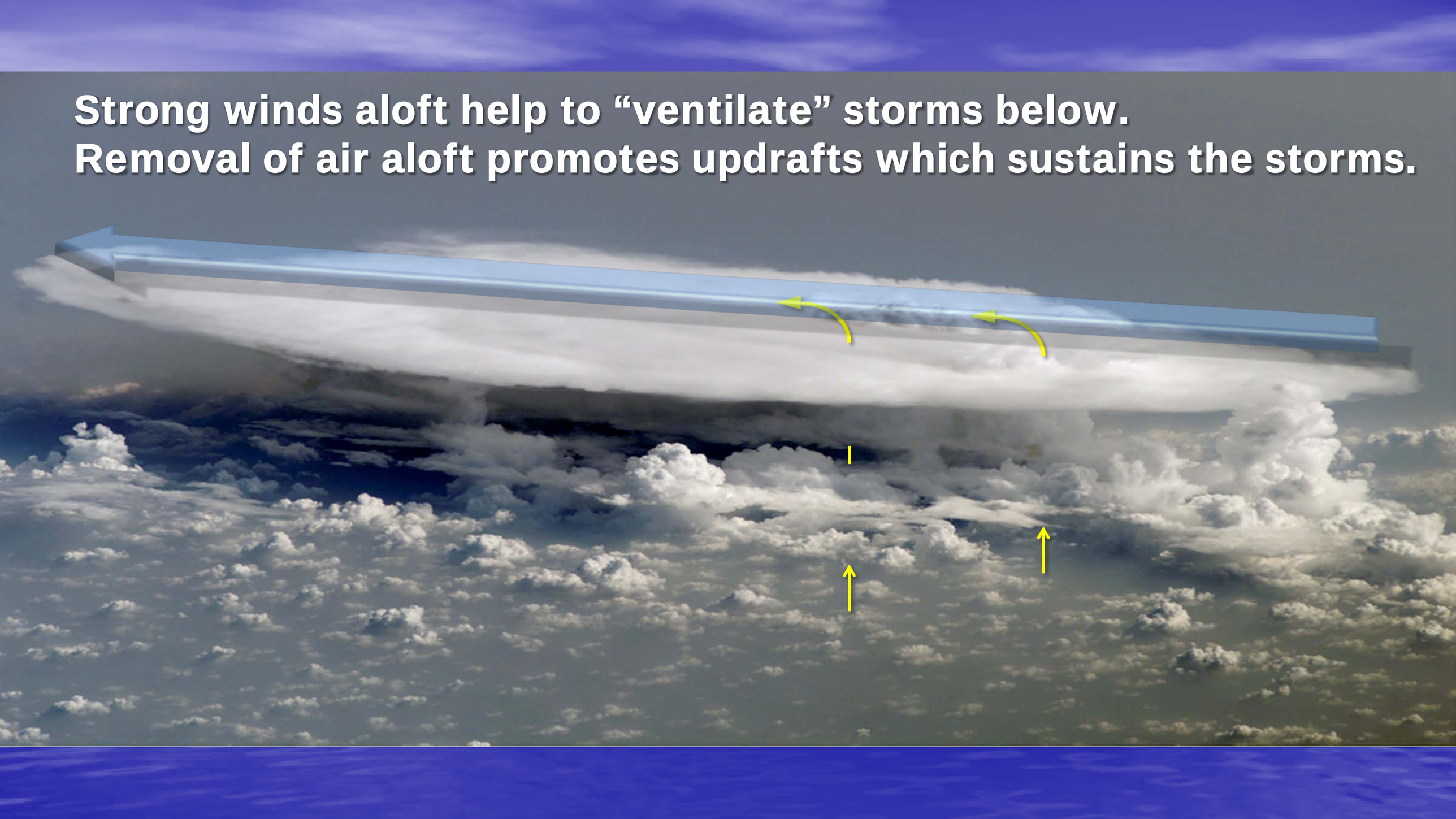
1) Weather systems slow down.

2) Weather systems weaken

Mid latitude Thunderstorms depend on Strong winds aloft.

Thunderstorm with it’s classic flat anvil top (Taken from Nasa Space Shuttle)

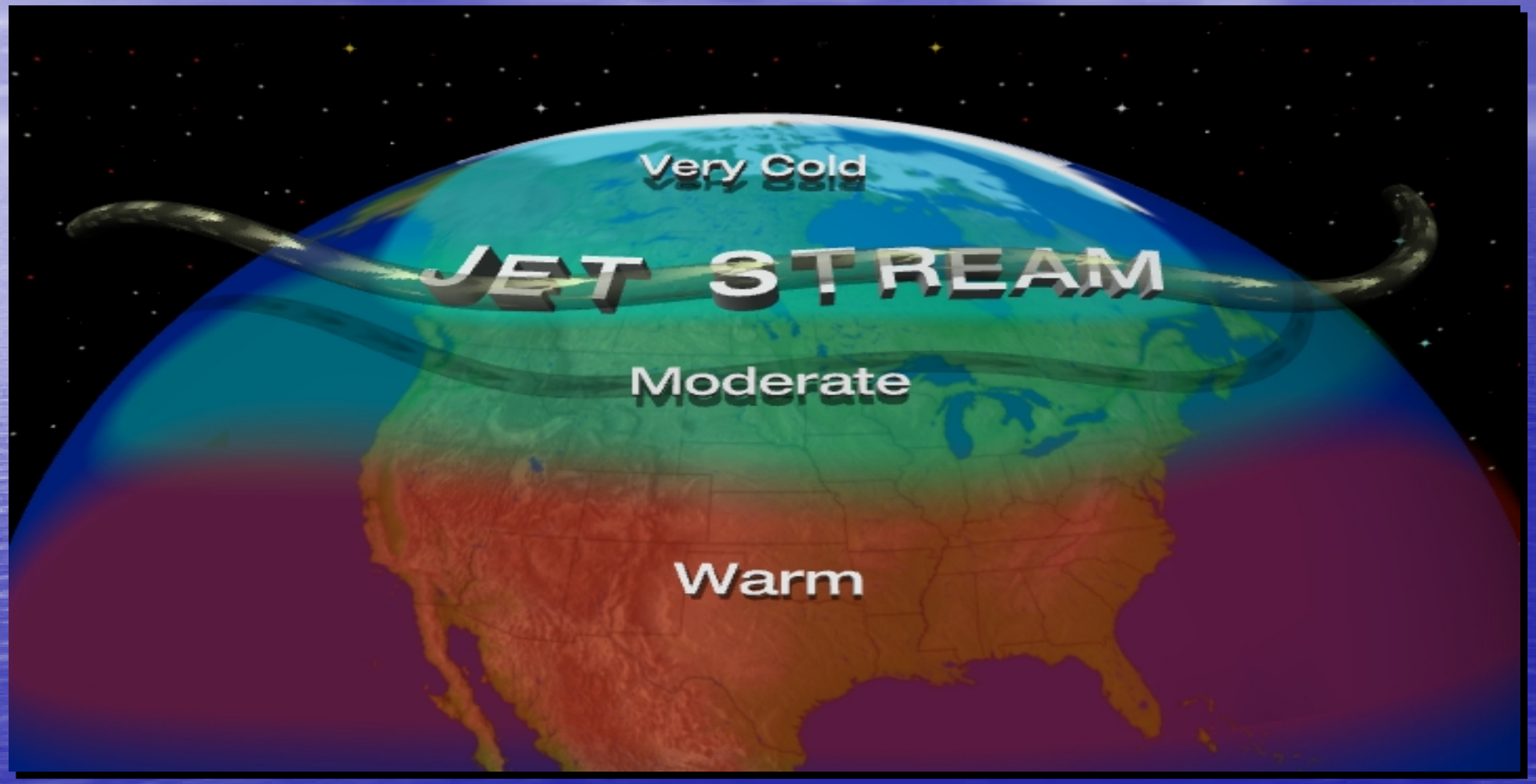
Strong winds aloft help to “ventilate” storms below.
Removal of air aloft promotes updrafts which sustains the storms.



Also: During Arctic Warm Periods,

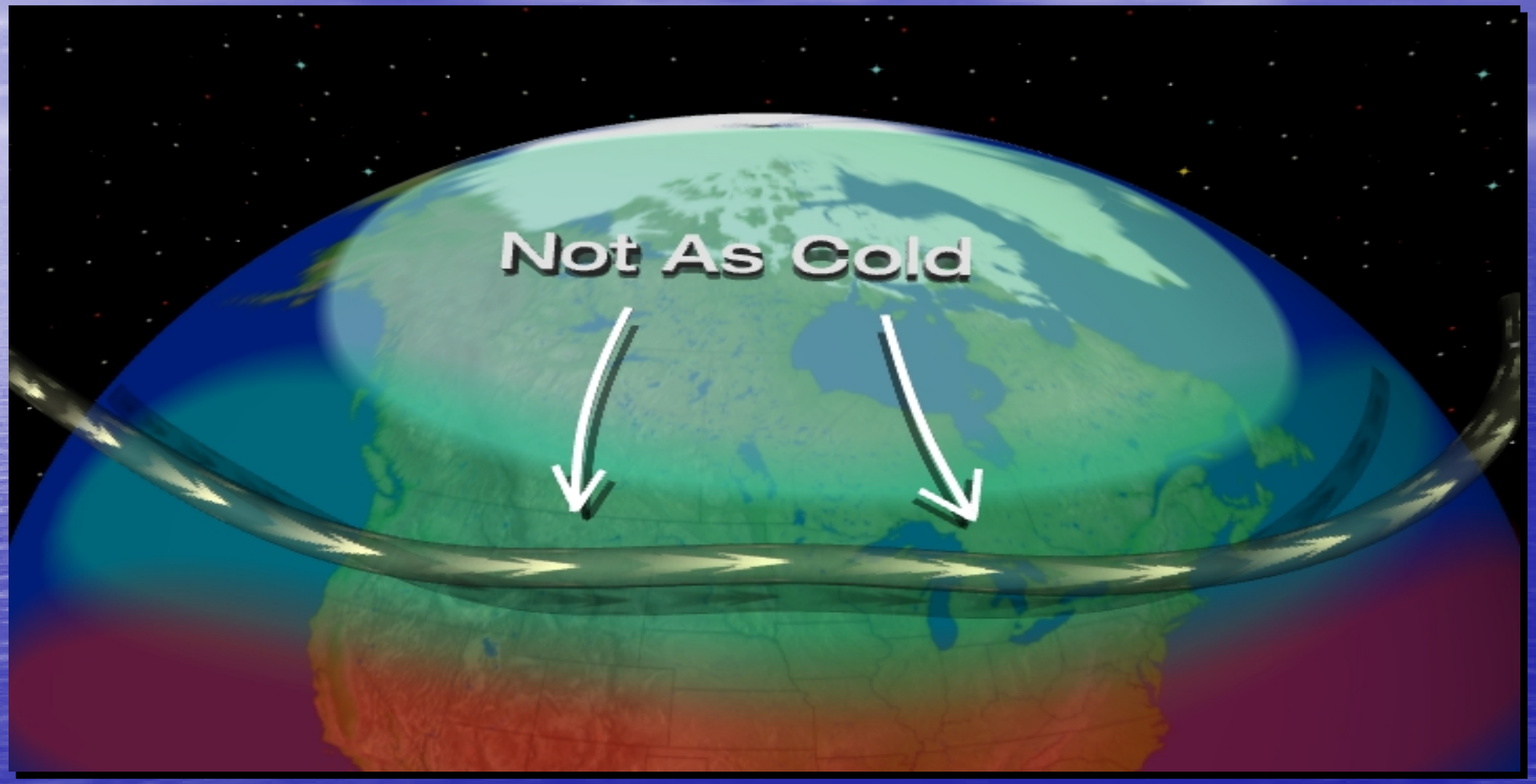
Jet stream winds shift south

Differential Heating between the equator and the poles drives the westerlies aloft.



Now consider a scenario where the air at the poles isn't so cold anymore.

For one thing, the stronger westerlies shift south (They are fitting to better temperature contrast)



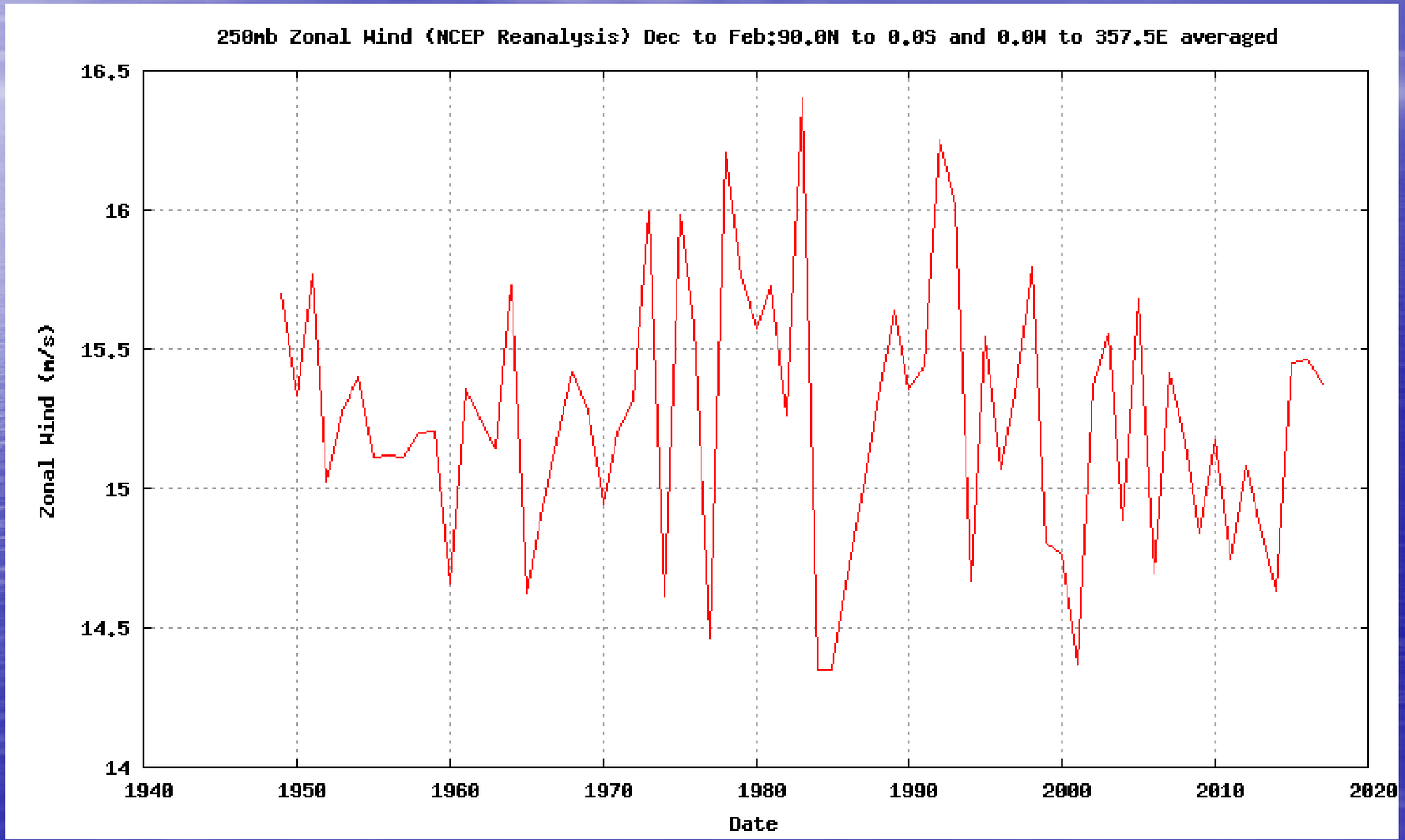
This explains the increase in Jet stream winds in the Mid-latitudes

But there is more going on as so far, everything we are seeing shows changes expressed in averages.

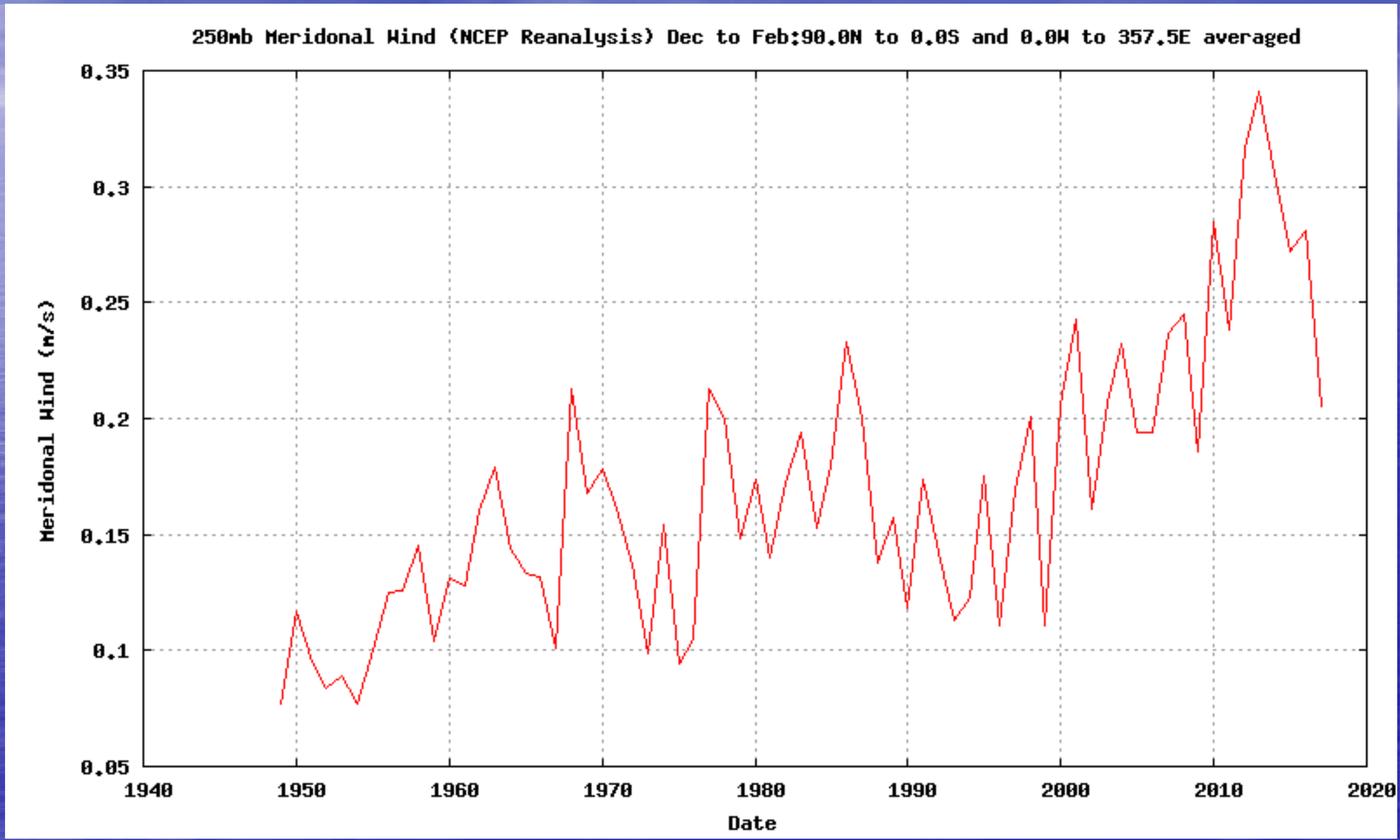
The devil is in the details:

For example, north and south trajectories In high altitude winds are increasing…or perhaps better said, becoming more persistent.

The West to East Component of High Altitude Winds (U) (Northern Hemisphere Winter) Decreasing



The Northward and Southward Component of High Altitude Winds (V) (Northern Hemisphere Winter)



U.S. Department of Commerce | National Oceanic and Atmospheric Administration
Earth System Research Laboratory https://www.esrl.noaa.gov/

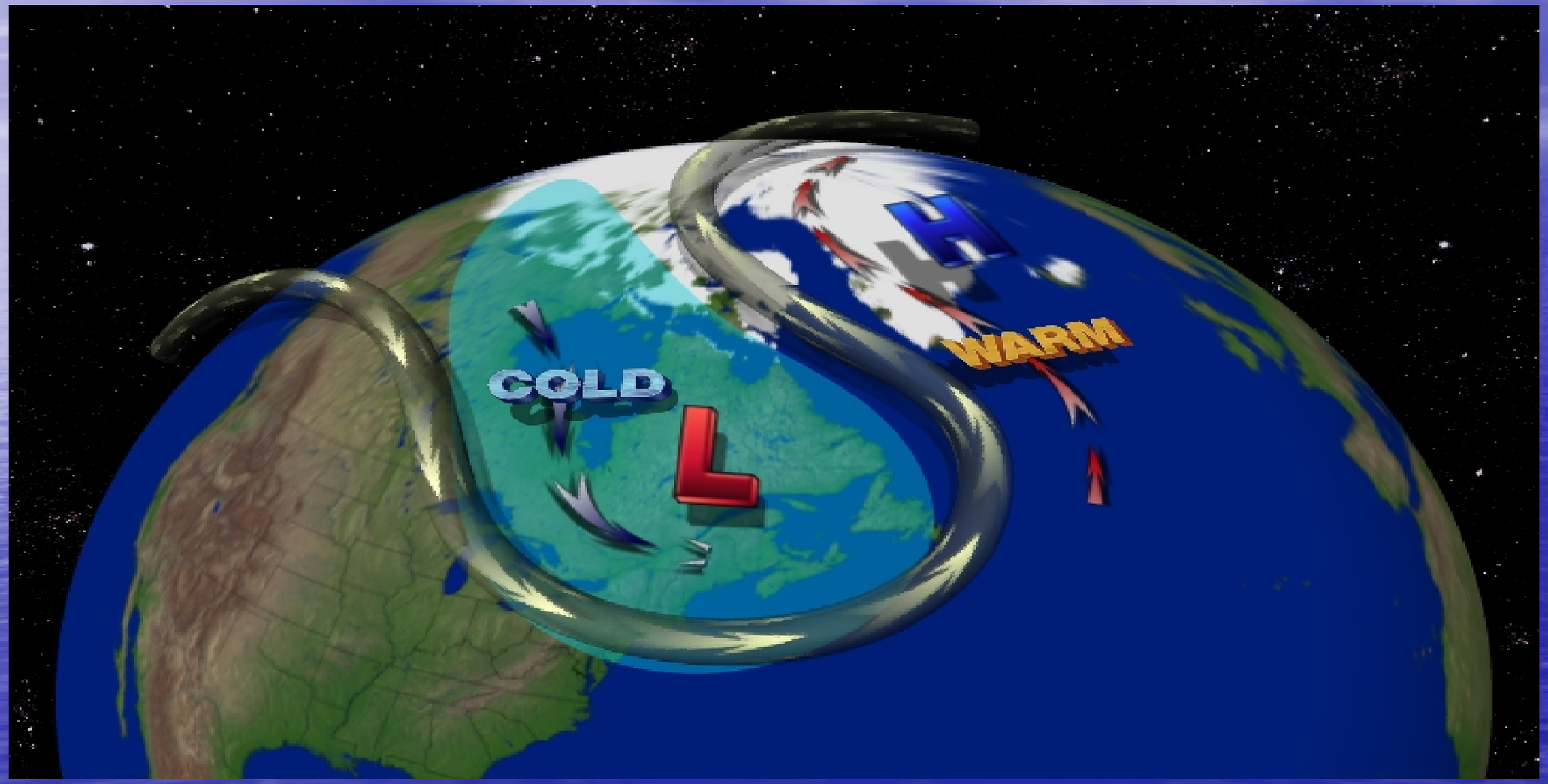
Winds aloft oscillate north in south (ridges and troughs).

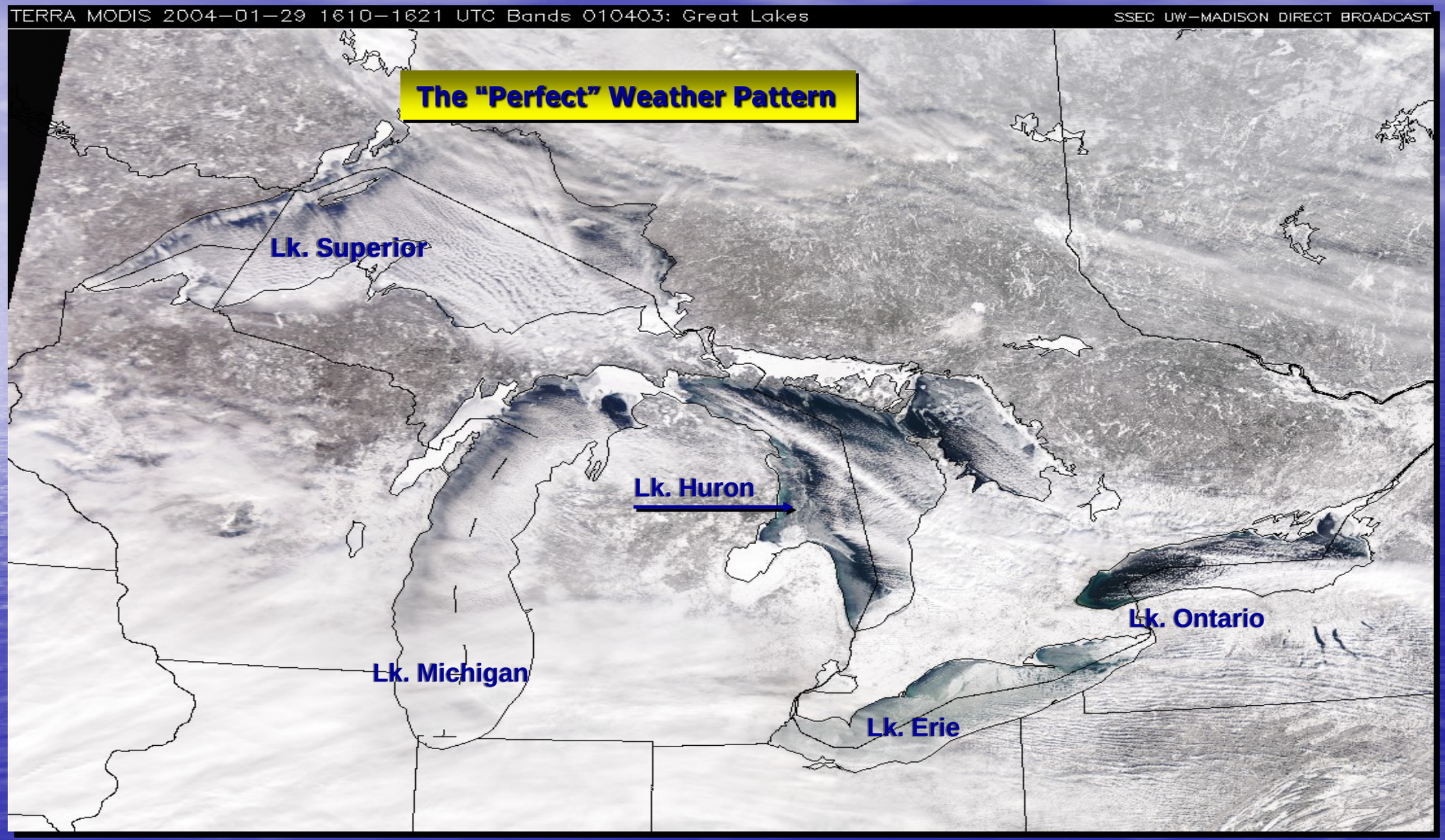
These waves propagate along like waves in the ocean.

The movement of those waves appear to be slowing.

Greenland Block
January 2004

A Good Example: More Blocking Highs (Lately over Greenland and Alaska)




TERRA MODIS 2004-01-29 1610-1621 UTC Bands 010403: Great Lakes
SSEC UW-MADISON DIRECT BROADCAST
The "Perfect" Weather Pattern
Lk. Superior
Lk. Huron
Lk. Michigan
Lk. Erie
Lk. Ontario

The results of the Greenland Block:

Release Date: April 14, 2004

ALBANY, N.Y. – The Federal Emergency Management Agency announced that the first $1 million in federal disaster aid.....

.... has been approved for local governments and non-profit organizations in Cayuga, Oneida, Oswego and Lewis counties.

We did it again! February, 2007

FEMA: February 2007 Lake Effect Snowstorm

“February 23, 2007, (The President) declared a federal emergency…to help recover from the February 2-12, 2007… lake-effect snowstorms.

Counties eligible for assistance include Lewis, Oneida and Oswego.”

Winter in a week, 2007

February 2007 : 9 Days of extreme Lake Effect

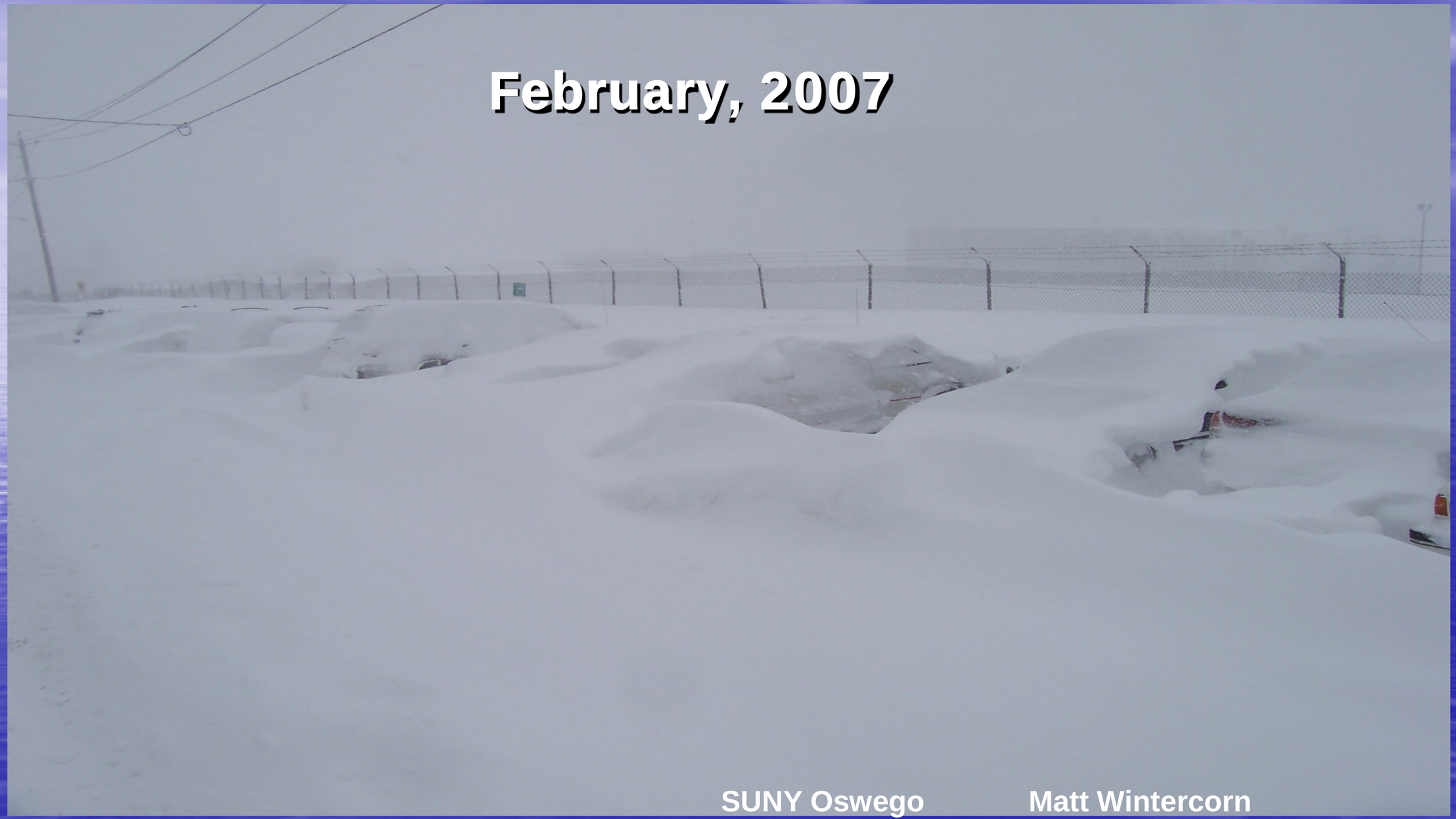
North Redfield, NY 144 inches of snow

Photo: Carol Yerdon

Parish, New York

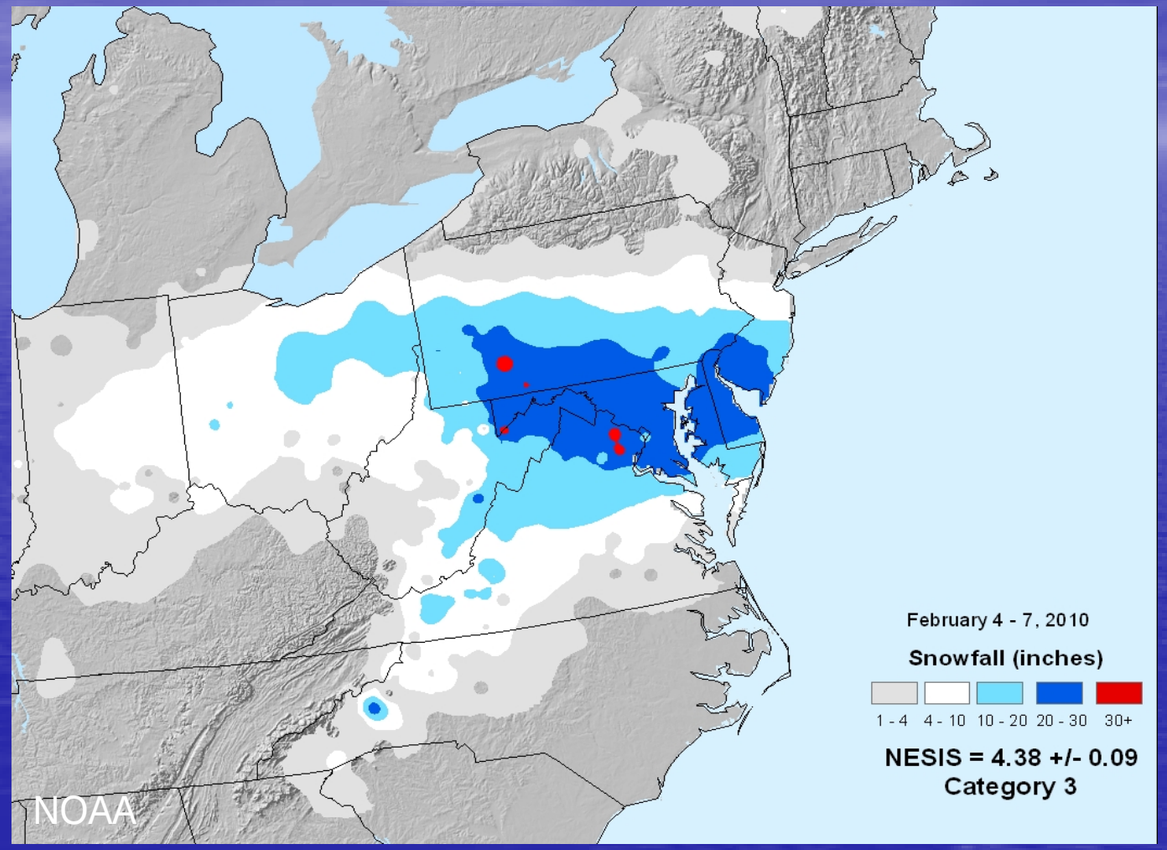
Photo: Mike Osborn

February, 2007



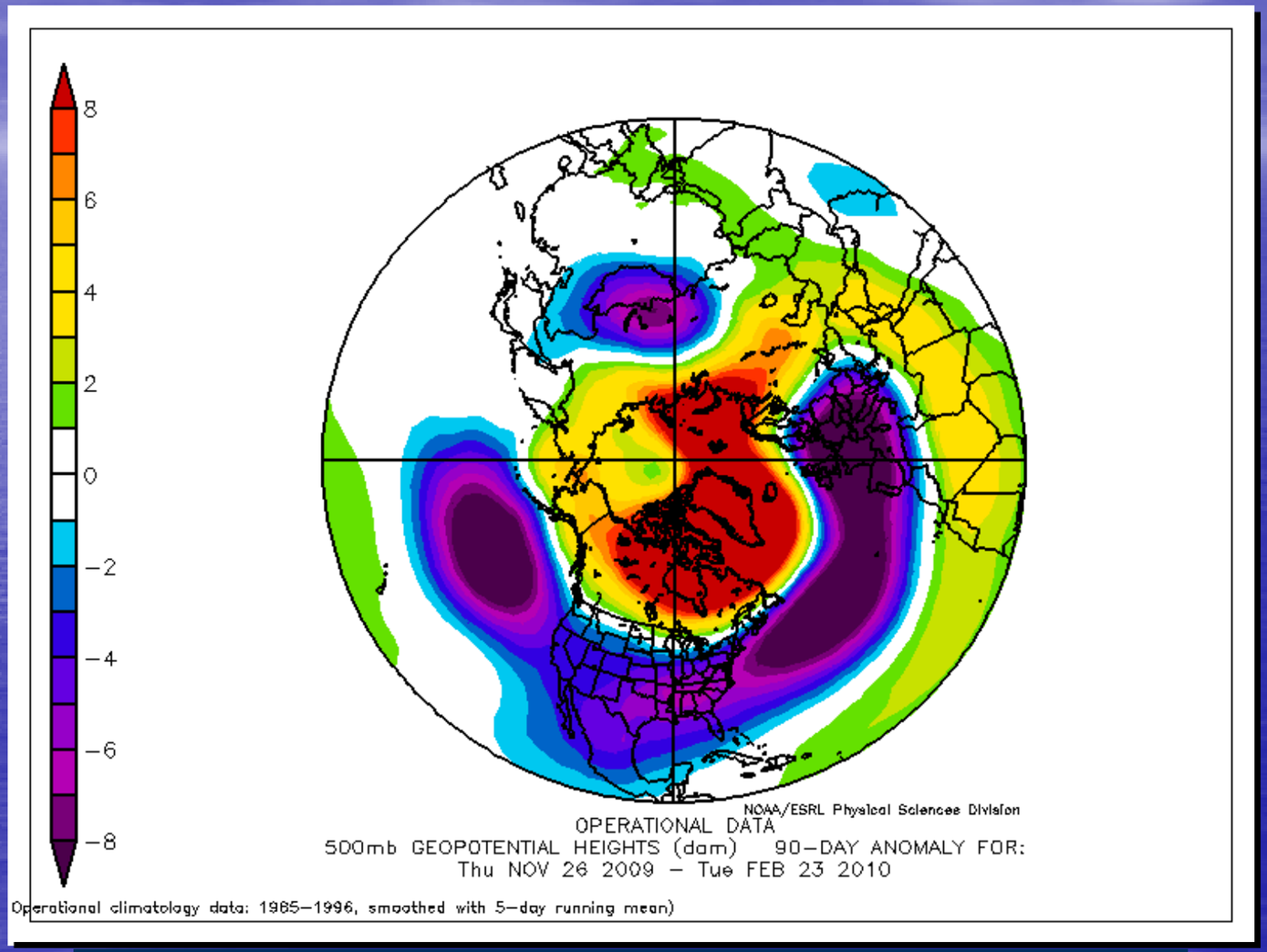
SUNY Oswego Matt Wintercorn

Washington and Philadelphia



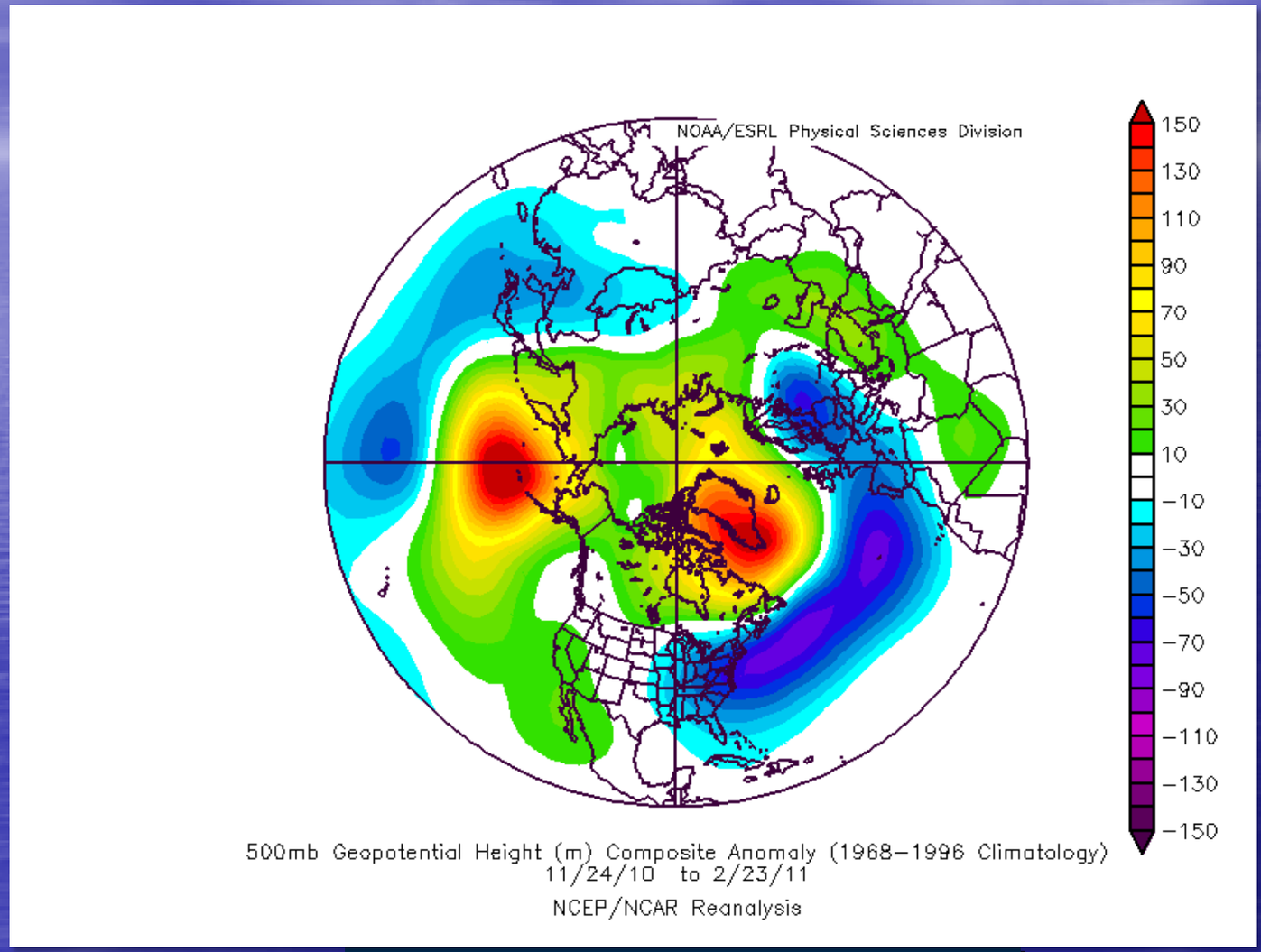
2010

Washington and Philadelphia



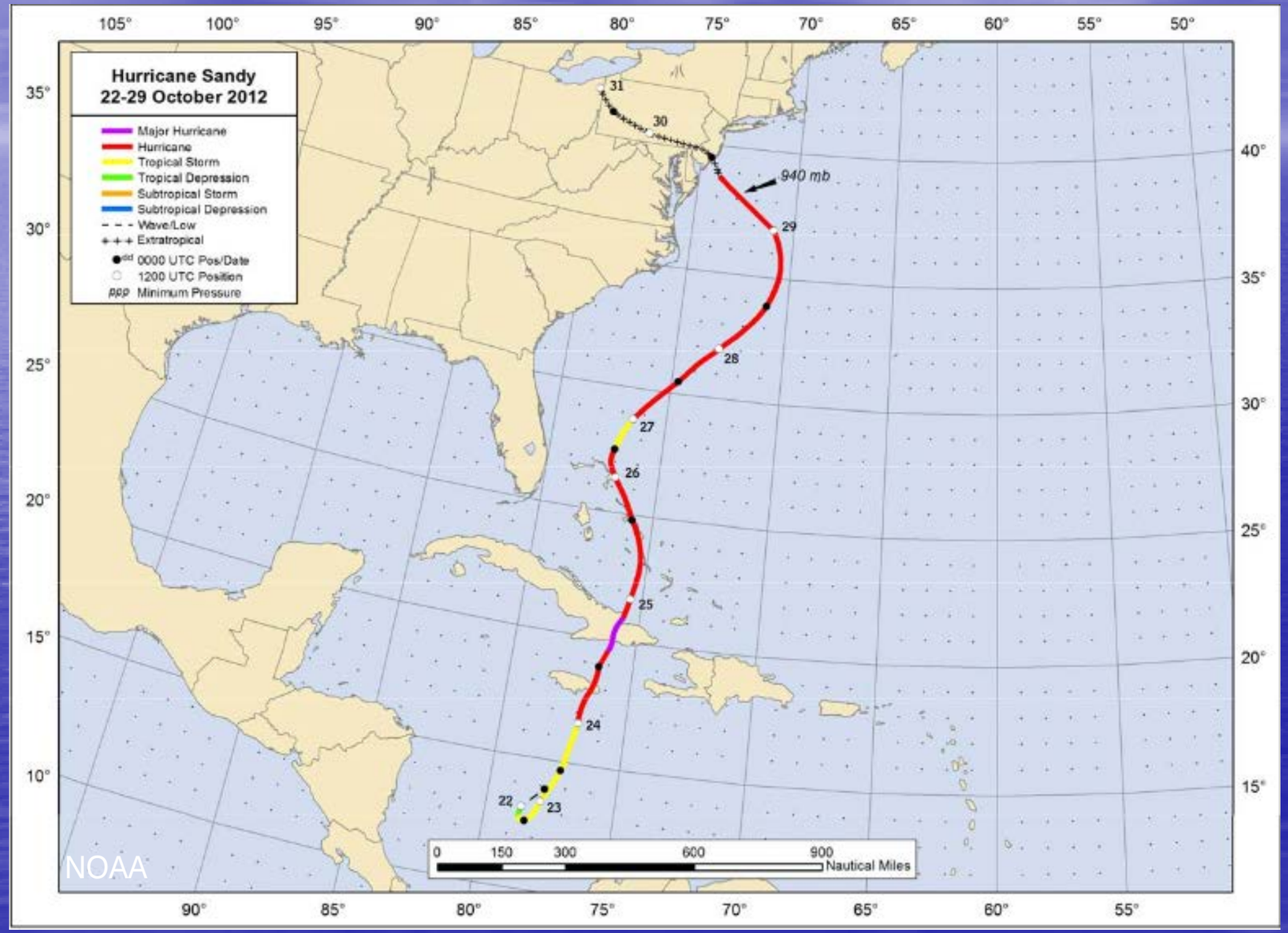
December – January 2009/2010

Another Extreme event in 2010-2011

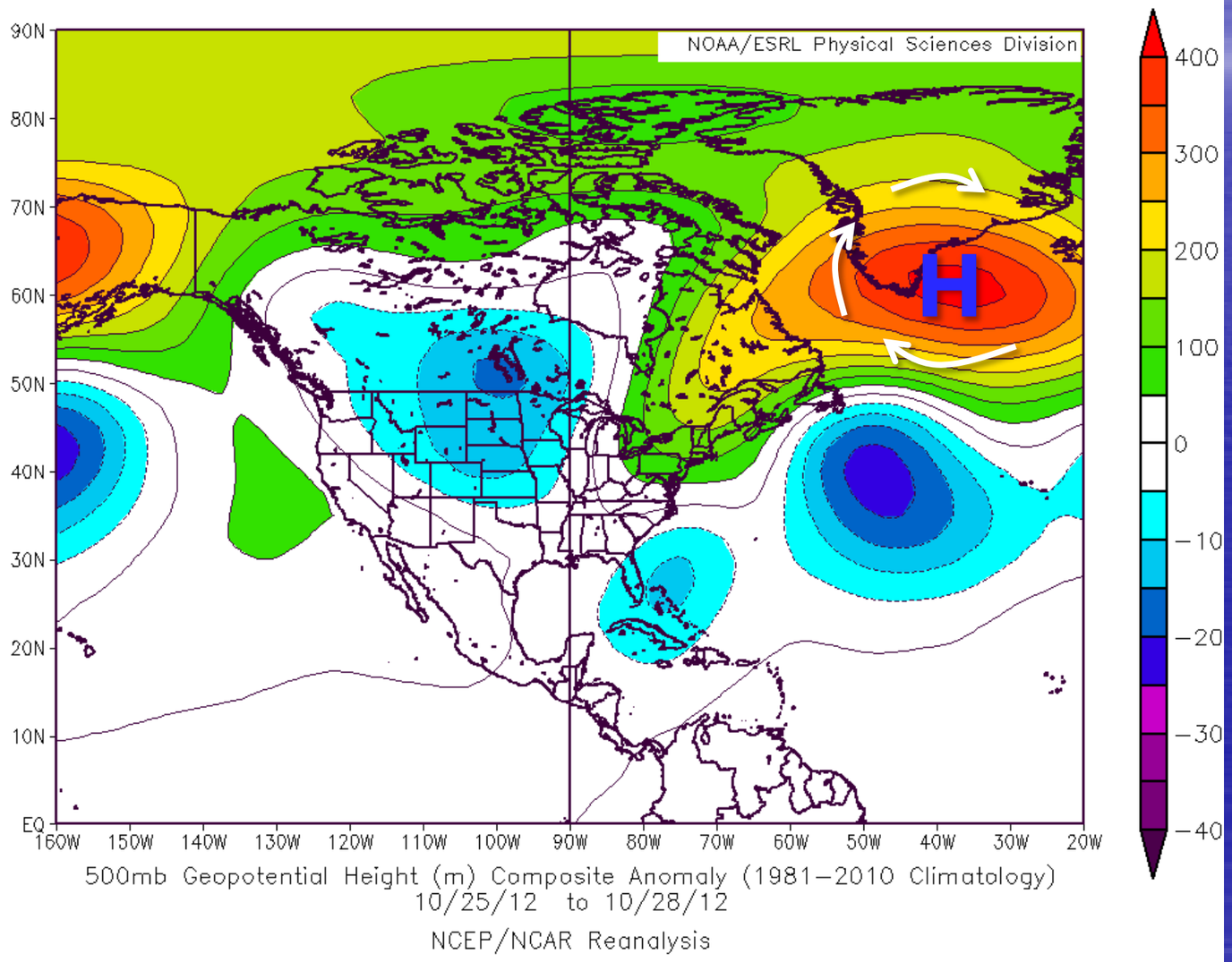


Nov 2010 – Feb 2011

Hurricane/Extratropical Storm Sandy



Hurricane/Extratropical Storm Sandy



As the Arctic Warms, The mid latitudes are greatly affected

"Climate change also alters dynamical characteristics of the atmosphere that in turn affect weather patterns and storms.

In the mid-latitudes, where most of the continental U.S. is located, there is an upward trend in extreme precipitation in the vicinity of fronts associated with mid-latitude storms."

Balling, Jr., R. C., and G. B. Goodrich, 2011: Spatial analysis of variations in precipitation intensity in the USA. *Theoretical and Applied Climatology*, **104**, 415-421, doi:10.1007/s00704-010-0353-0.

Regional Consequences
The Northeast

As internal forcing (GHG),
and external forcing “duke it out”,
more variability in our weather?

Regional Change: Max Temps NE U.S.

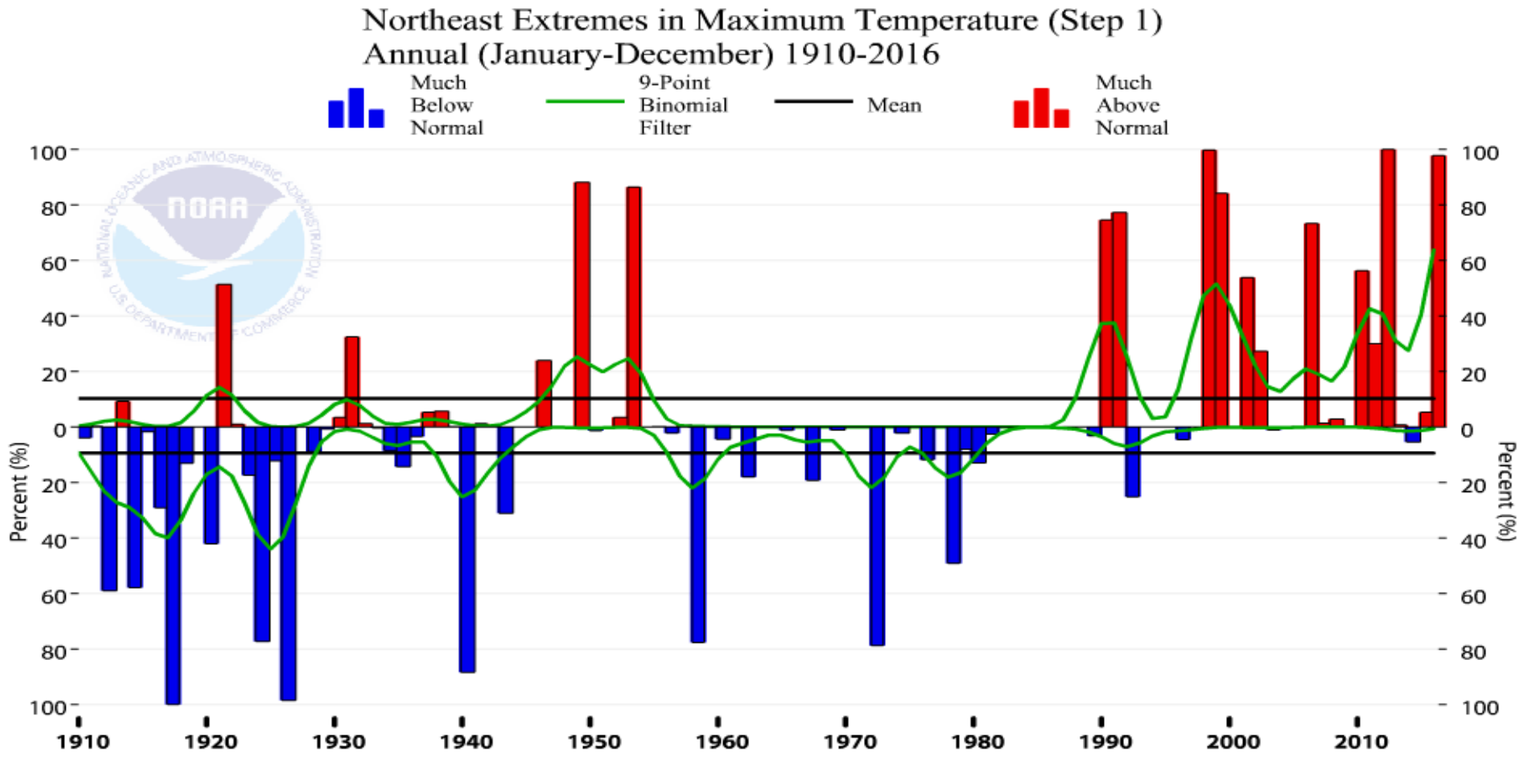
Region: Northeast

Period: Annual (January-December)

Indicator: Extremes in Maximum Temperature (Step 1)

Plot

Move mouse towards an axis until highlighted. Left-click mouse to **pan**. *Shift key + left-click to* **zoom**.



http://www.ncdc.noaa.gov/extremes/cei/graph/ne/4/12-02

NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)

Regional Change: Min Temps NE U.S.

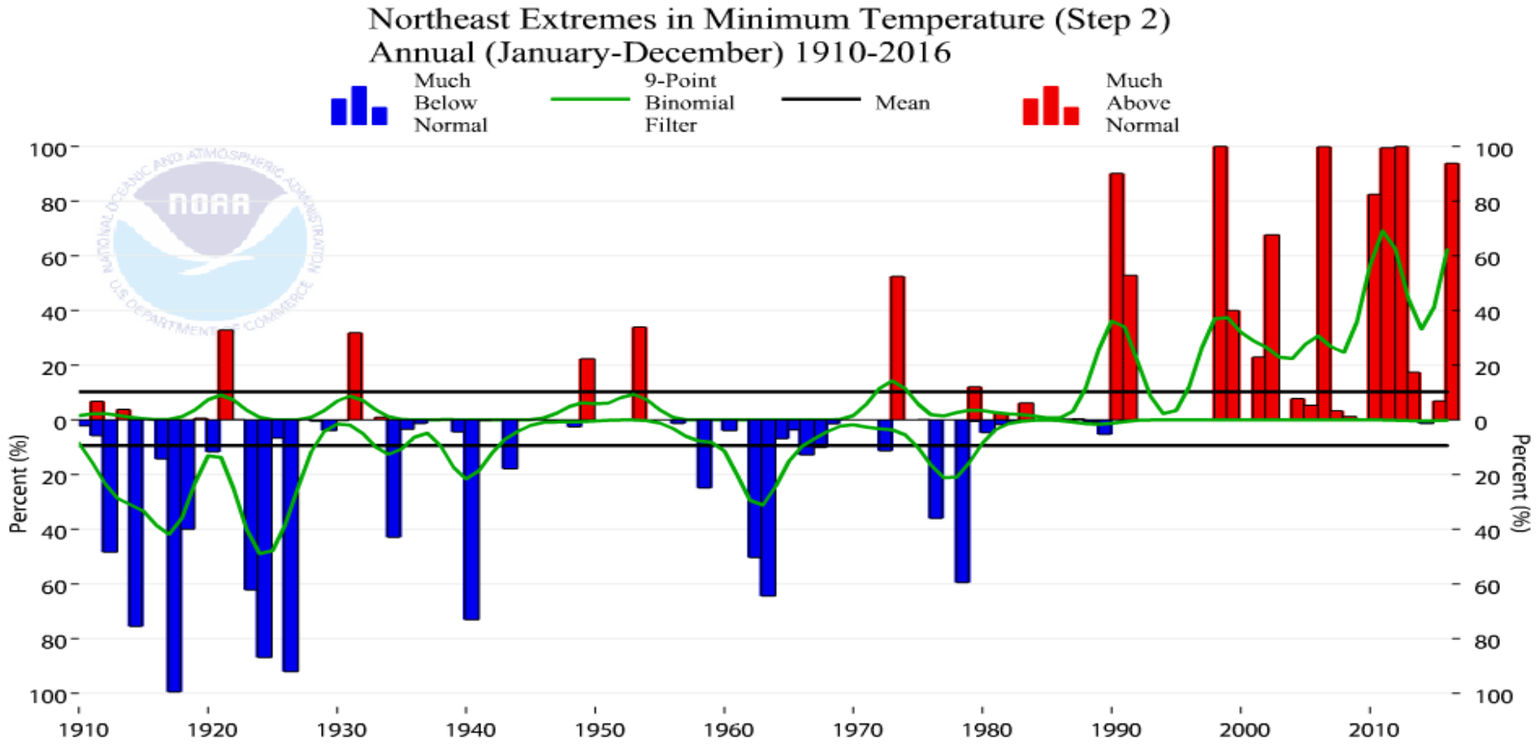
Region: Northeast

Period: Annual (January-December)

Indicator: Extremes in Minimum Temperature (Step 2)

Plot

Move mouse towards an axis until highlighted. Left-click mouse to **pan**. *Shift key + left-click to* **zoom**.



http://www.ncdc.noaa.gov/extremes/cei/graph/ne/4/12-02

NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)

Regional Change: Precip NE U.S.

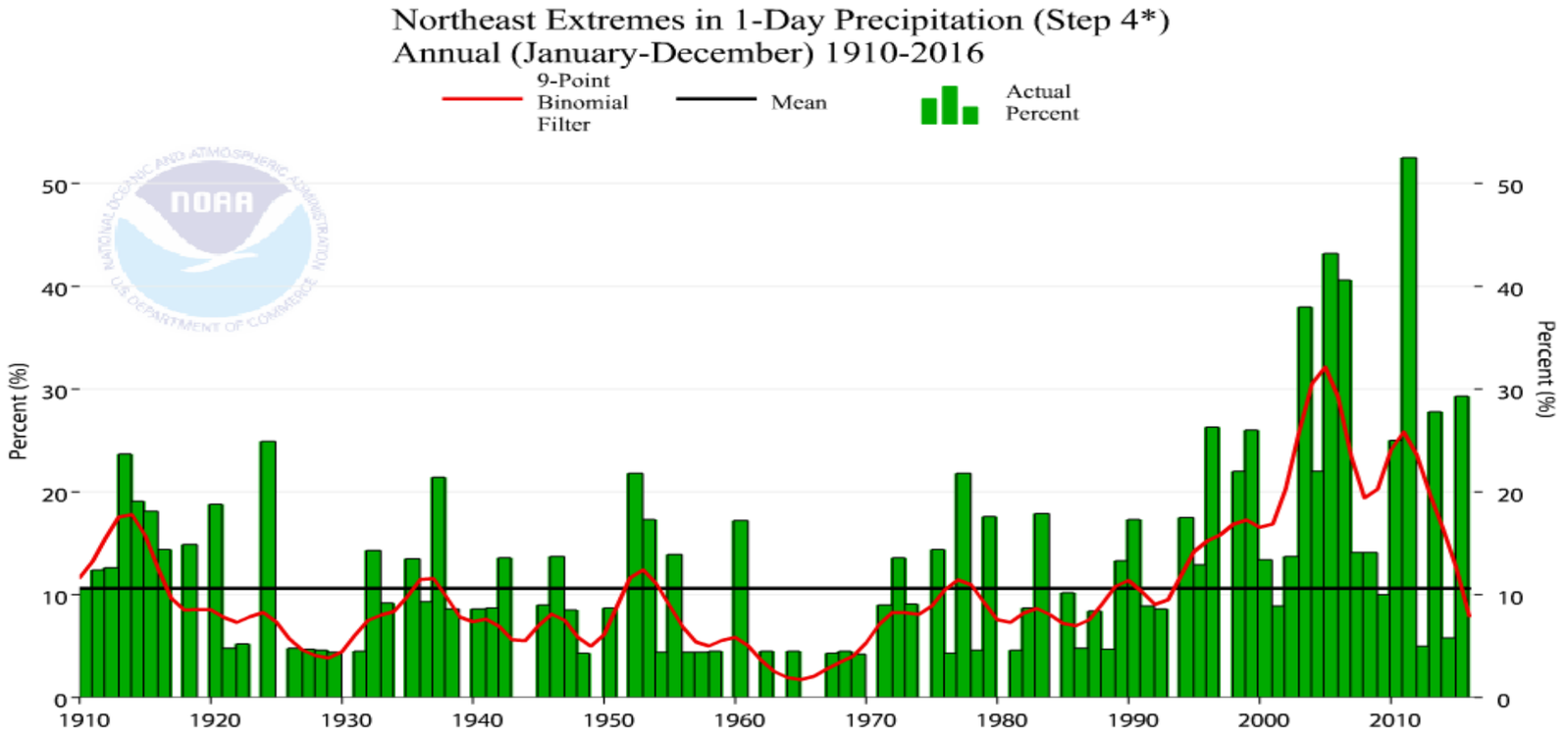
Region: Northeast

Period: Annual (January-December)

Indicator: Extremes in 1-Day Precipitation (Step 4*)

Plot

Move mouse towards an axis until highlighted. Left-click mouse to **pan**. *Shift key + left-click to* **zoom**.



http://www.ncdc.noaa.gov/extremes/cei/graph/ne/4/12-02

NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)

Regional Change: Summer Drought NE U.S.

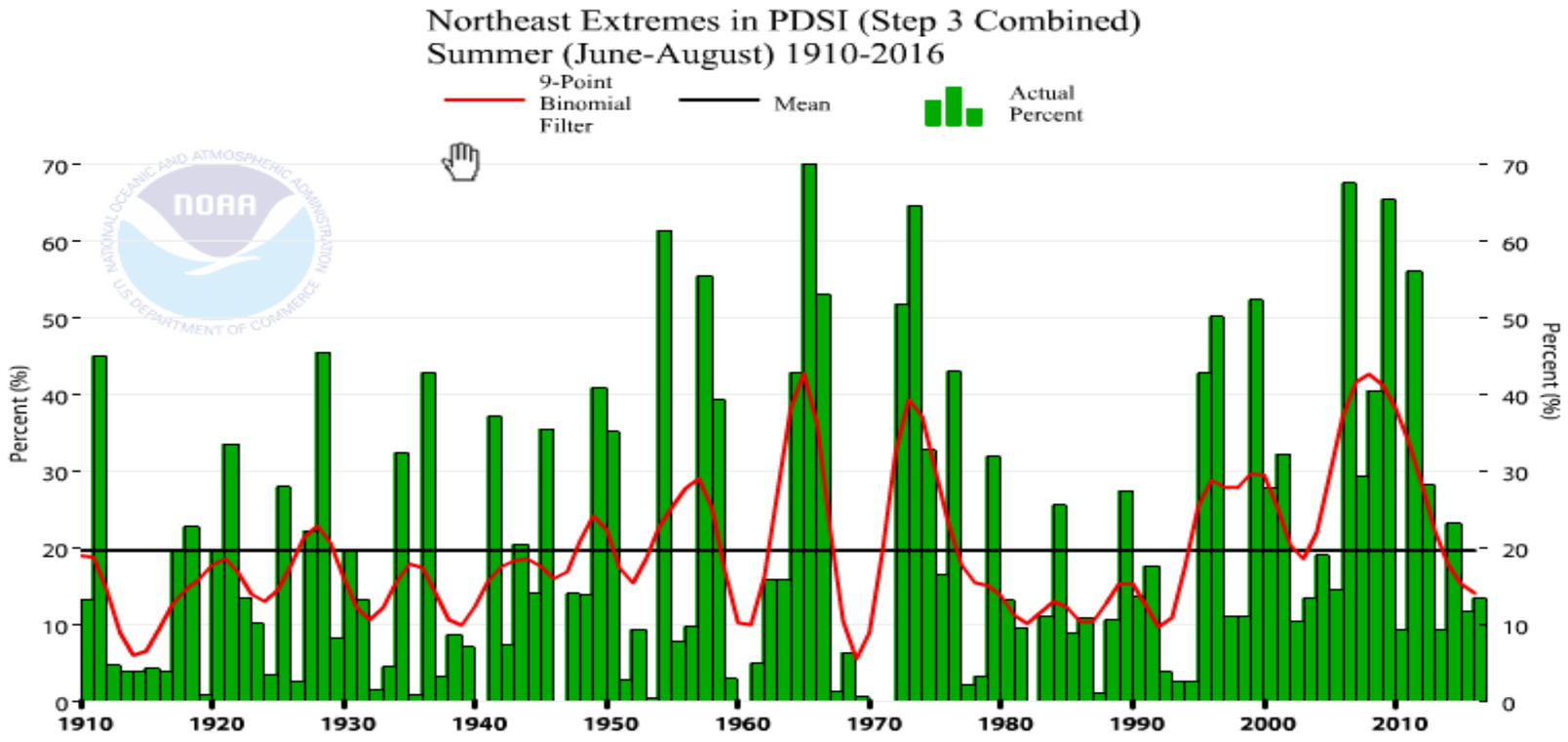
Region: Northeast

Period: Summer (June-August)

Indicator: Extremes in PDSI (Step 3 Combined)

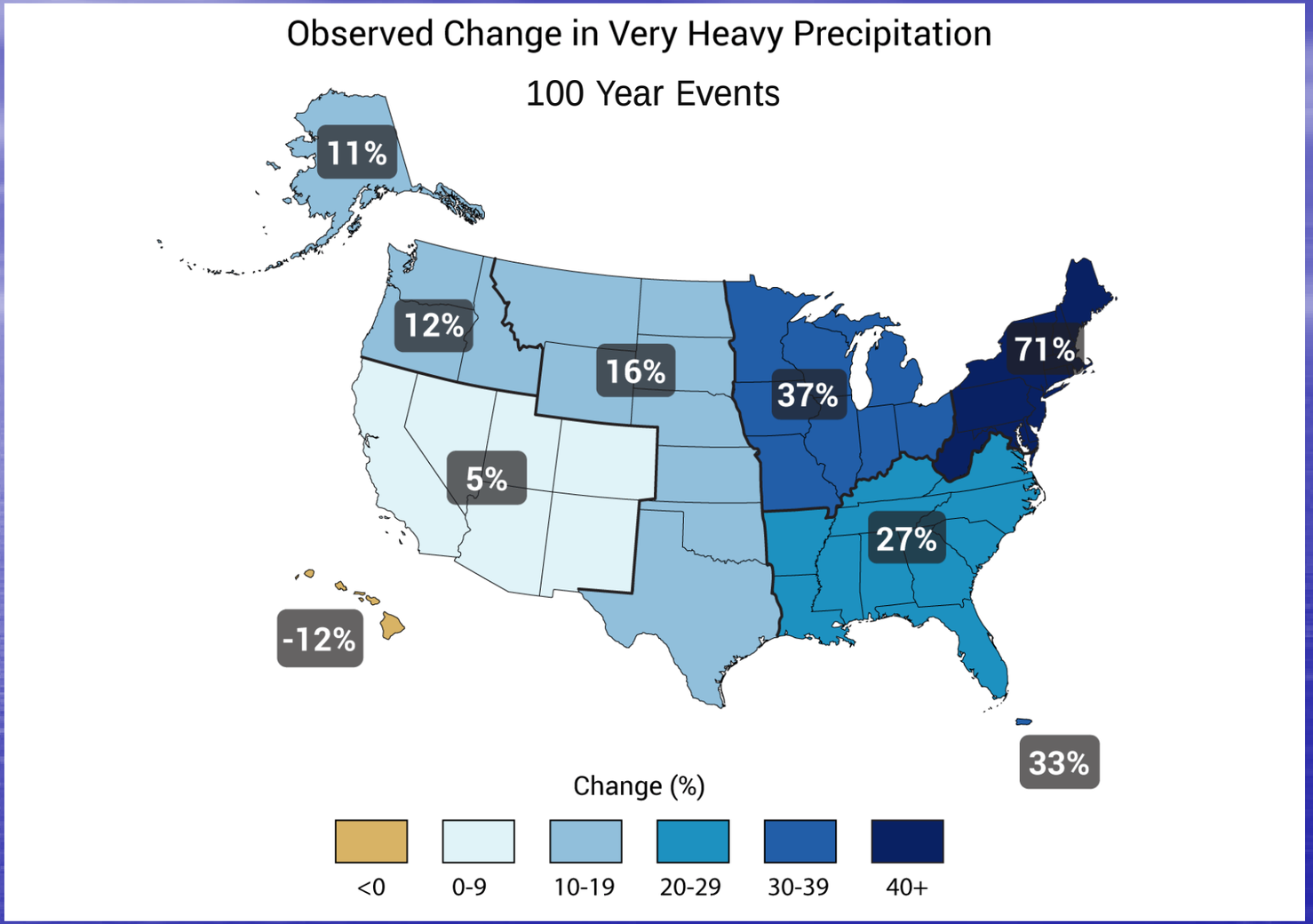
Plot

Move mouse towards an axis until highlighted. Left-click mouse to **pan**. *Shift key + left-click to* **zoom**.



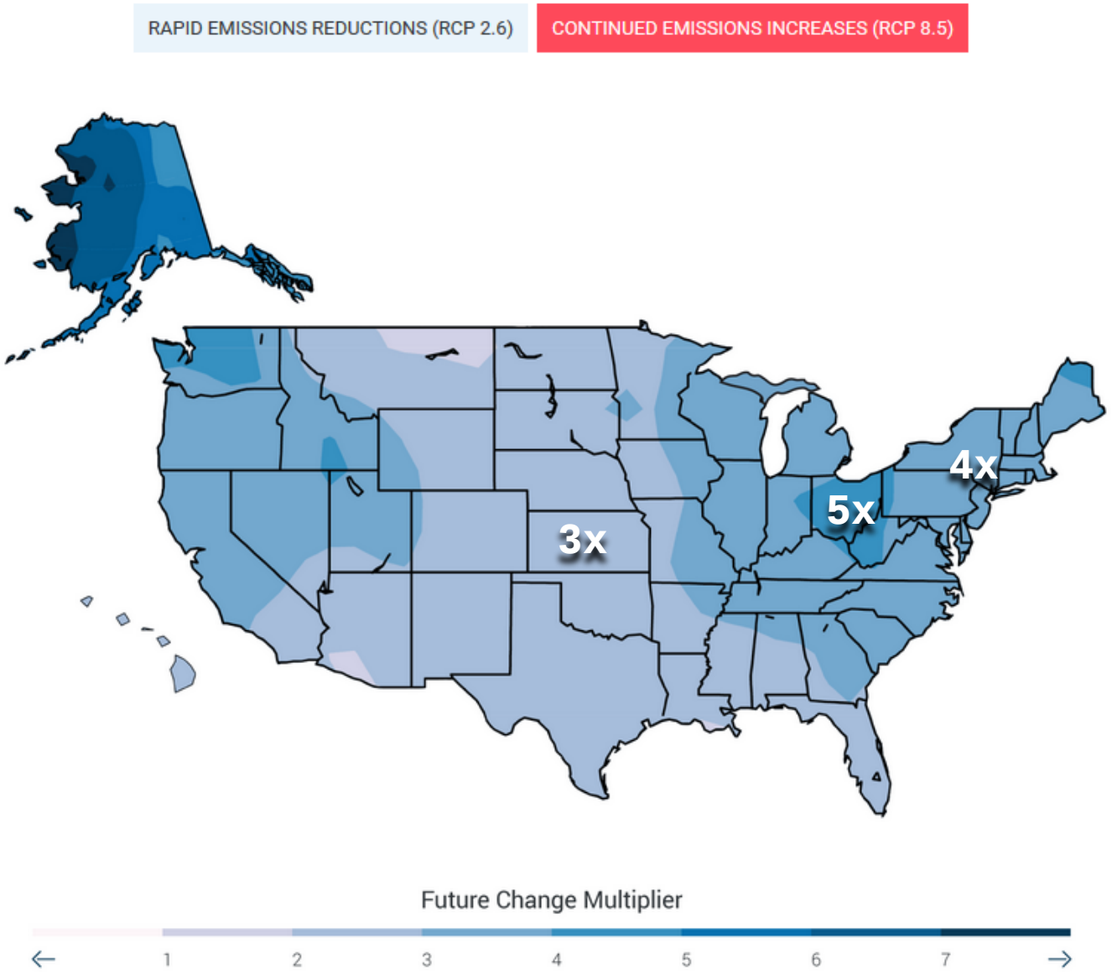
http://www.ncdc.noaa.gov/extremes/cei/graph/ne/4/12-02

NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)



The Northeast has experienced a greater recent increase in extreme precipitation than any other region in the United States; between 1958 and 2010, the Northeast saw more than a 70% increase in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events) (Figure source: updated from Karl et al. 2009).

The Future (With Current rate of GHG Increases)

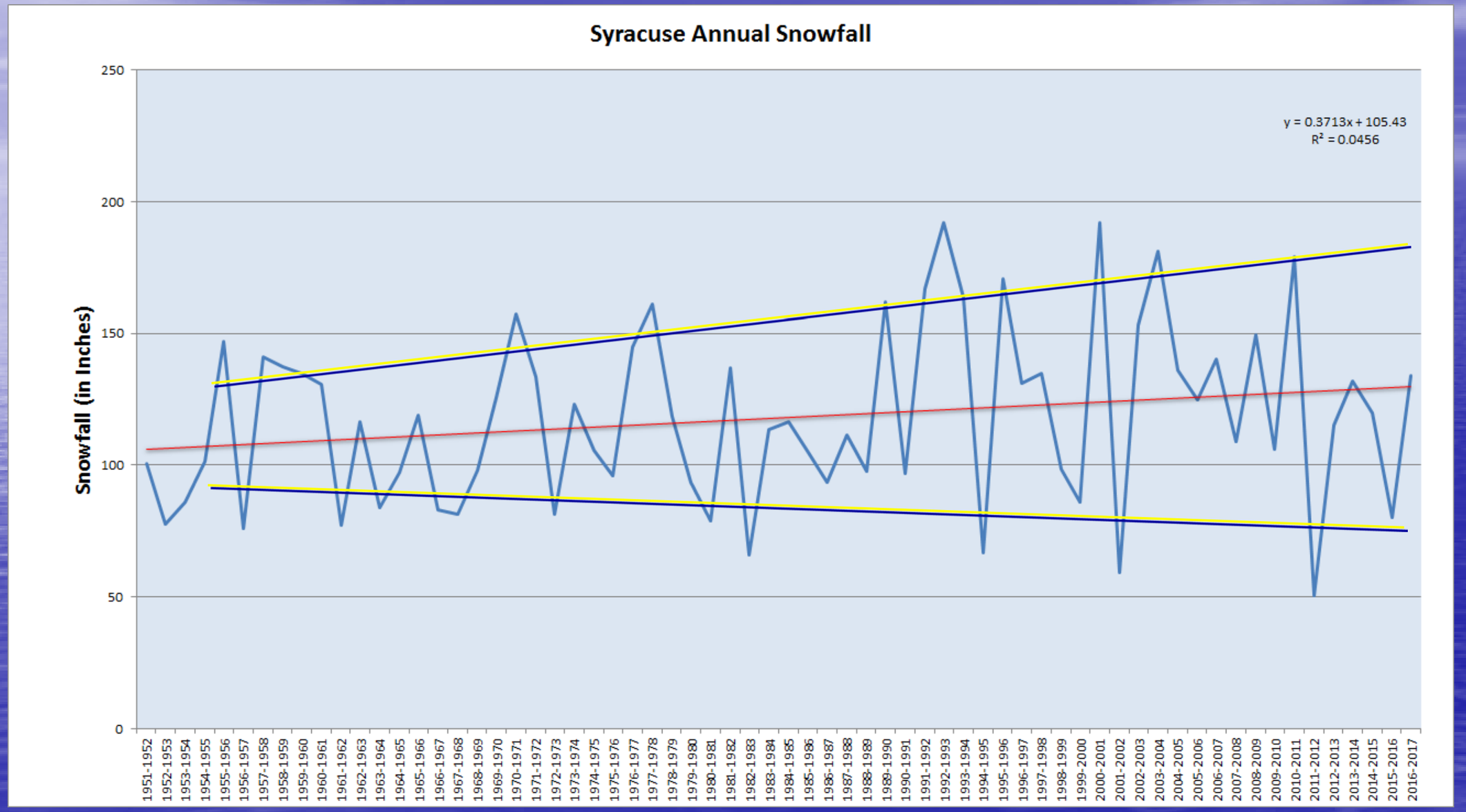


Projected 2081-2100 Precipitation Extremes relative to 1981-2000
(Figure source: NOAA NCDC / CICS-NC
From: Climate Change Impacts in the United States

Why the Northeastern U.S.?

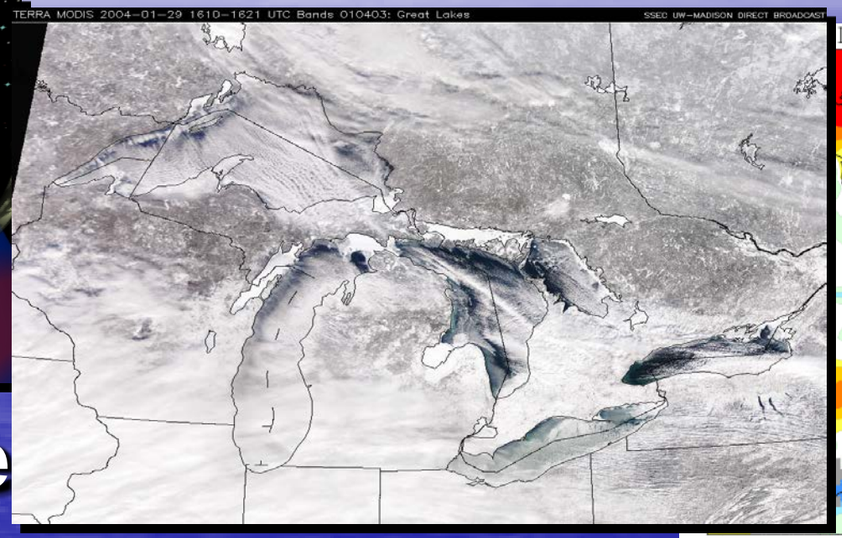
Storms generally track through the NE U.S.

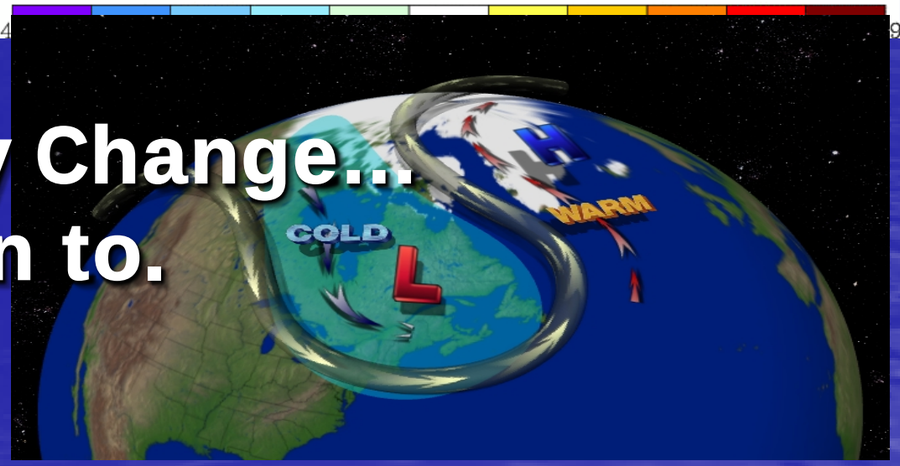
Local Change: Syracuse Annual Snowfall



Data: NOAA, National Weather Service

Summary:





3) Weather patterns here will likely Change…
They may have already begun to.

References

NOAA's Arctic Report Card

http://www.arctic.noaa.gov/report-card

NOAA's Arctic Climate Extremes Index

https://www.ncdc.noaa.gov/extremes/cei/

Arctic Warming and Greenland Blocking.

http://onlinelibrary.wiley.com/doi/10.1002/joc.4673/full

Arctic Warming and Greenland Blocking.

http://iopscience.iop.org/article/10.1088/1748-9326/10/1/014005#citations

Research In Planetary Wave amplification and Motion:

https://ore.exeter.ac.uk/repository/bitstream/handle/10871/10401/Screen_Simmonds_2013_GRL.pdf?sequence=2

Reference to sea Ice Loss:

https://www.esrl.noaa.gov/psd/people/lantao.sun/publications/2016_SPH_GRL.pdf

https://nsidc.org/arcticseaicenews/