Climate Change and the Future Impacts across the Southwest Region

Darren McCollum

and

Robert Bohlin

National Weather Service Flagstaff, Arizona

What is Climate Change?

DEFINITION

Climate change: is a significant and lasting change in the average weather patterns over periods ranging from decades to millions of years. Climate change may be limited to a specific region or may occur across the whole Earth in which case **global climate change** is a more appropriate term.

Climate change includes: major changes in temperature, precipitation, and/or wind patterns, among others, that occur over several decades or longer.

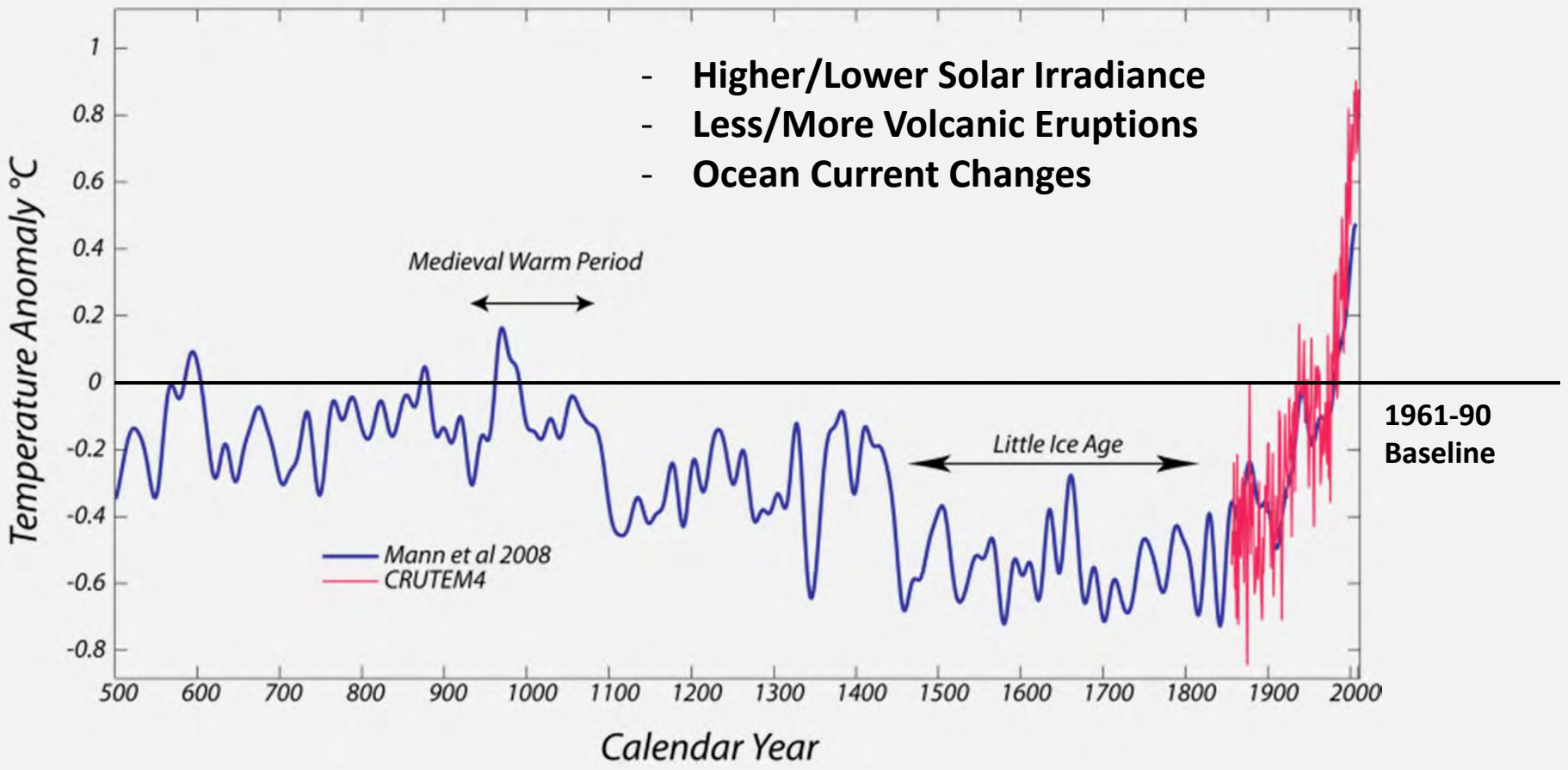
What is Climate Change?

Laki Volcanic Fissure in Iceland erupts 1783

- Northern Hemisphere 1 to 3 degrees Fahrenheit cooler
- Sun Intensity Dramatically Lowered (perpetual brown fog)
- Major Crop Failures in Europe and Portions of northern Africa and Asia

*globerove.com/**Iceland/Laki-Volcano-Eruption-Iceland**/529*

What is Climate Change?



https://www.e-education.psu.edu/earth103/node/659

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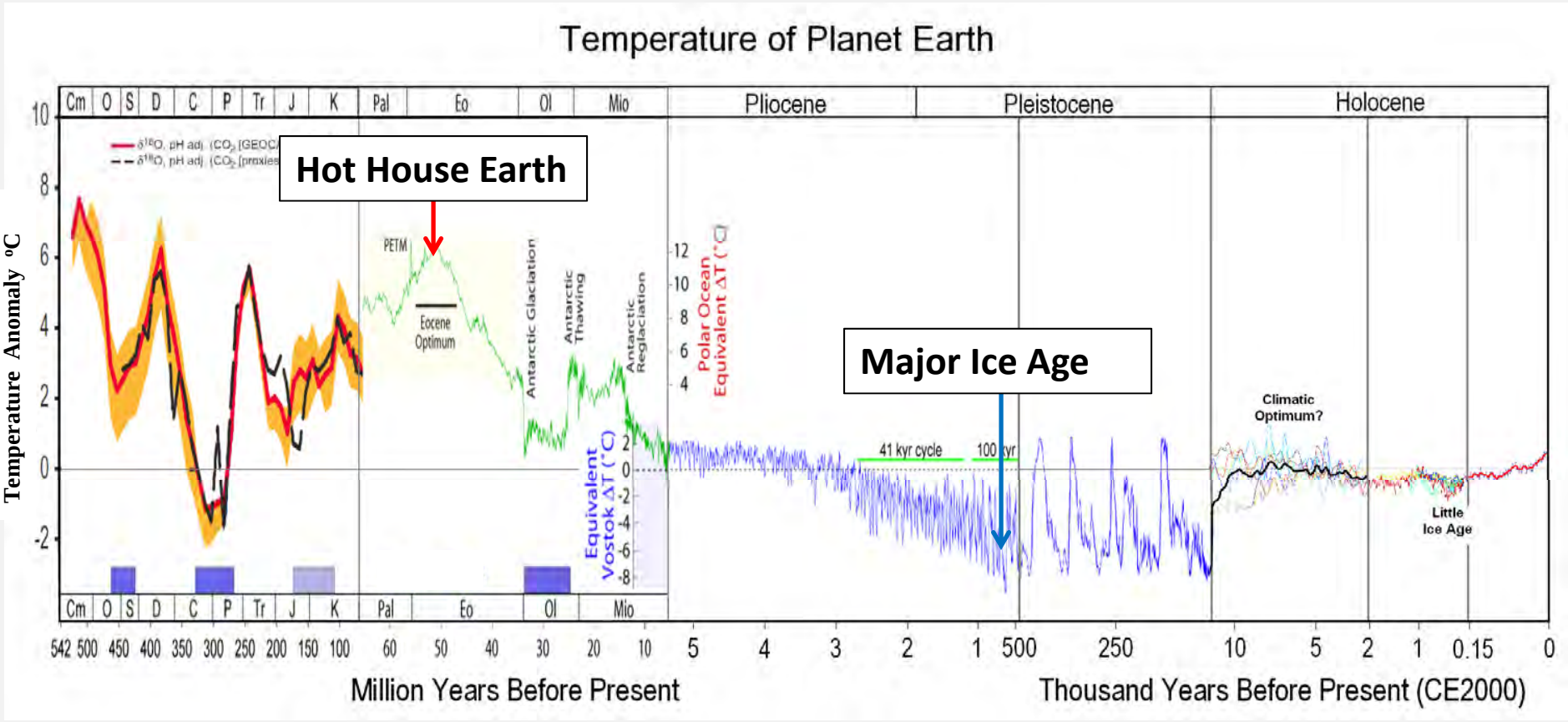

http://commons.wikimedia.org/wiki/File:All_palaeotemps.png

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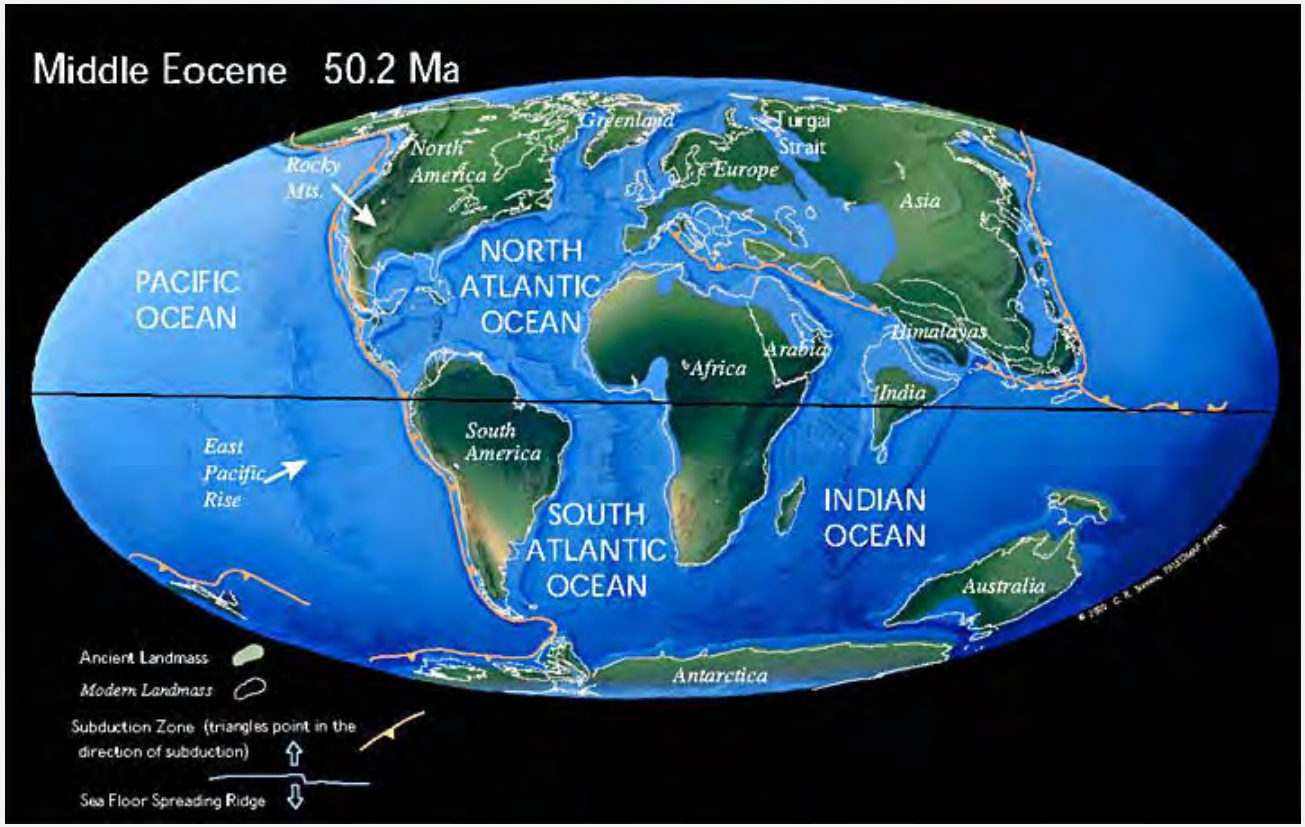

9 degrees Fahrenheit higher than current global temperatures

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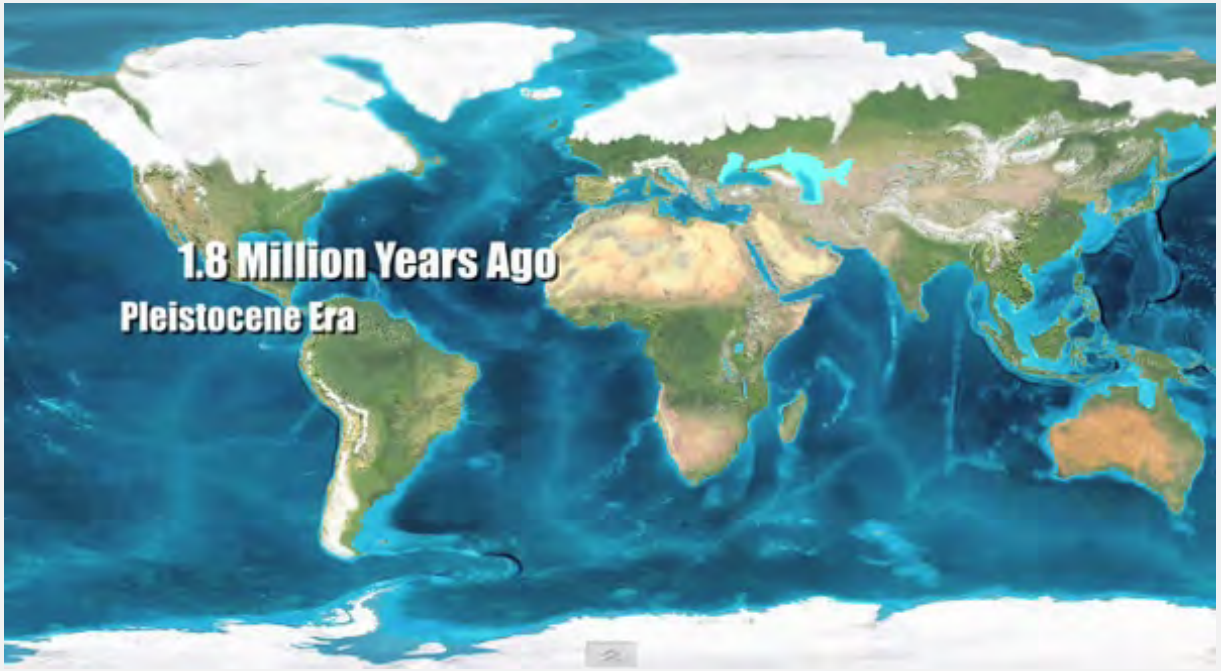
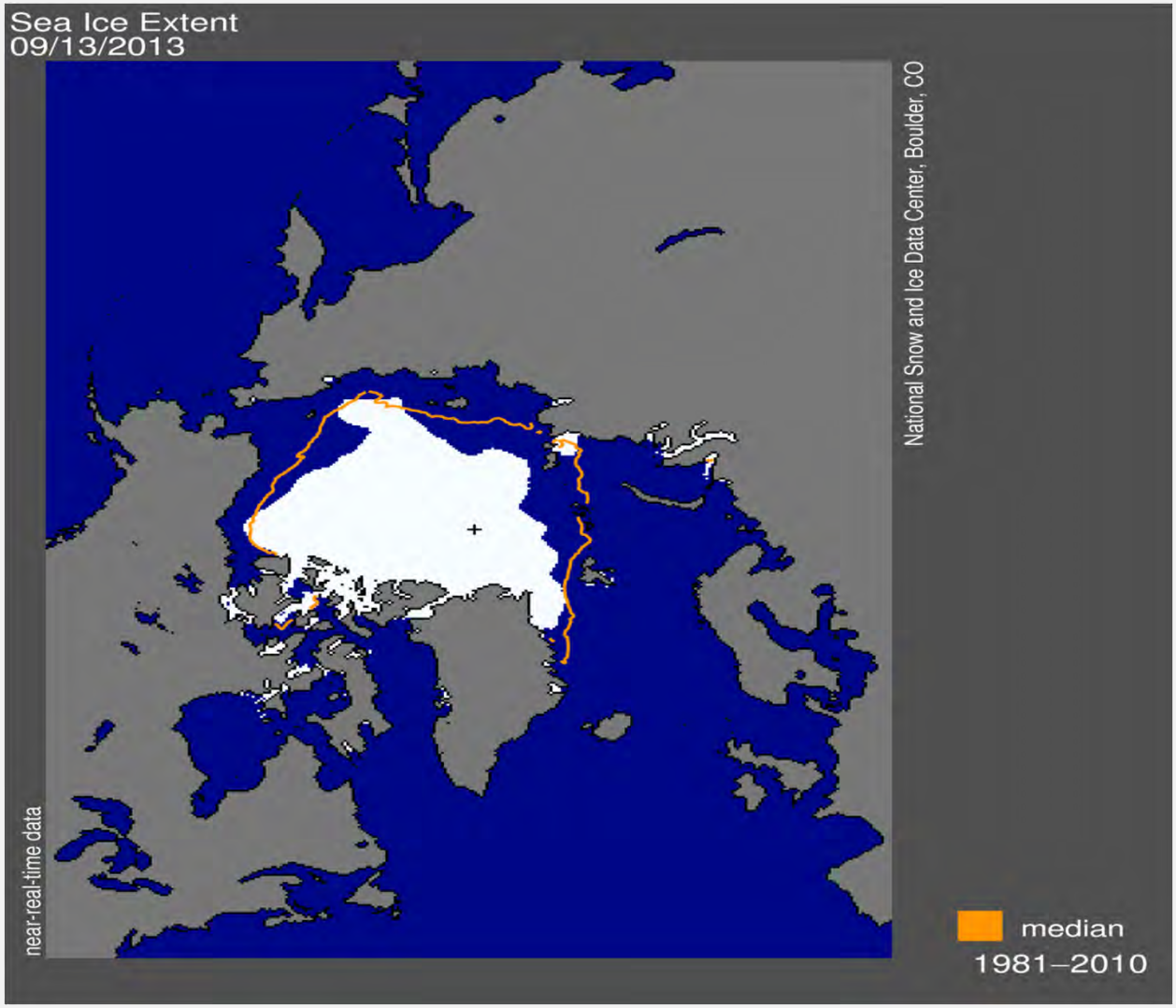


5 degrees Fahrenheit lower than current global temperatures

Climate Change Fingerprints

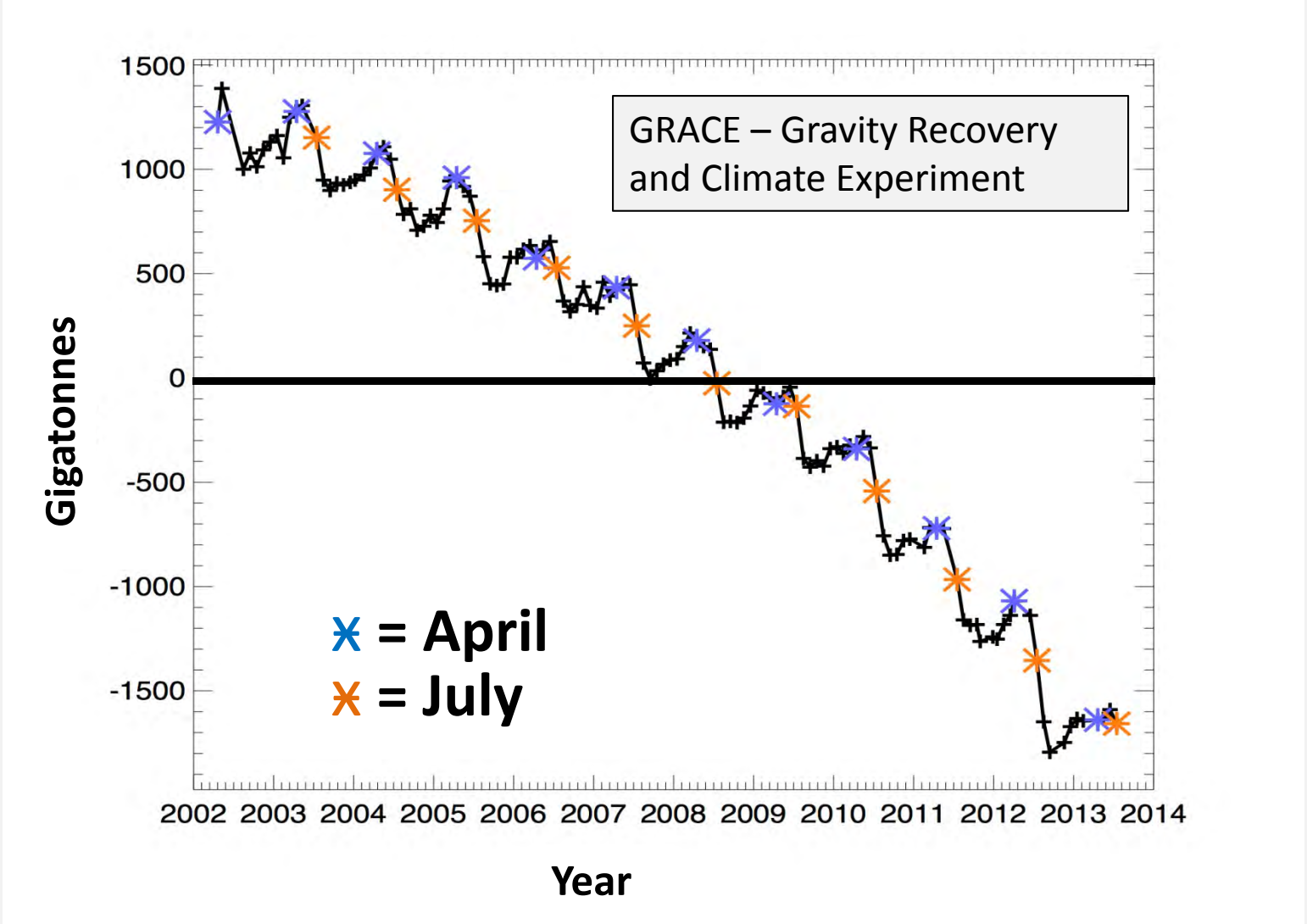
THE ICE IS MELTING!

Arctic Sea Ice Extent is Decreasing



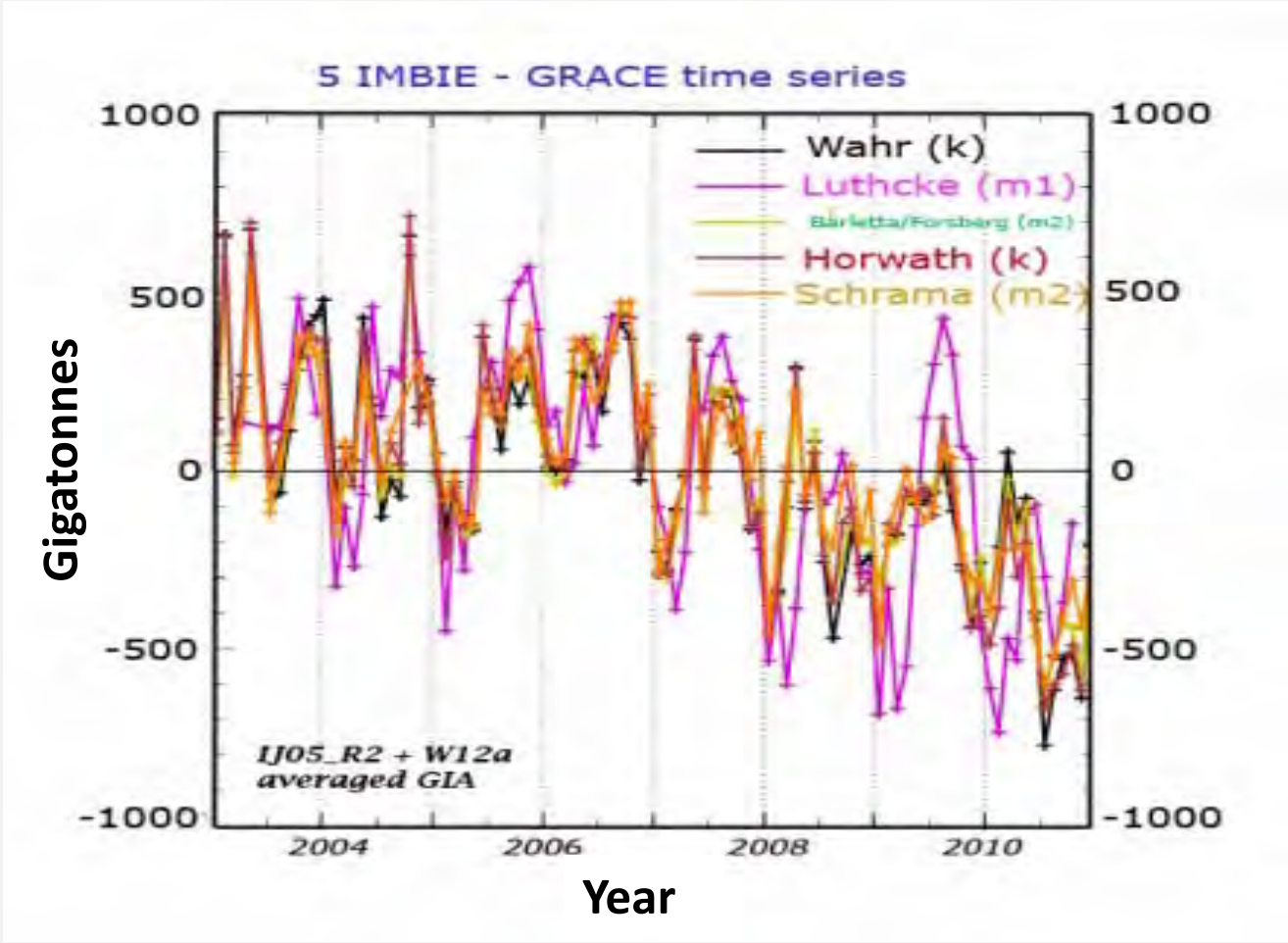
http://nsidc.org/arcticseaicenews/2013/09/

Greenland Ice Sheet is Melting



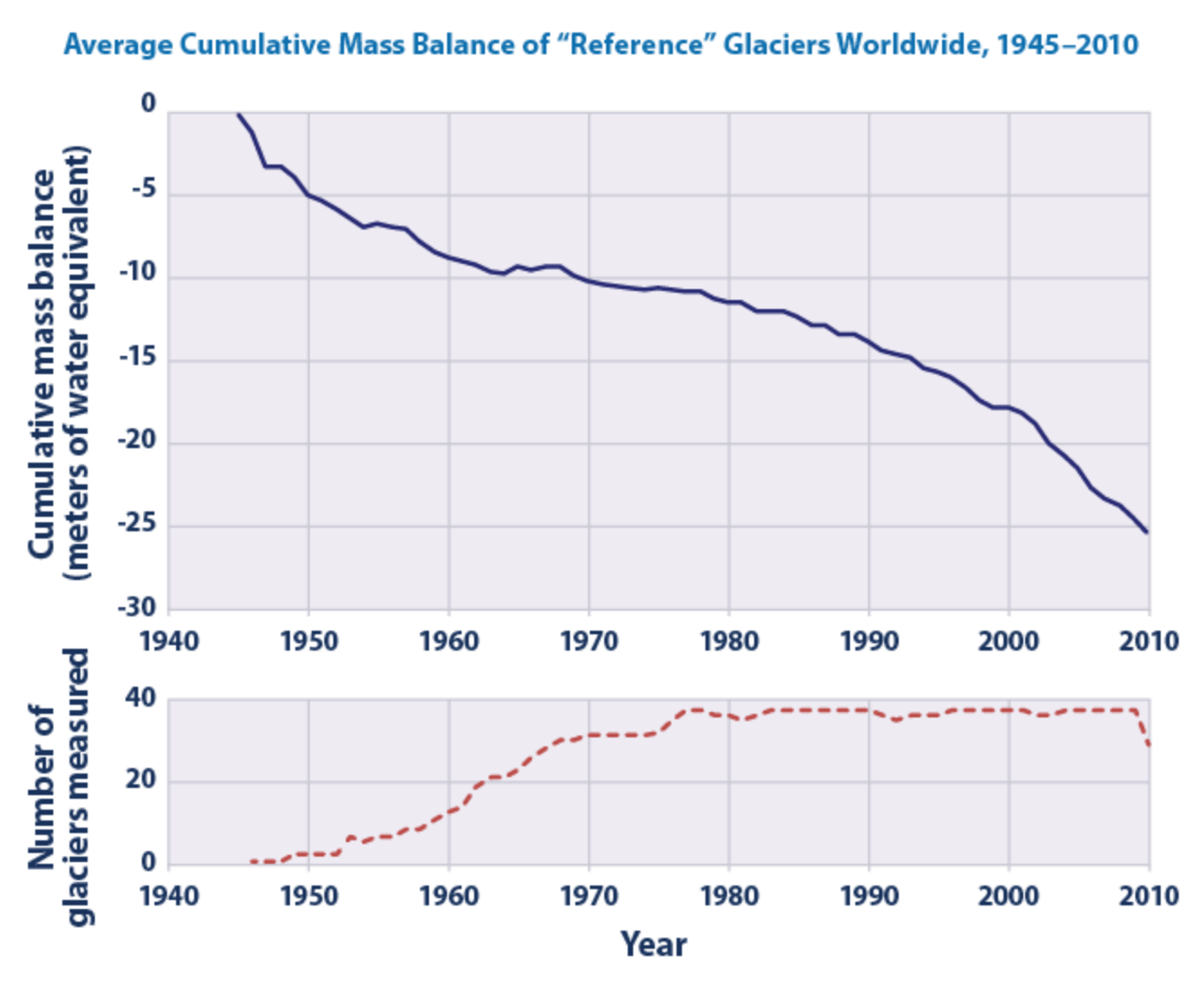
http://www.arctic.noaa.gov/reportcard/greenland_ice_sheet.html

Antarctica Ice Sheet is Melting



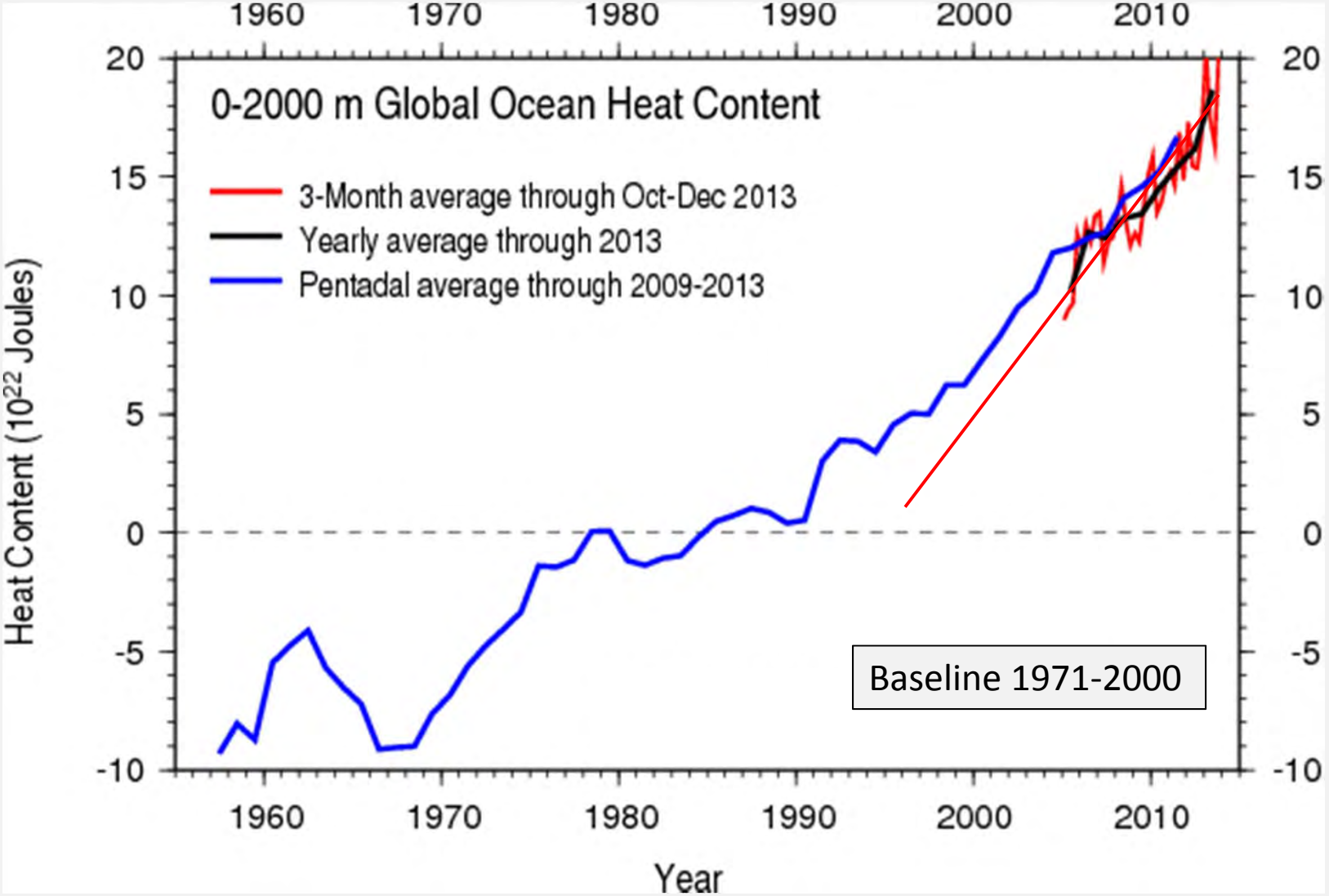
http://www.nasa.gov/mission_pages/Grace/index.html#.UstE17R0m1i

Glaciers are Melting



http://www.epa.gov/climatechange/science/indicators/snow-ice/glaciers.html

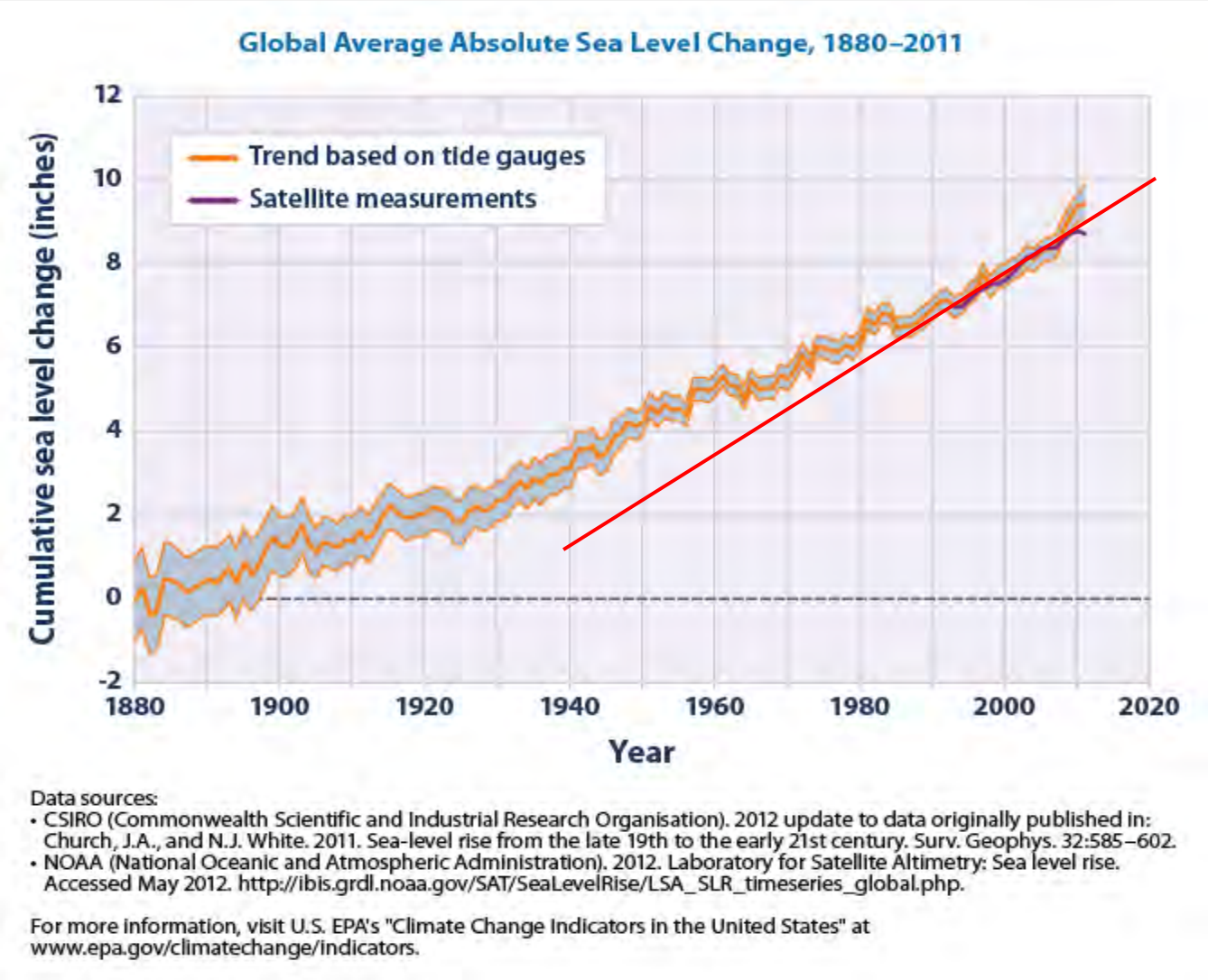
THE OCEANS ARE WARMING!



http://www.nodc.noaa.gov/OC5/3M_HEAT_CONTENT/

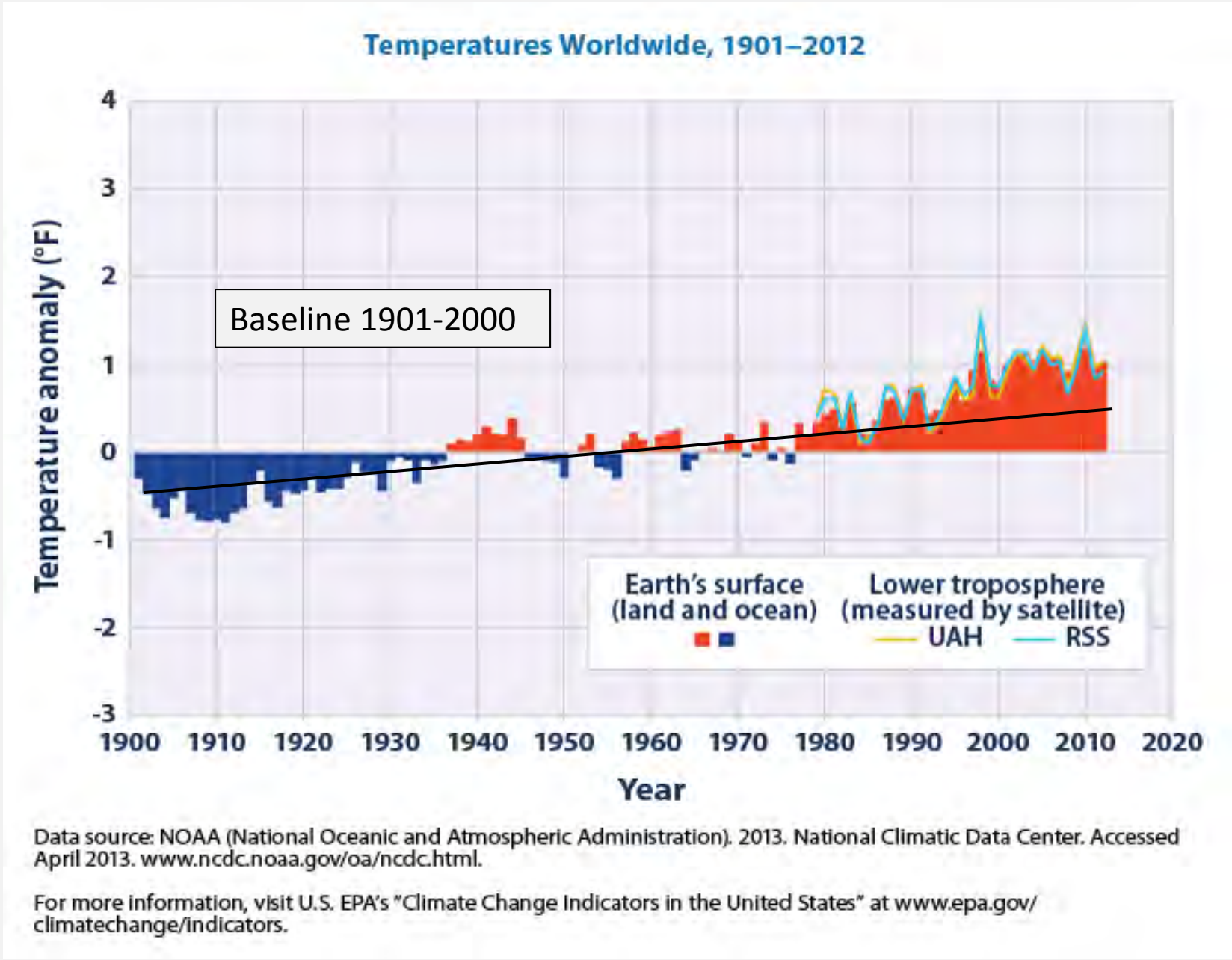
MELTING ICE AND WARMING OCEANS RESULT IN...

Rising Sea Level



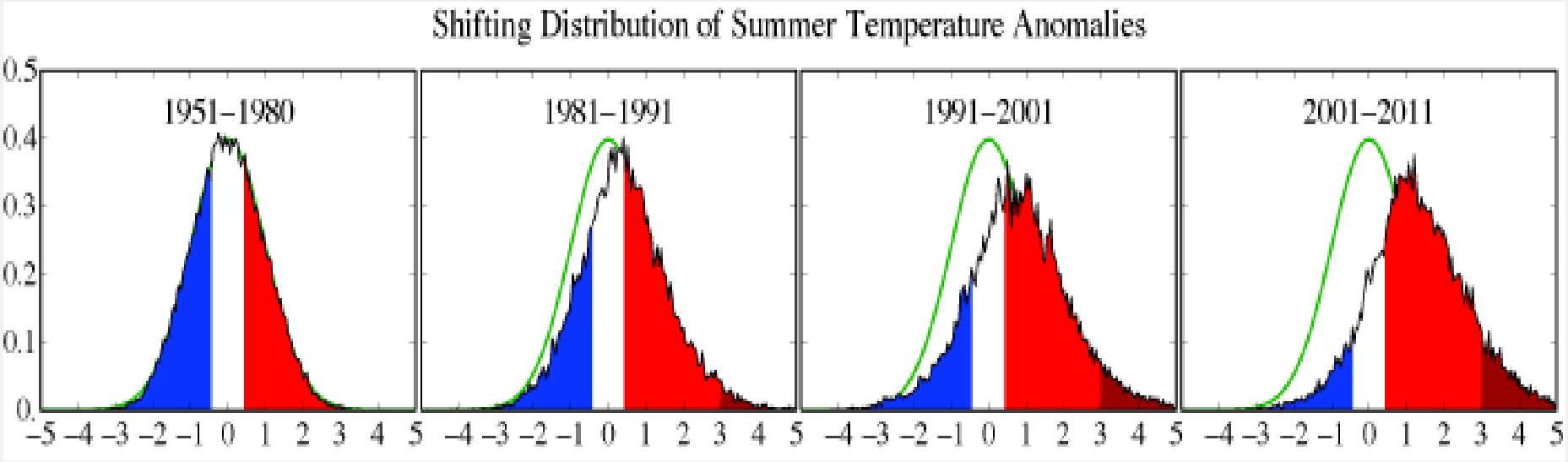
http://www.epa.gov/climatechange/science/indicators/oceans/sea-level.html

LAND/SEA SURFACE TEMPERATURES ARE RISING…



http://www.epa.gov/climatechange/science/indicators/weather-climate/temperature.html

LAND TEMPERATURES ARE SHIFTING TOWARD HIGHER EXTREMES...



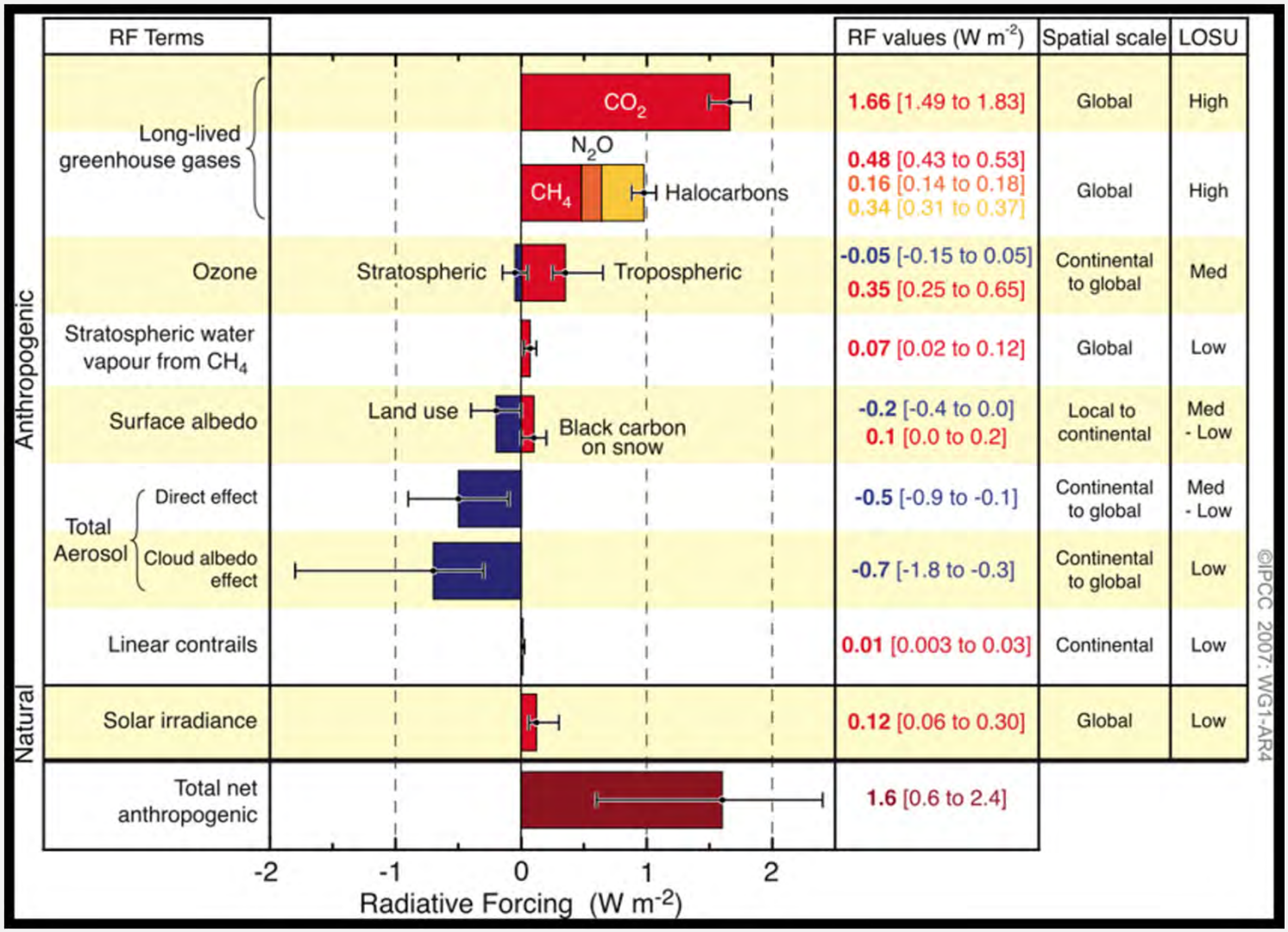
= Below Normal Temperatures

= Above Normal Temperatures

http://www.giss.nasa.gov/research/briefs/hansen_17/

WHAT FACTORS ARE INFLUENCING THE OBSERVED WARMING?

Radiative Forcing Perspective



http://www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-human-and.html

Modeling Perspective

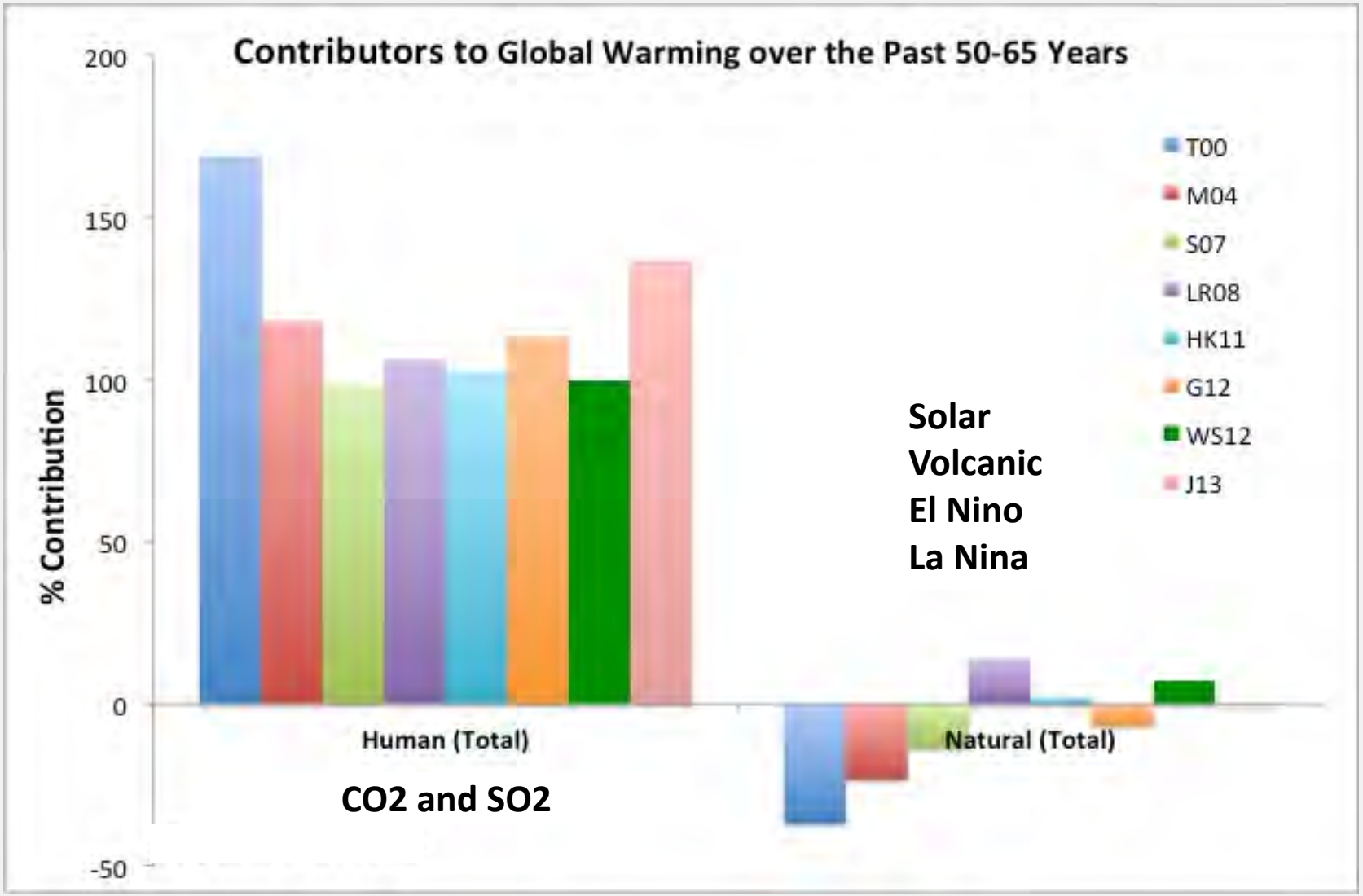
1) **Take 25 to 65 years of well sampled surface and atmospheric data.**
2) **Run your model over the same 25 to 65 year period of record.**
3) **Compare the model results to the observations.**

Types of Models:

a) **Dynamic Models/Ensembles**
b) **Statistical/Attribution Models**

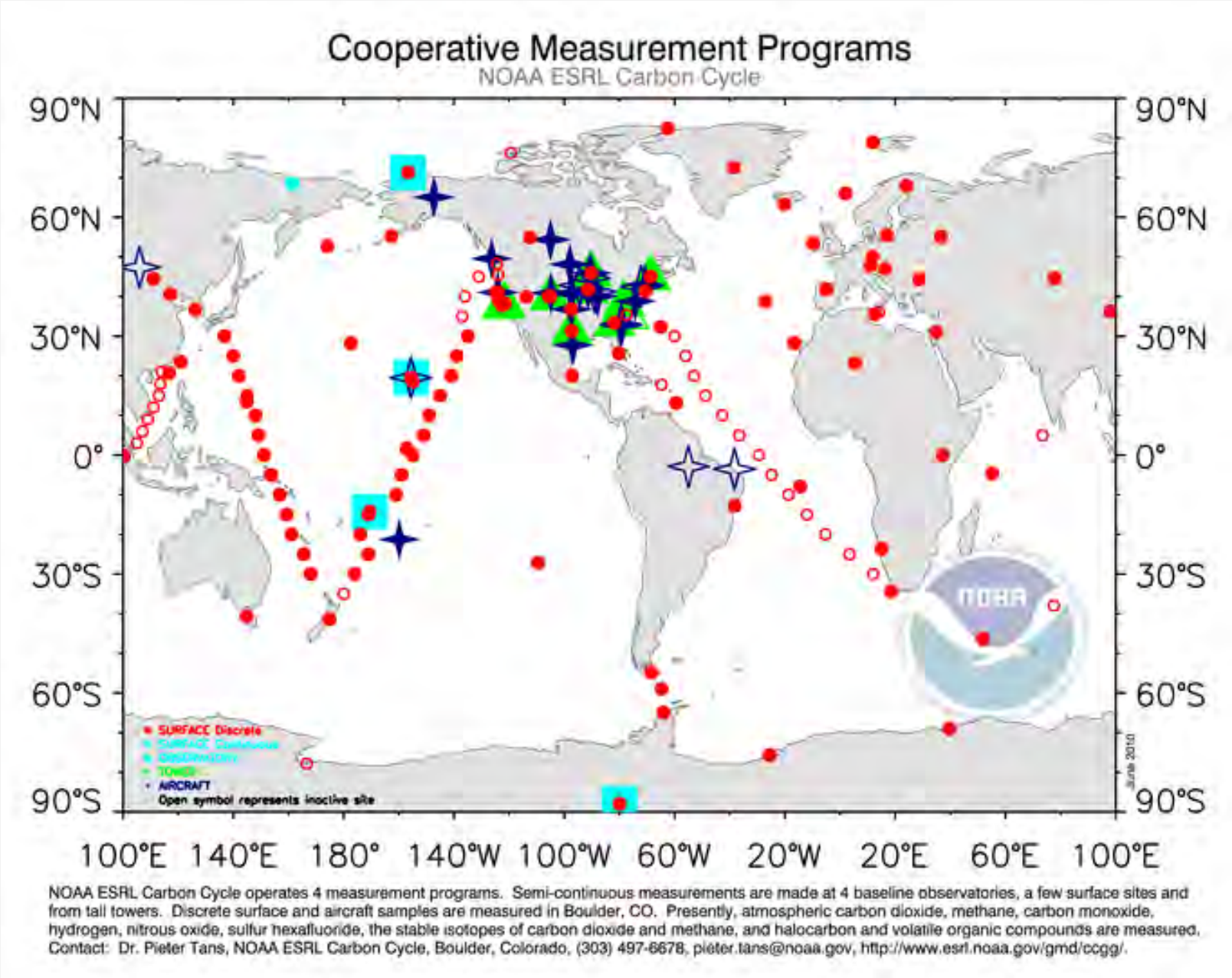
AND THE ANSWER IS…

Modeling Perspective



http://www.skepticalscience.com/graphics.php?g=57

WHAT IS CAUSING CO2 TO INCREASE?



http://www.esrl.noaa.gov/gmd/outreach/isotopes/

CO2 Balance Sheet

CO2 Increases by 2 ppm = 15 Billion tons per year

Fossil Fuel Burning = 30 Billion tons per year

Change in CO2 = CO2 Sources - CO2 Sinks

Change in CO2 = (CO2 Sources Natural - CO2 Sinks Natural)
+ (CO2 Sources Human - CO2 Sinks Human)

15 = (CO2 Sources Natural - CO2 Sinks Natural)
+ (30 - CO2 Sinks Human)

-15 = (CO2 Source Natural - CO2 Sink Natural - CO2 Sink Human)

Everything Else put together is a sink!

Summary

- Numerous “fingerprints” point toward a warming planet.
- Physical understanding and modeling show that CO2 is the main player in the observed warming.
- Human activity/fossil fuel burning is resulting in Increasing CO2 levels.
- Shift to a discussion about IMPACTS!

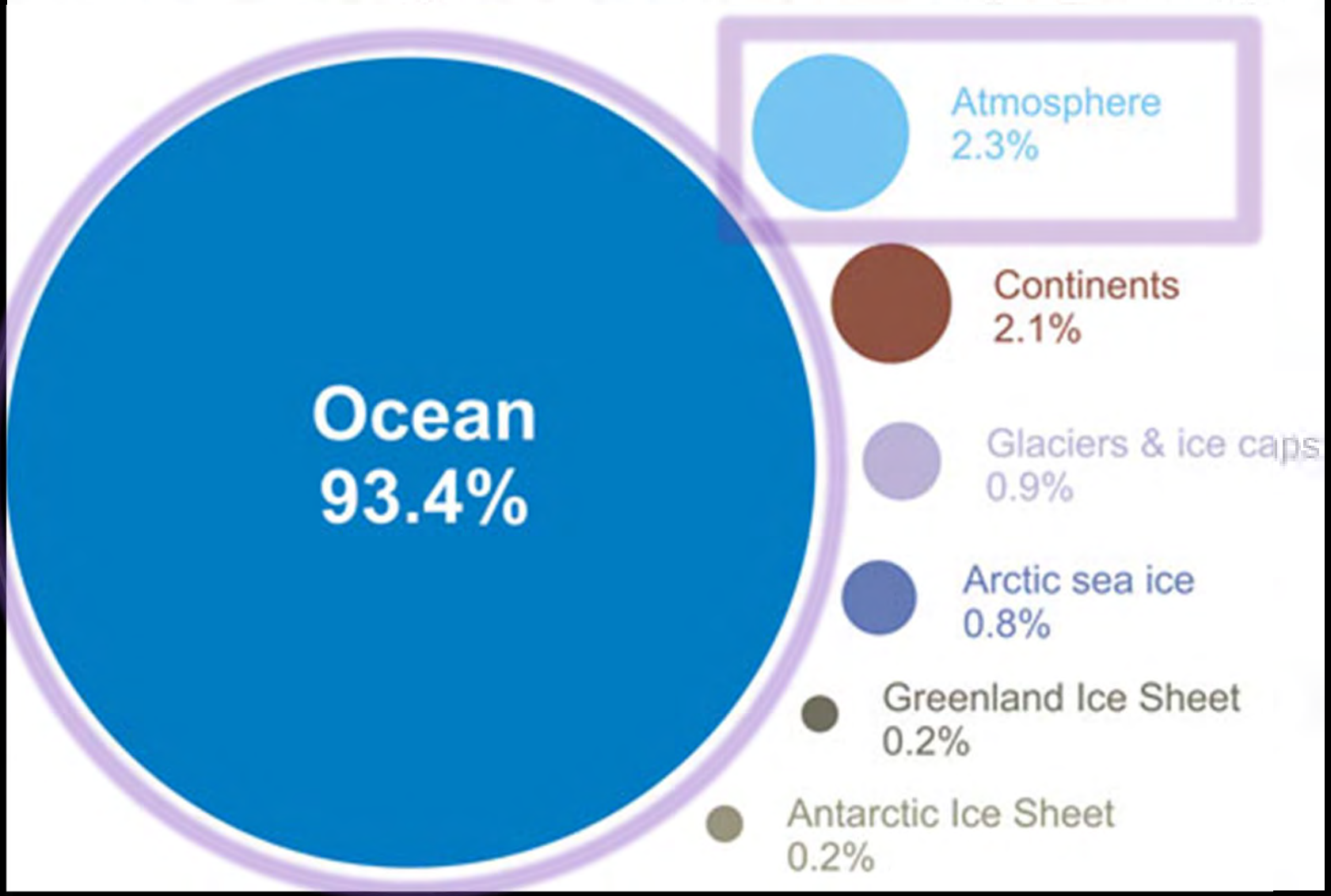
Modeling References

The studies are Tett et al. 2000 (T00, dark blue), Meehl et al. 2004 (M04, red), Stone et al. 2007 (S07, green), Lean and Rind 2008 (LR08, purple), Huber and Knutti 2011 (HK11, light blue), Gillett et al. 2012 (G12, orange), Wigley and Santer 2012 (WS12, dark green), and Jones et al. 2013 (J13, pink). The numbers in this summary are best estimates from each study; uncertainty ranges can be found in the original research.

http://www.skepticalscience.com/graphics.php?g=57

CLIMATE CHANGE IMPACTS

Where is global warming going?



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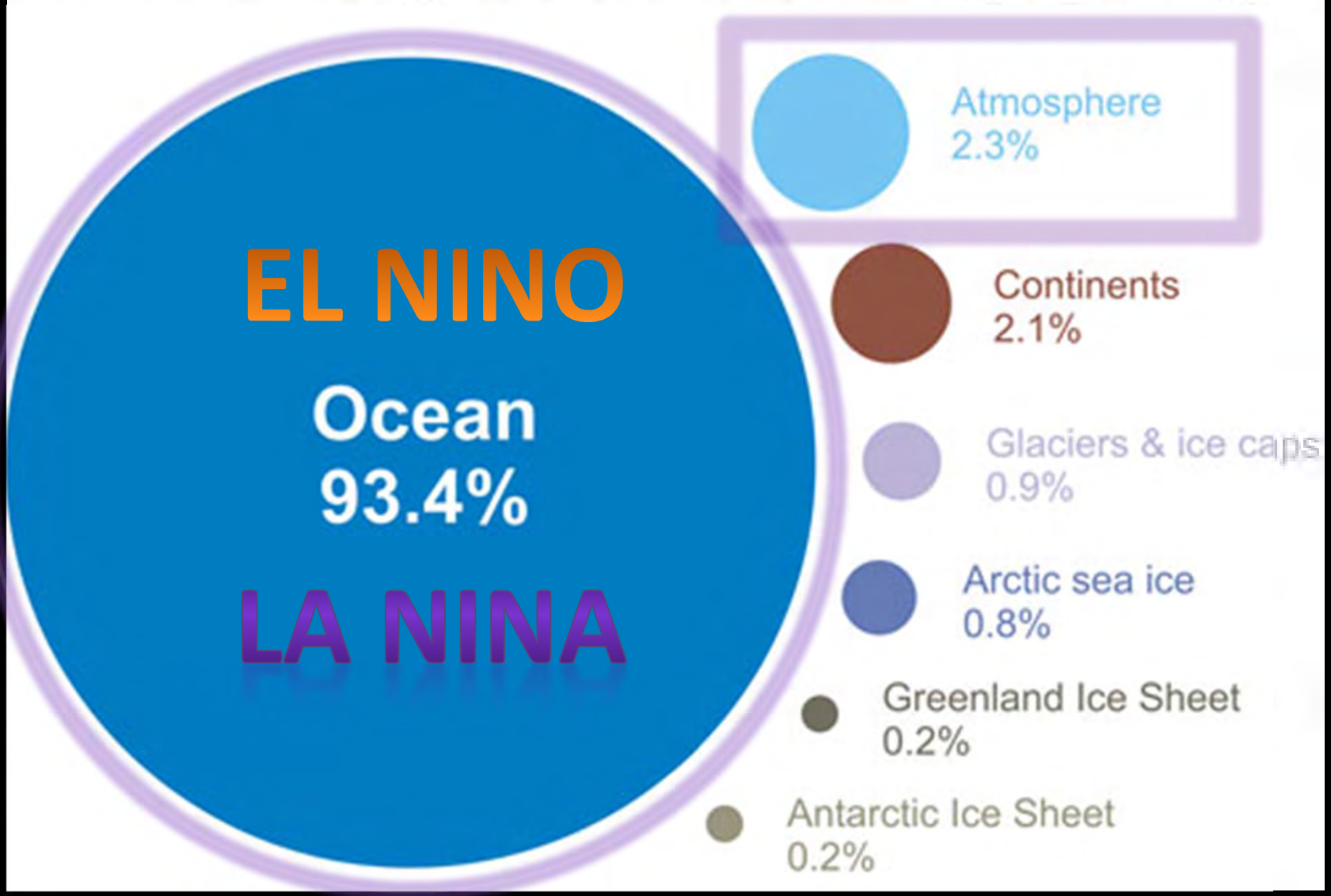

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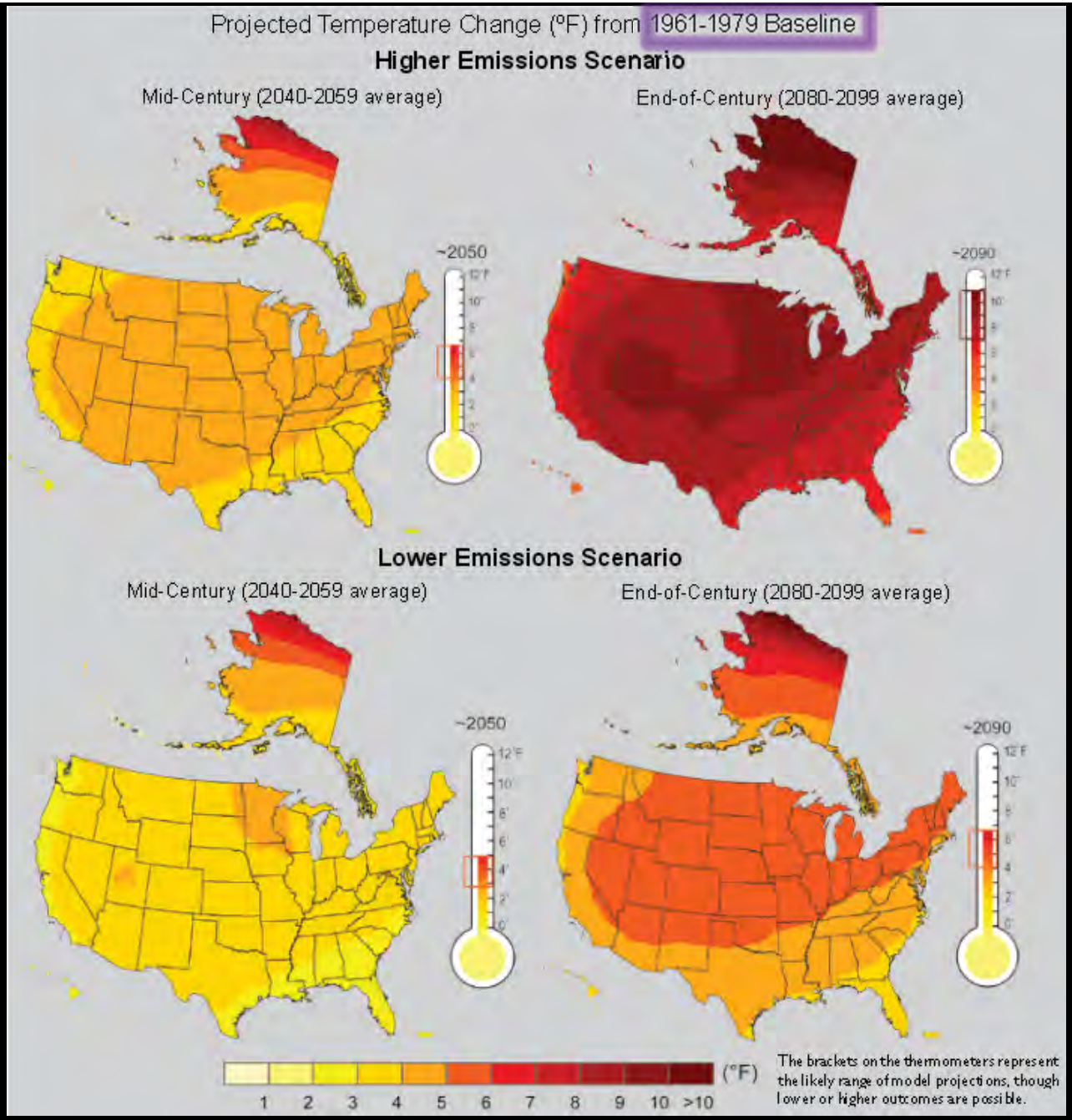
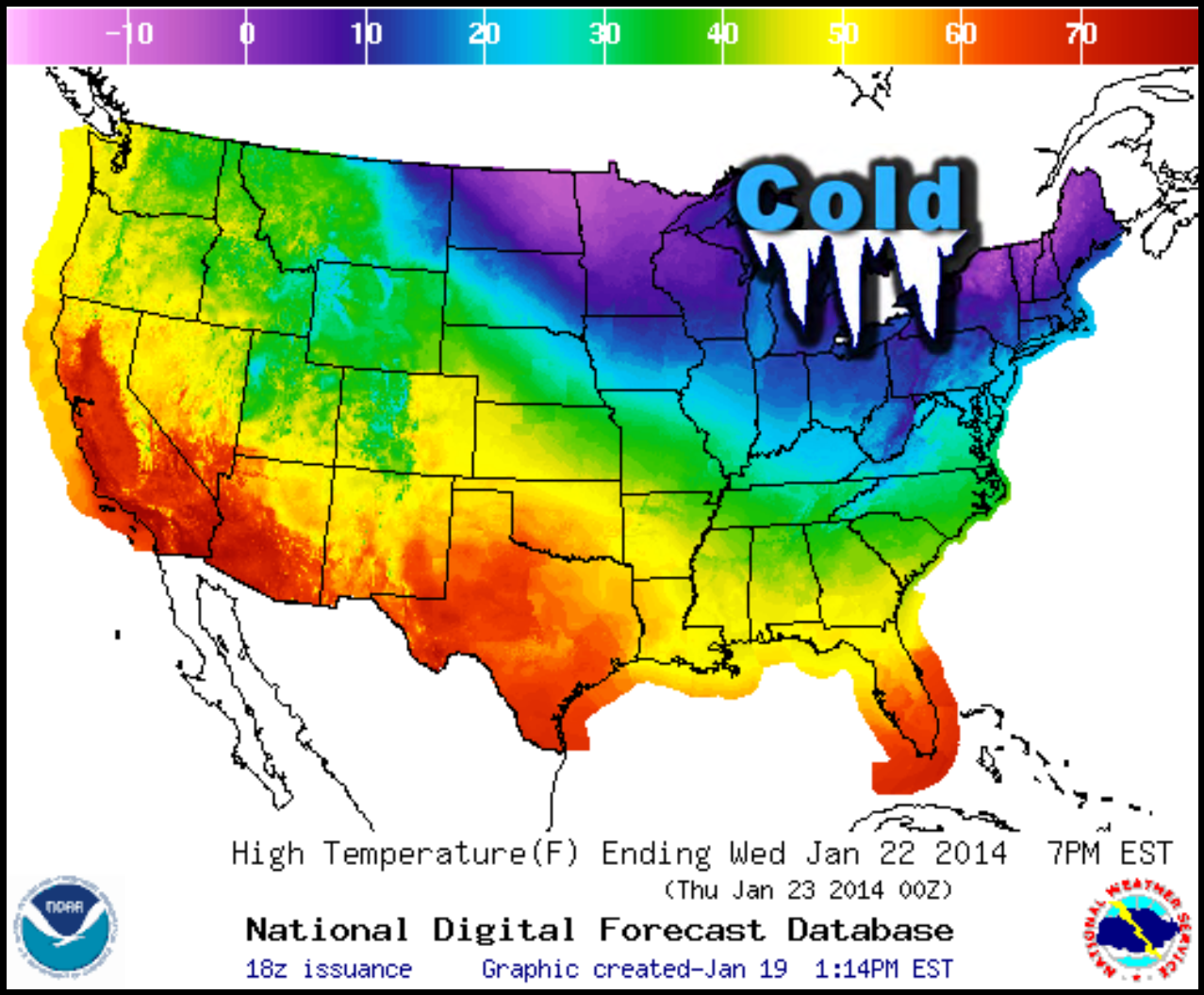


http://downloads.globalchange.gov/usimpacts/pdfs/20page-highlights-brochure.pdf

POLAR JET STREAM



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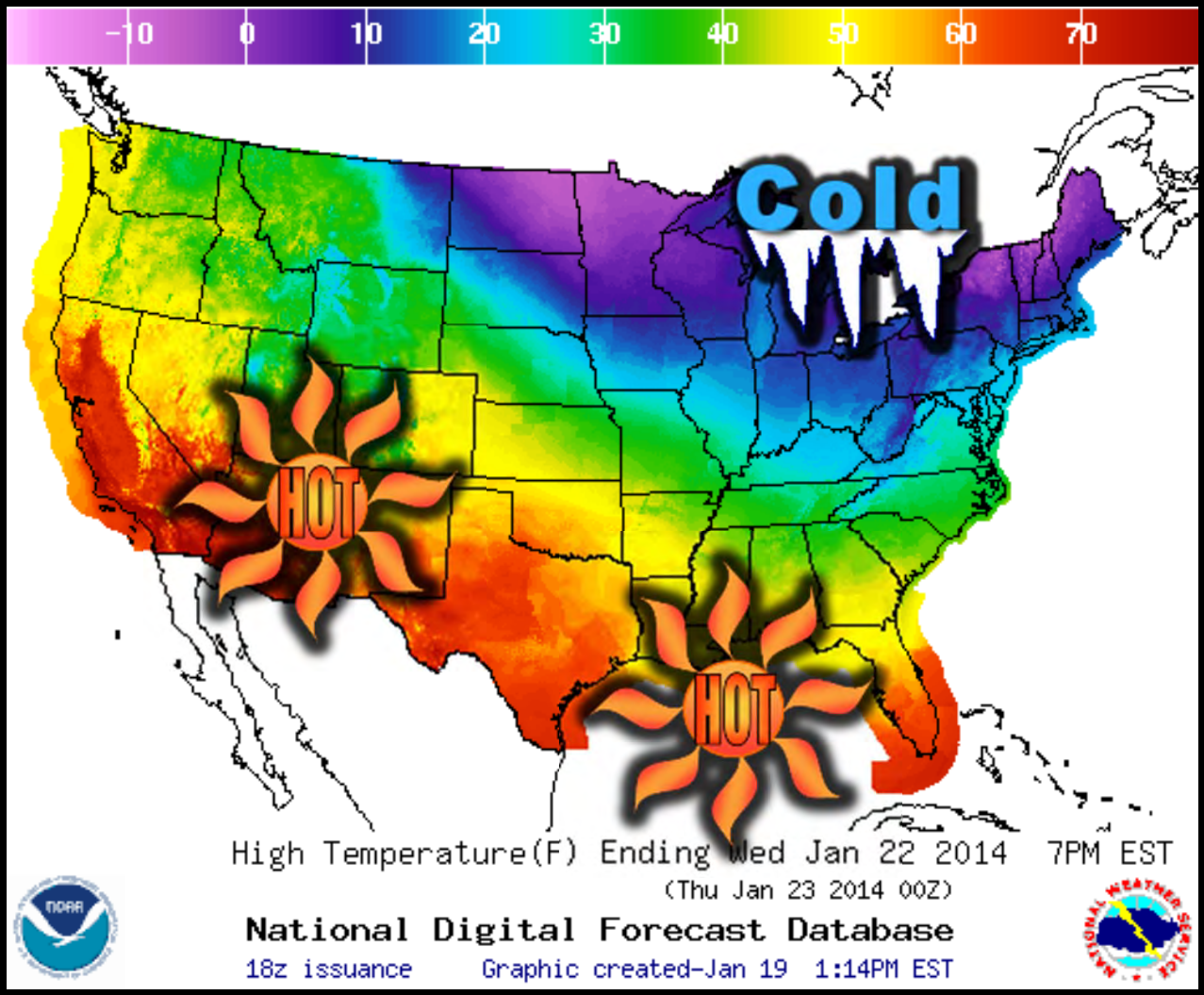

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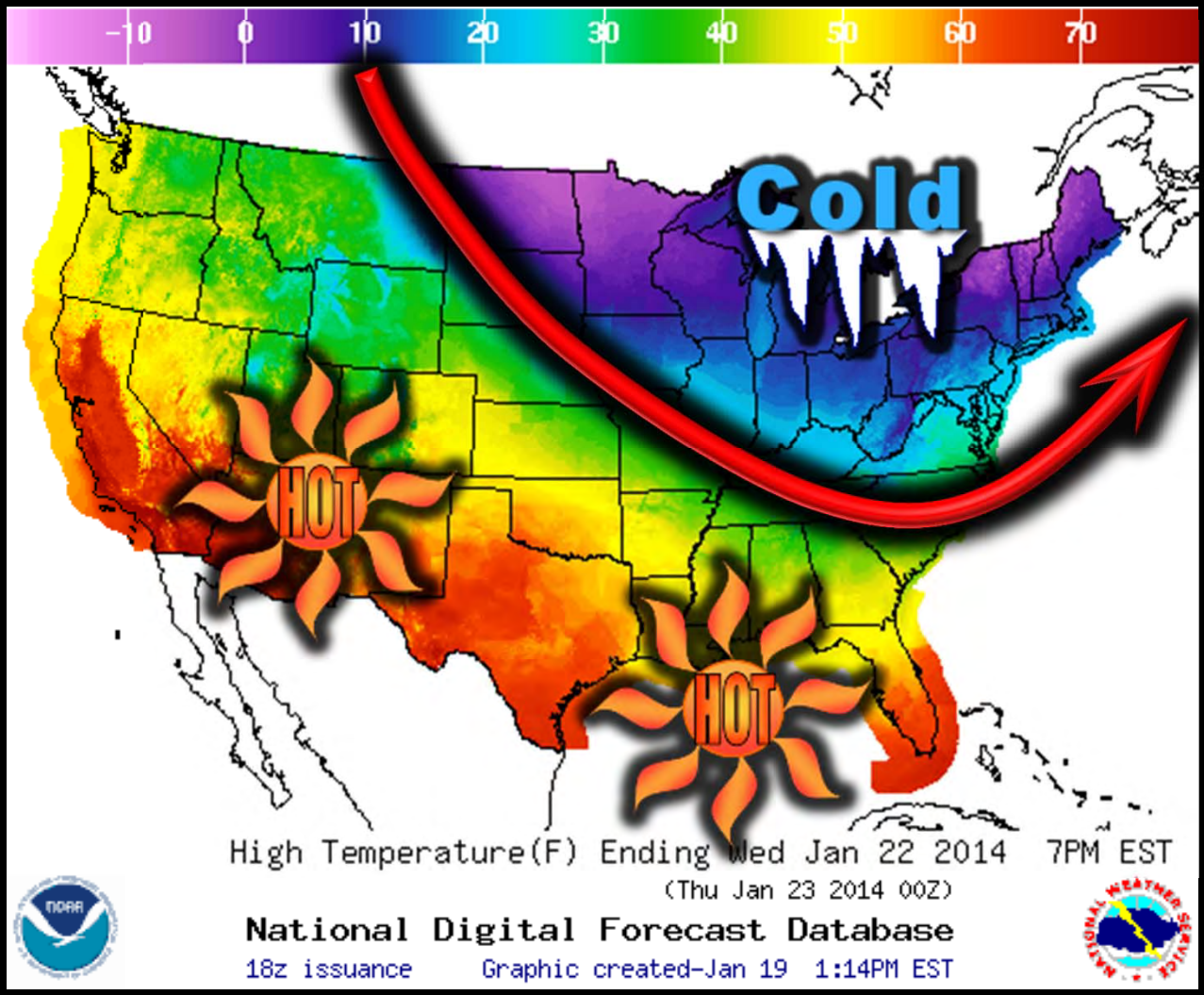

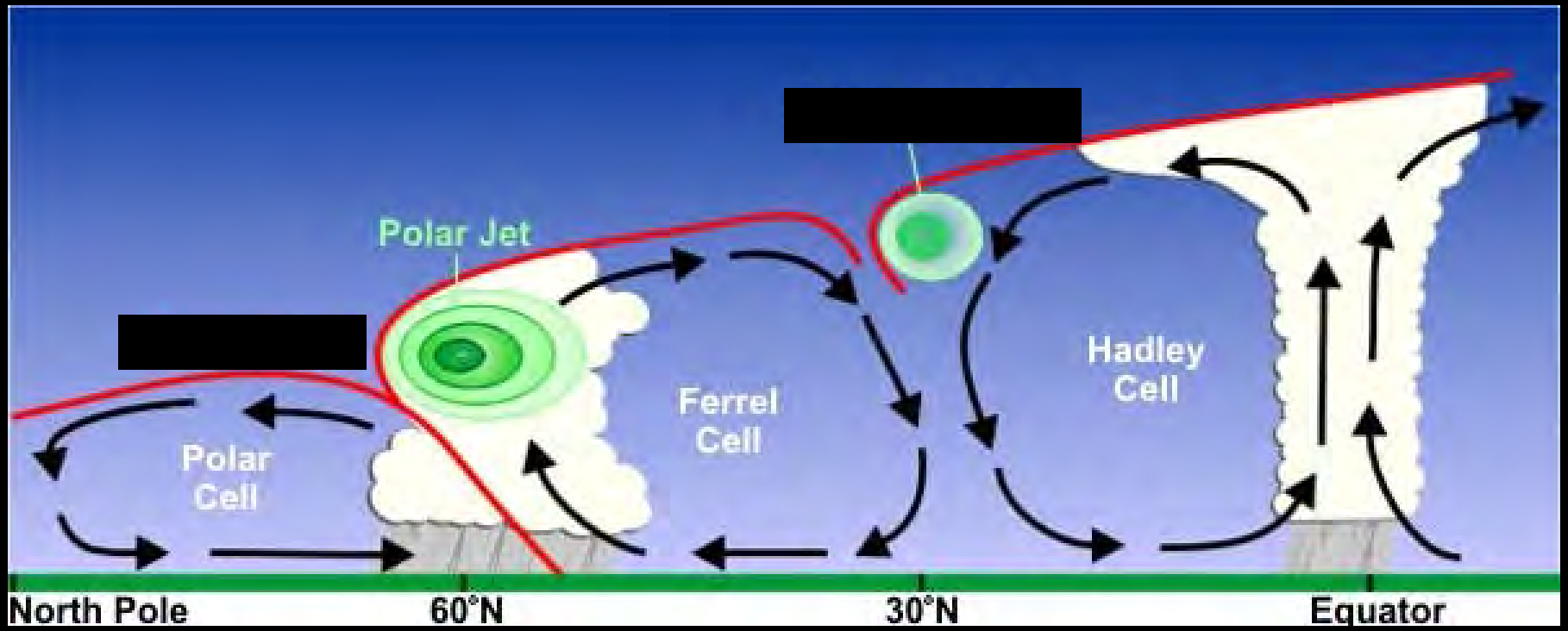
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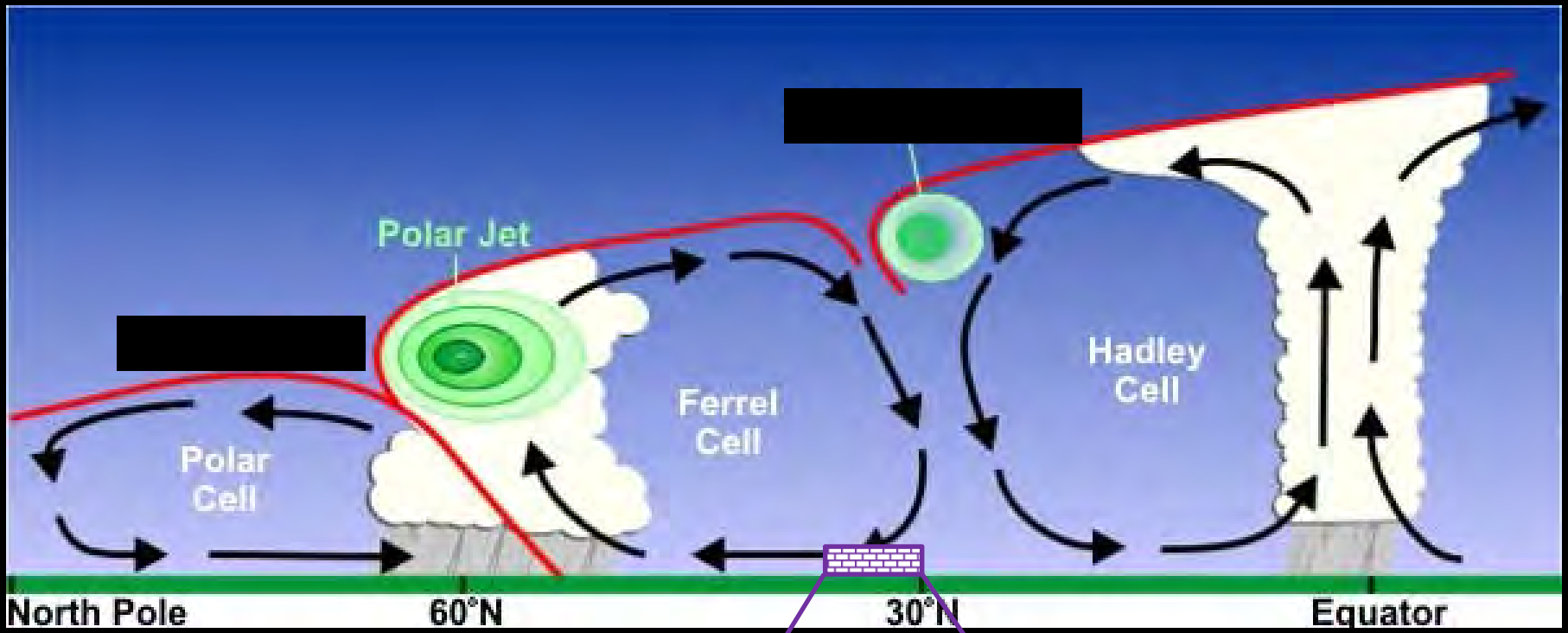
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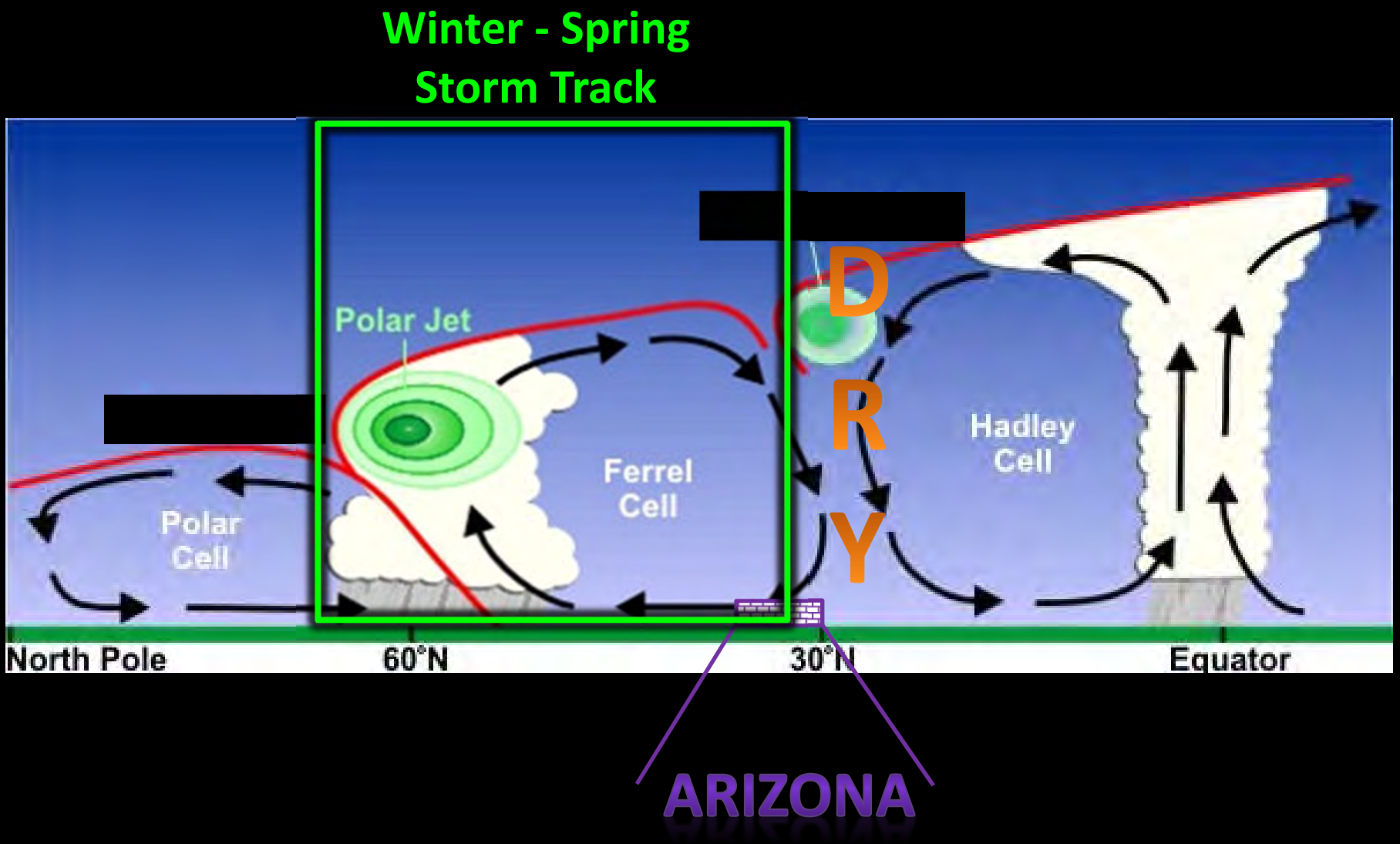
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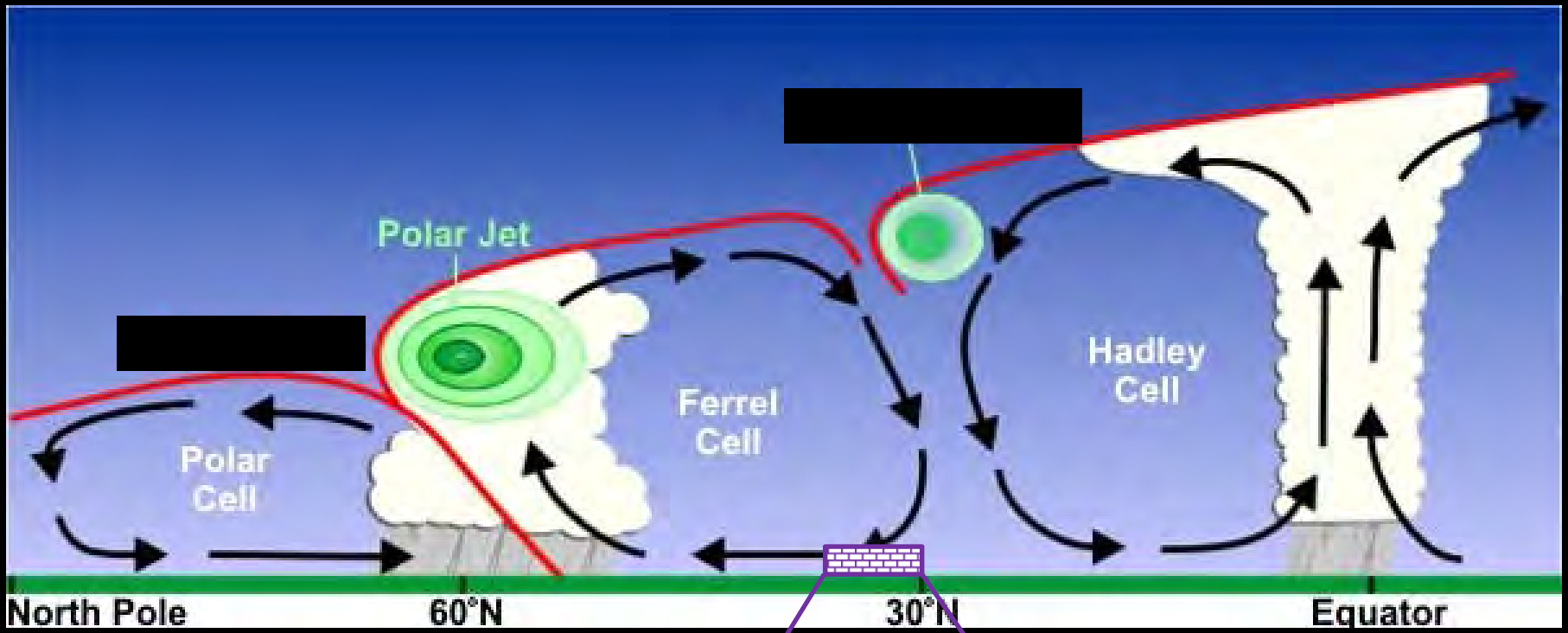
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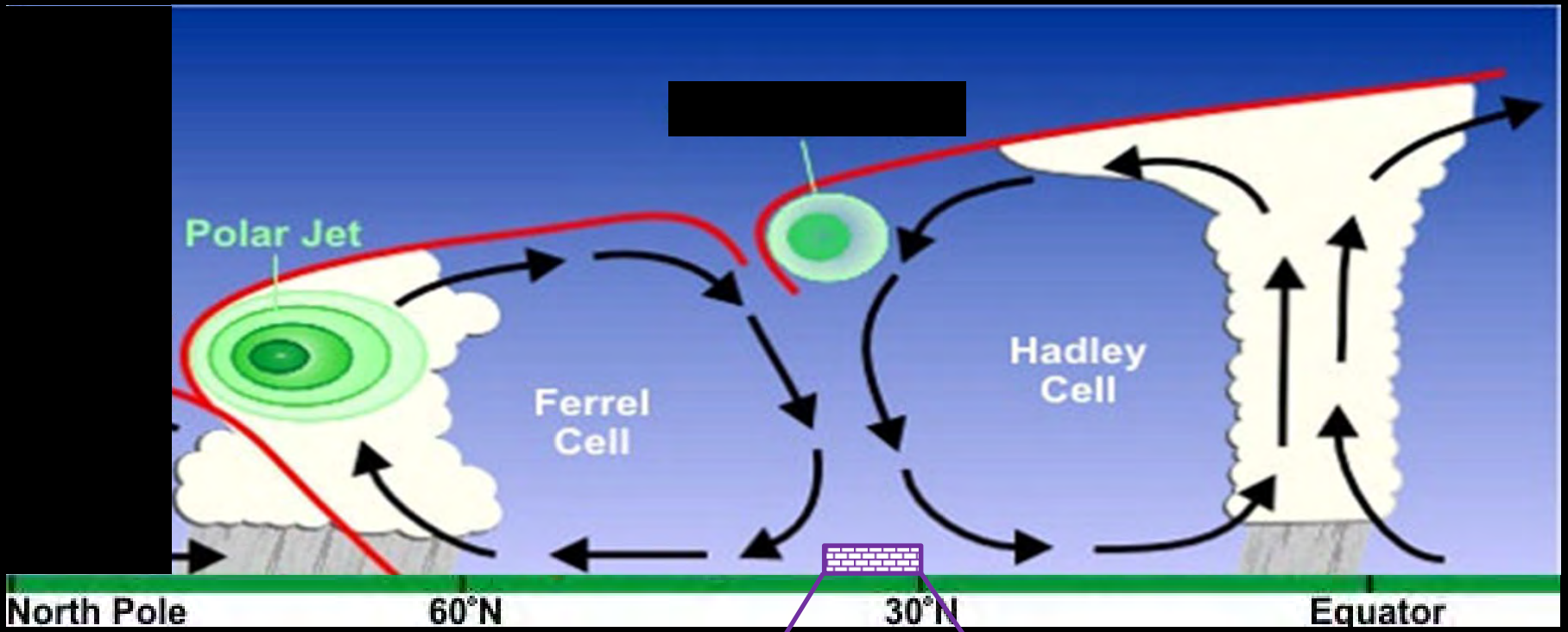
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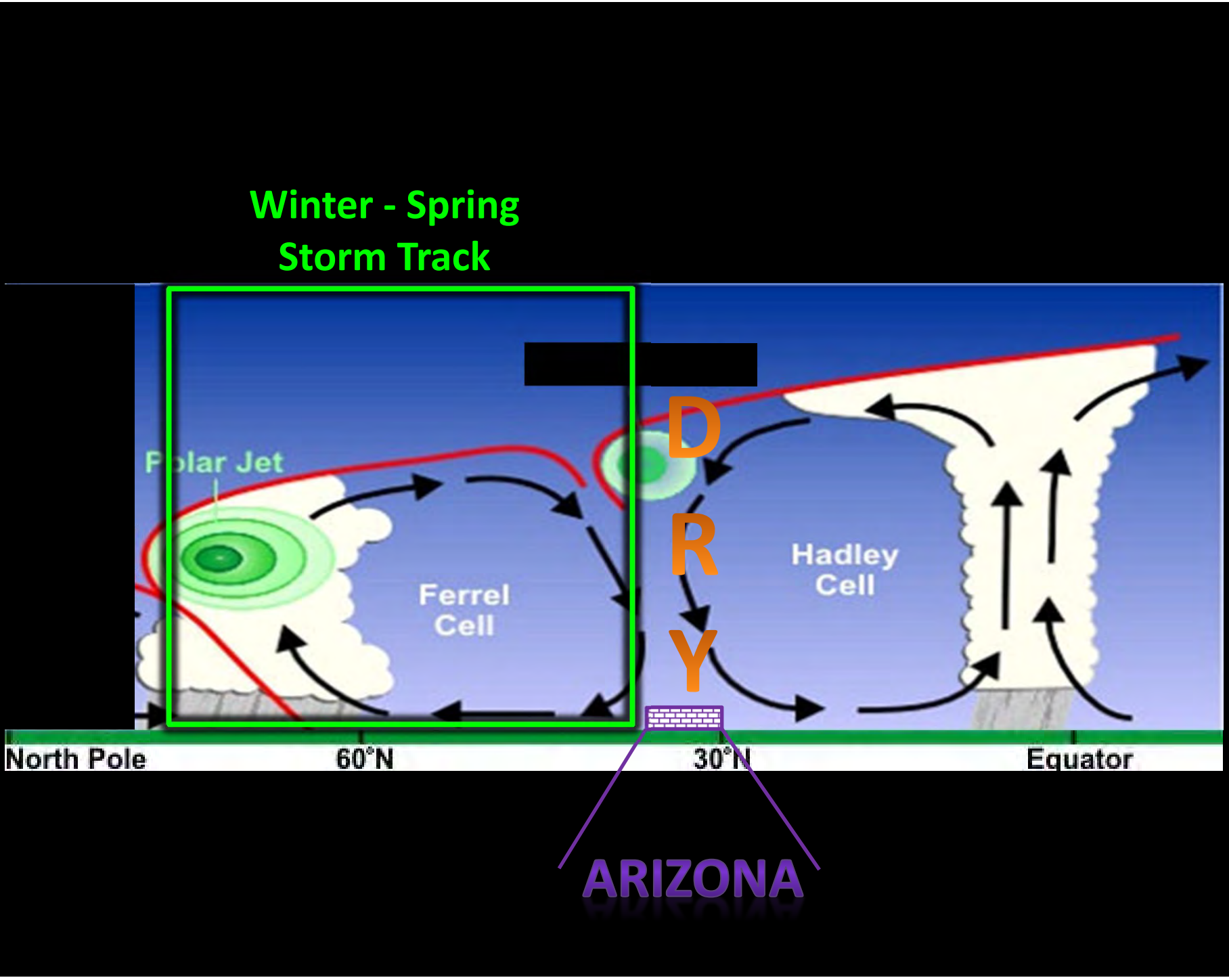
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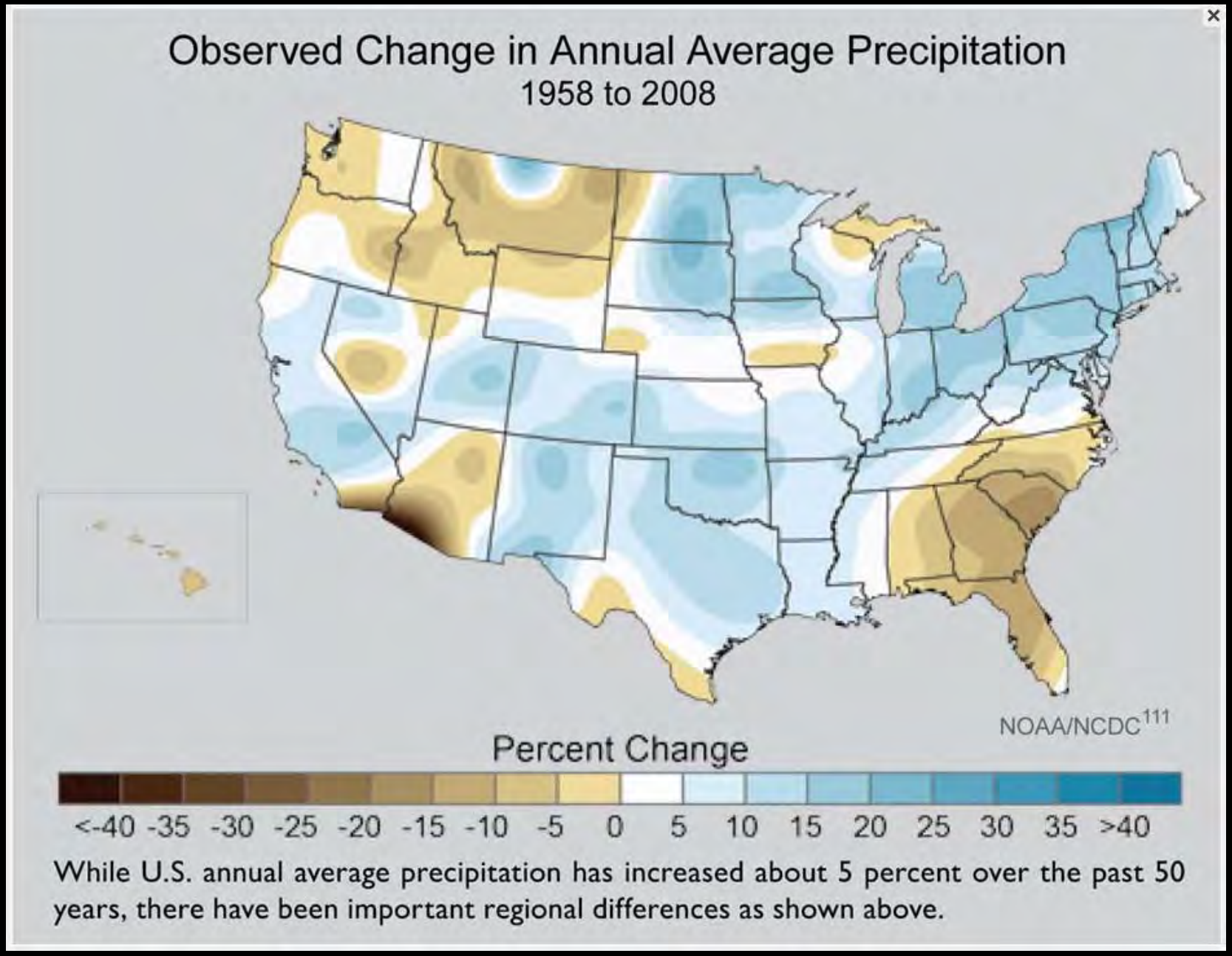
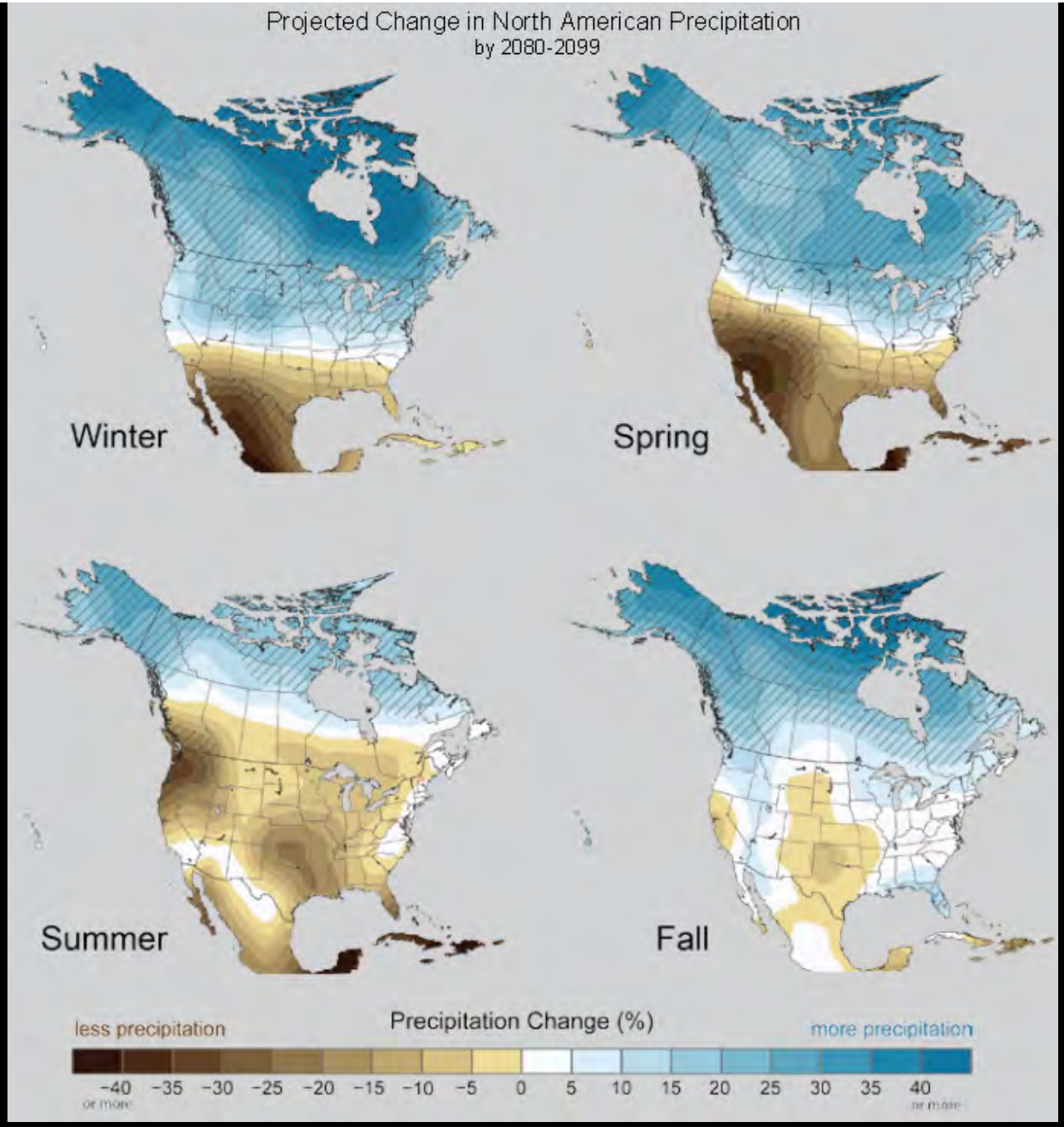


http://www.climas.arizona.edu/sw-climate/climate-change



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Regional Downscaling

Statistical

- Cheap
- Easy Computations
- Point Scale Output

Dynamic

- Output based on physical processes.
- Dynamic forcing from regional processes and terrain.

Regional Downscaling

Statistical

- Cheap
- Easy Computations
- Point Scale Output

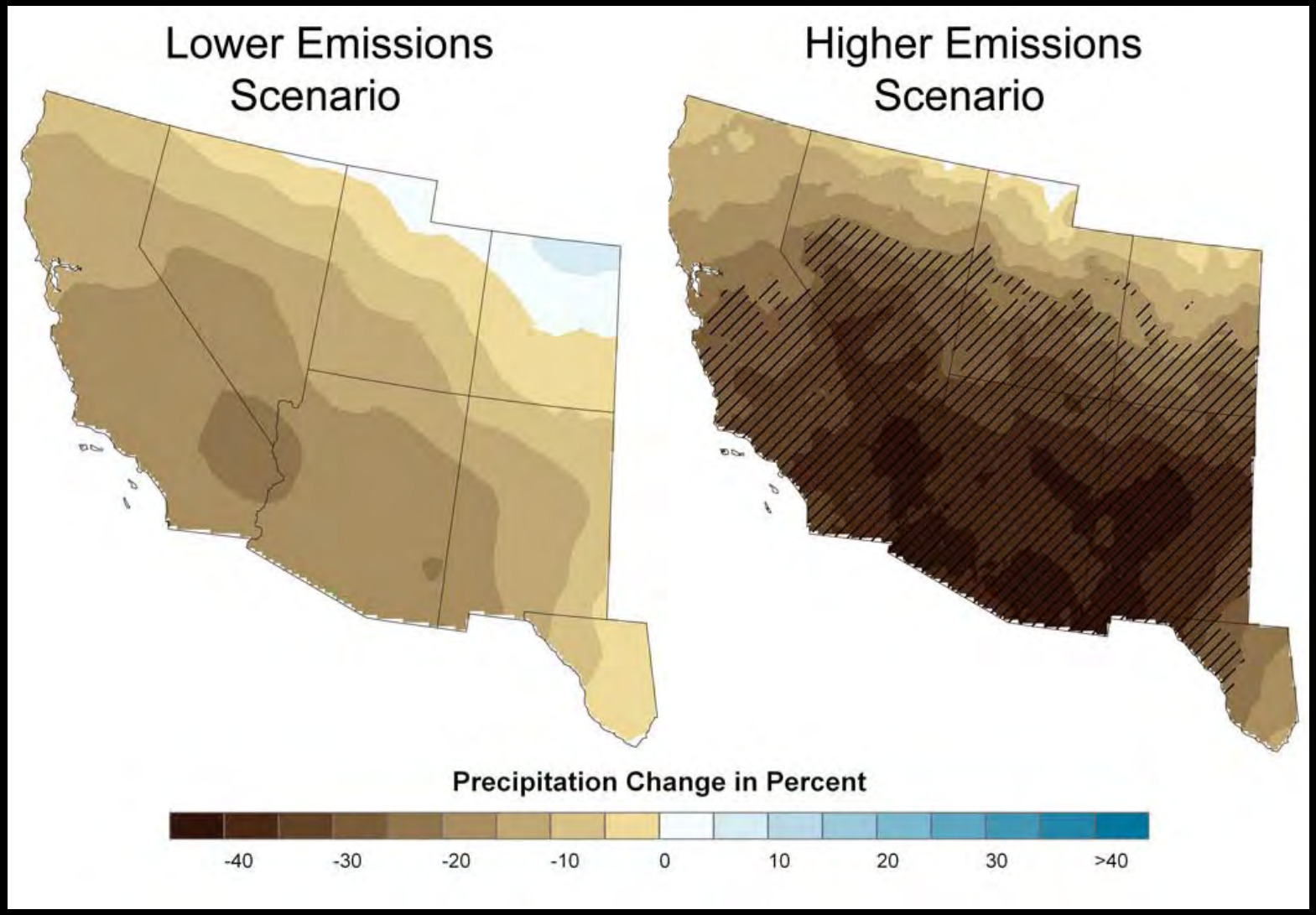
- Terrain effects limited
- Regional climate forcing not applied

Dynamic

- Output based on physical processes.
- Dynamic forcing from regional processes and terrain.

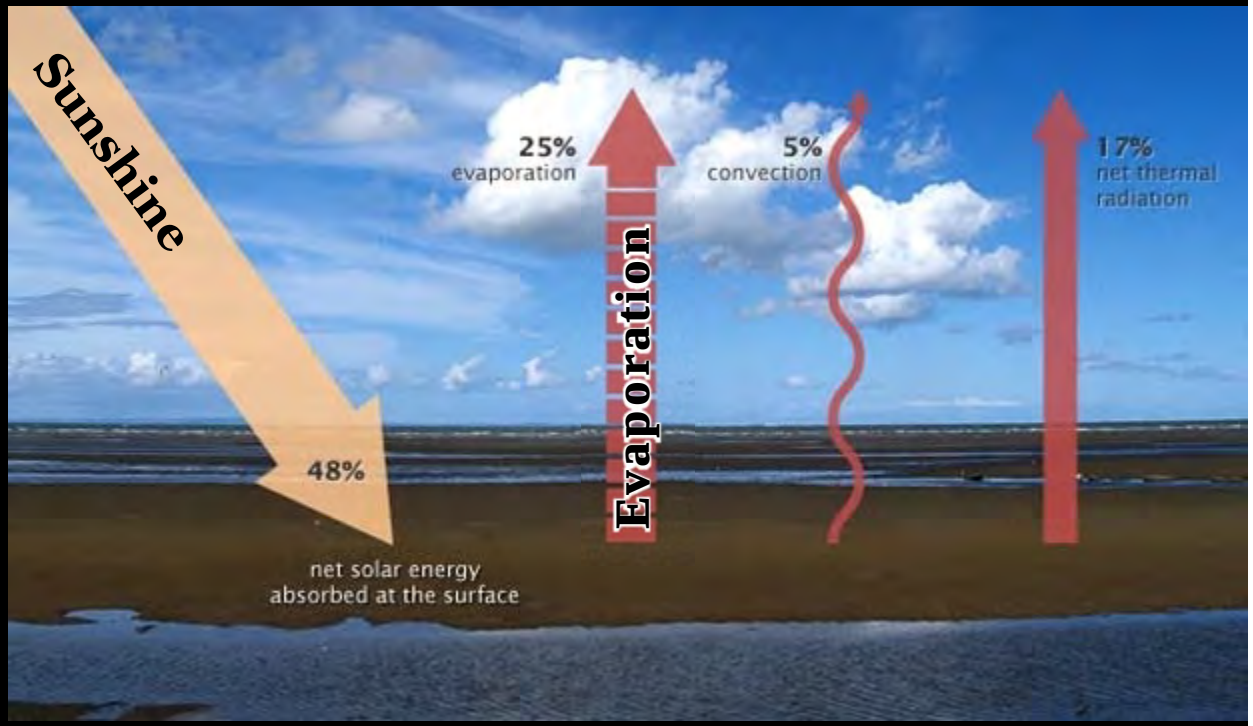
- Expensive
- Heavy Computations
- Biases dependent upon global and regional climate model parameters

Regional Downscaling



http://learningcenter.nsta.org/products/symposia_seminars/fall09/NOAA/webseminar1.aspx

Soil Moisture Changes



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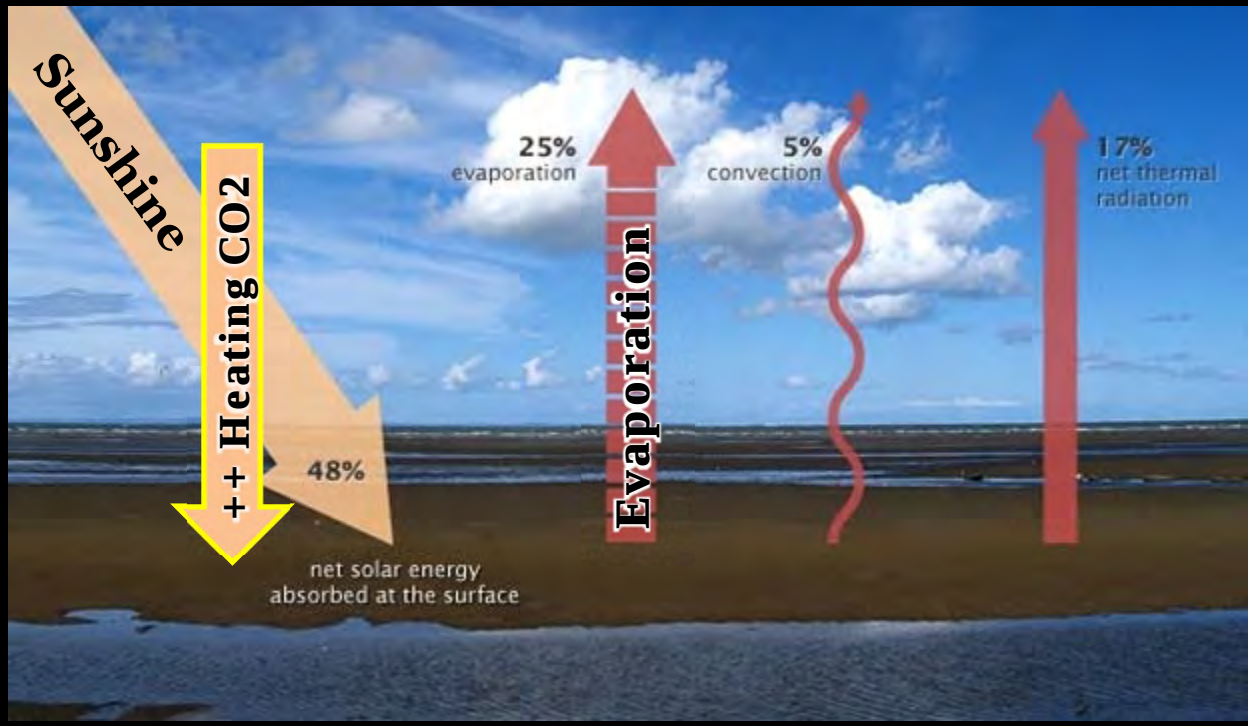

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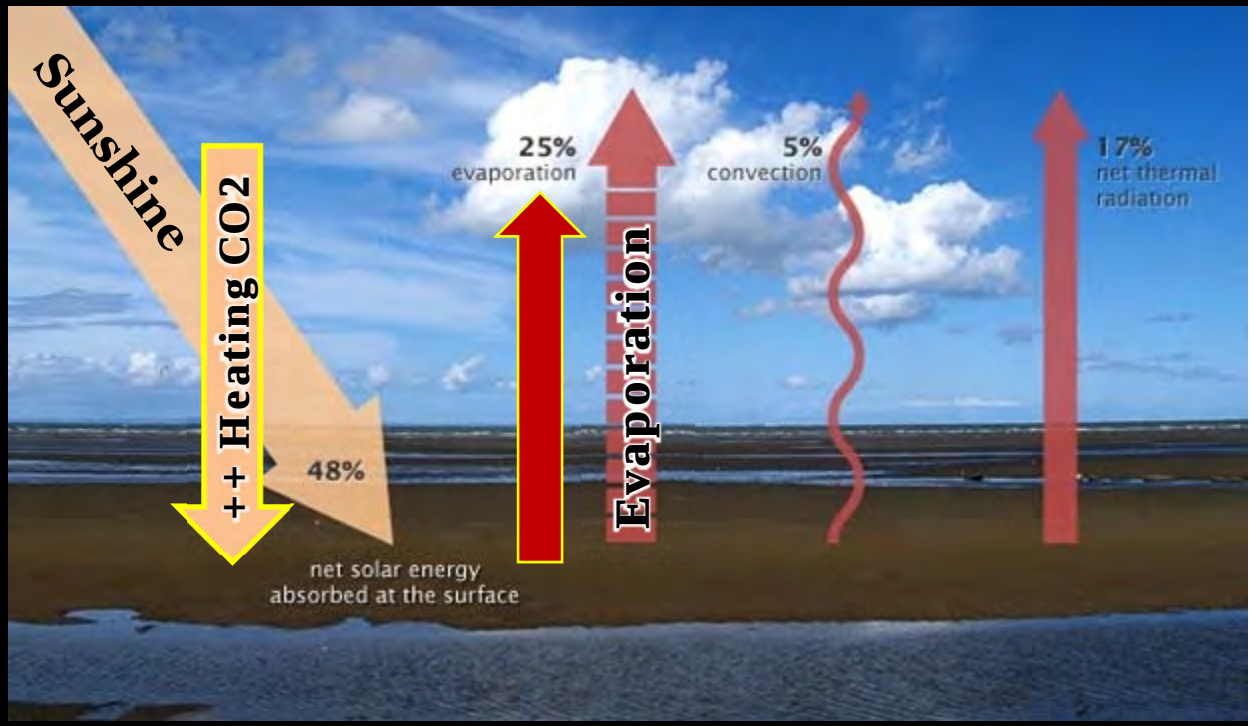

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From

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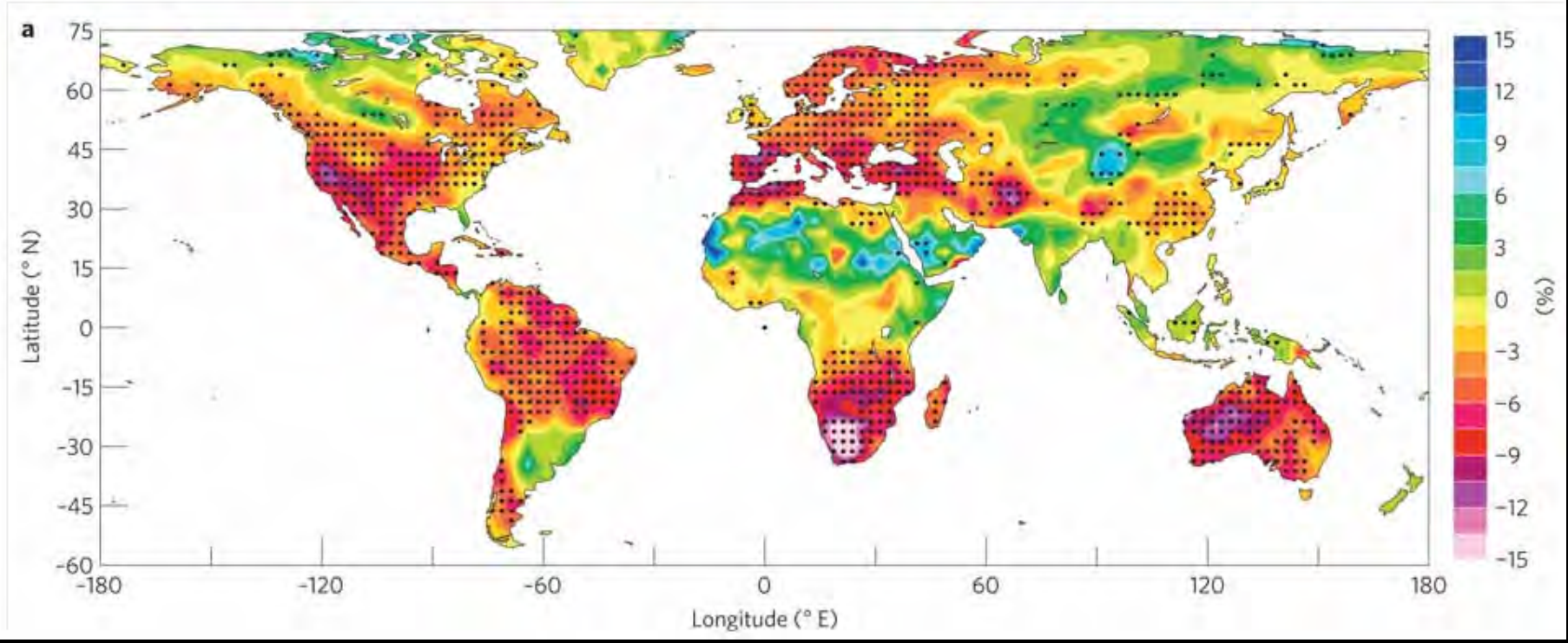
Received 30 April 2012 | Accepted 25 June 2012 | Published online 05 August 2012 | Corrected online **22 January 2013**



RCP 4.5w/m2 Emissions Scenario

http://www.nature.com/nclimate/journal/v3/n1/fig_tab/nclimate1633_F2.html

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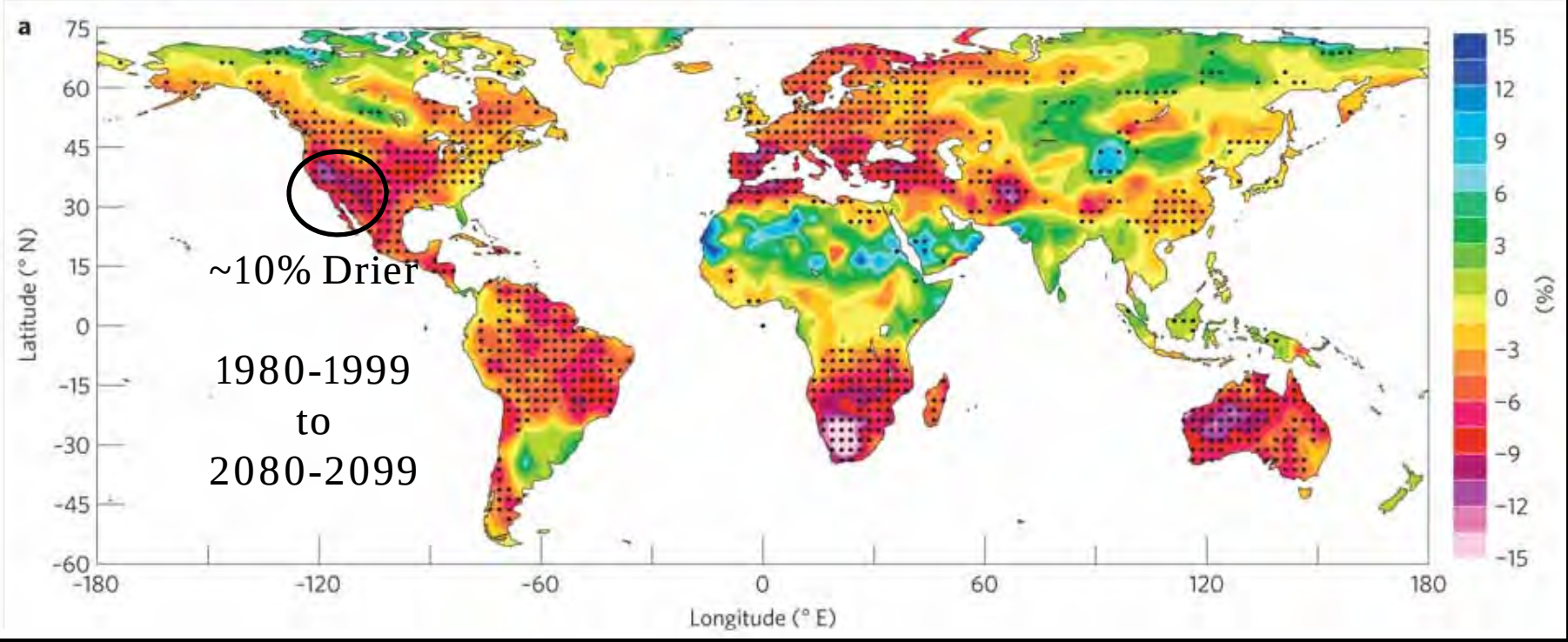

RCP 4.5w/m2 Emissions Scenario

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Warmer Earth

Soil Moisture Changes

Storm Track Changes

Warmer Earth

Soil Moisture Changes

- Warmer ground increases evaporation rates
- Resulting in drier soil moisture

Storm Track Changes

Warmer Earth

Soil Moisture Changes

- Warmer ground increases evaporation rates
- Resulting in drier soil moisture

Storm Track Changes

- Winter & Spring storm track moves further north
- Decreasing storm activity in the southwest
- Less precipitation events
- Higher chances for extended drought periods

Ecology Questions ???

Given the climate change forecast for drier soil moisture, along with drier winters and springs.

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What happens if...

we plan for a drier climate and in 50 years the climate is less dry?

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What happens if...
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What happens if...
we plan for a no change climate and in 50 years the climate is drier?