



University of Colorado **Boulder**



National Snow and Ice Data Center  
Advancing knowledge of Earth's frozen regions



# Climate Change: The Arctic Leading the Way

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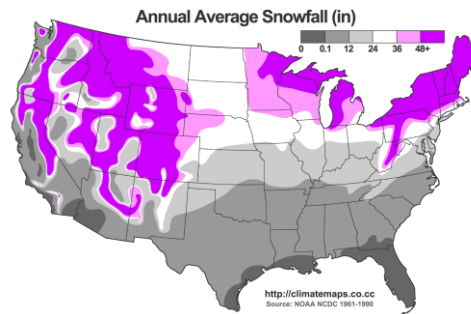
# Climate Versus Weather

Weather is the day-to-day state of the atmosphere, and its short-term variation in minutes to weeks. "How hot is it right now?" "Will we get a snowstorm next week?"

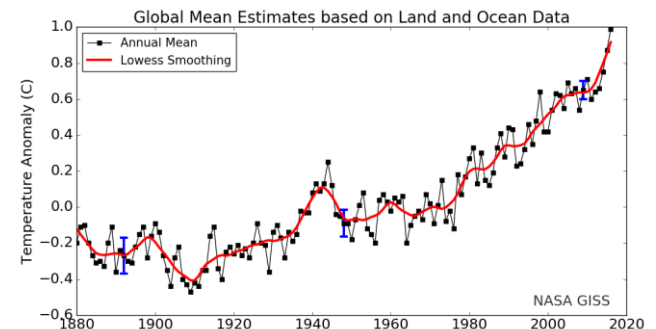
Climate is the weather averaged over a period of time, often 30 years. Climate information includes the statistical weather information that tells us about the average weather, as well as the range of weather extremes.



Weather



Regional climate

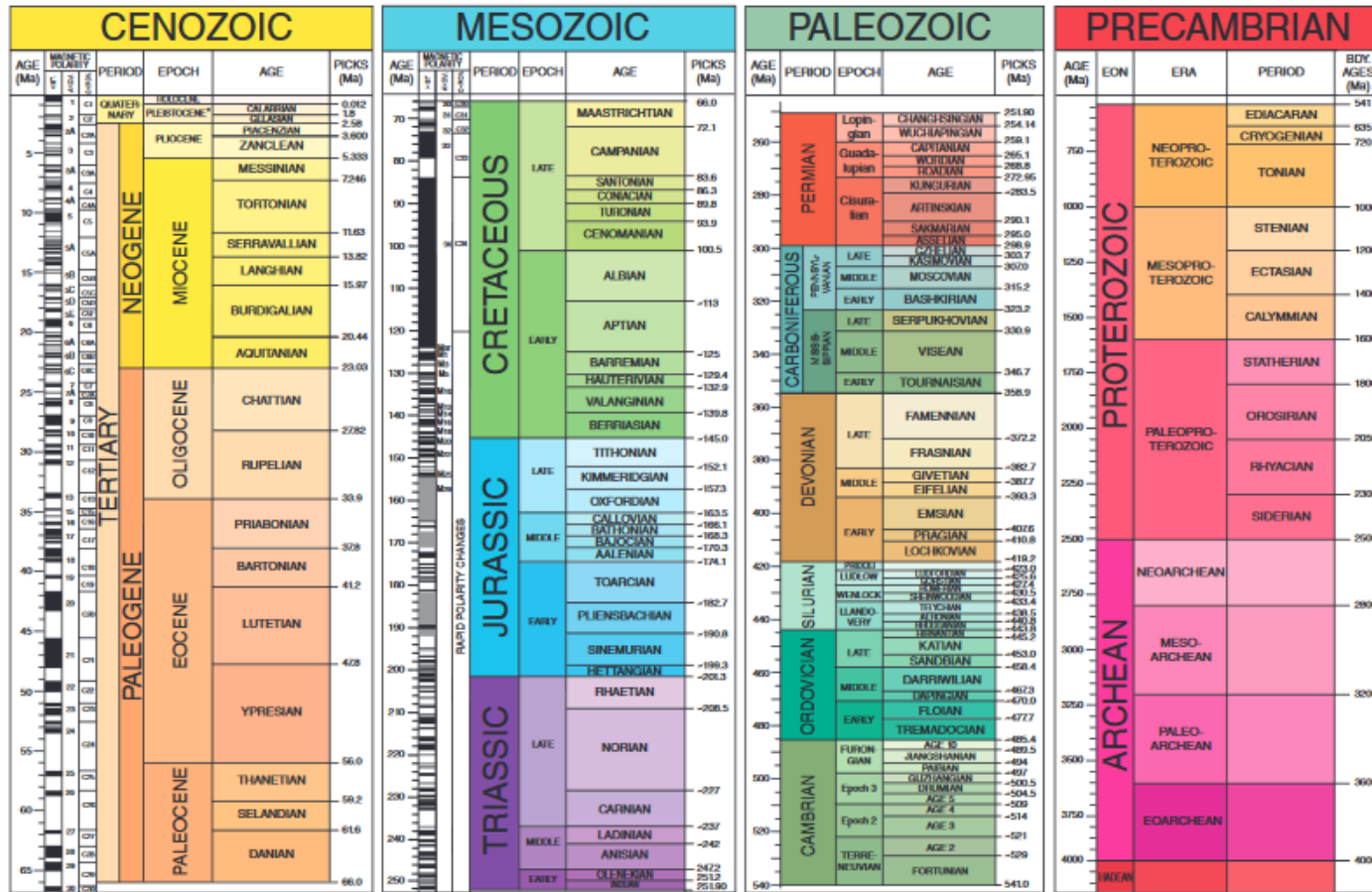


Global climate

# Climate Change

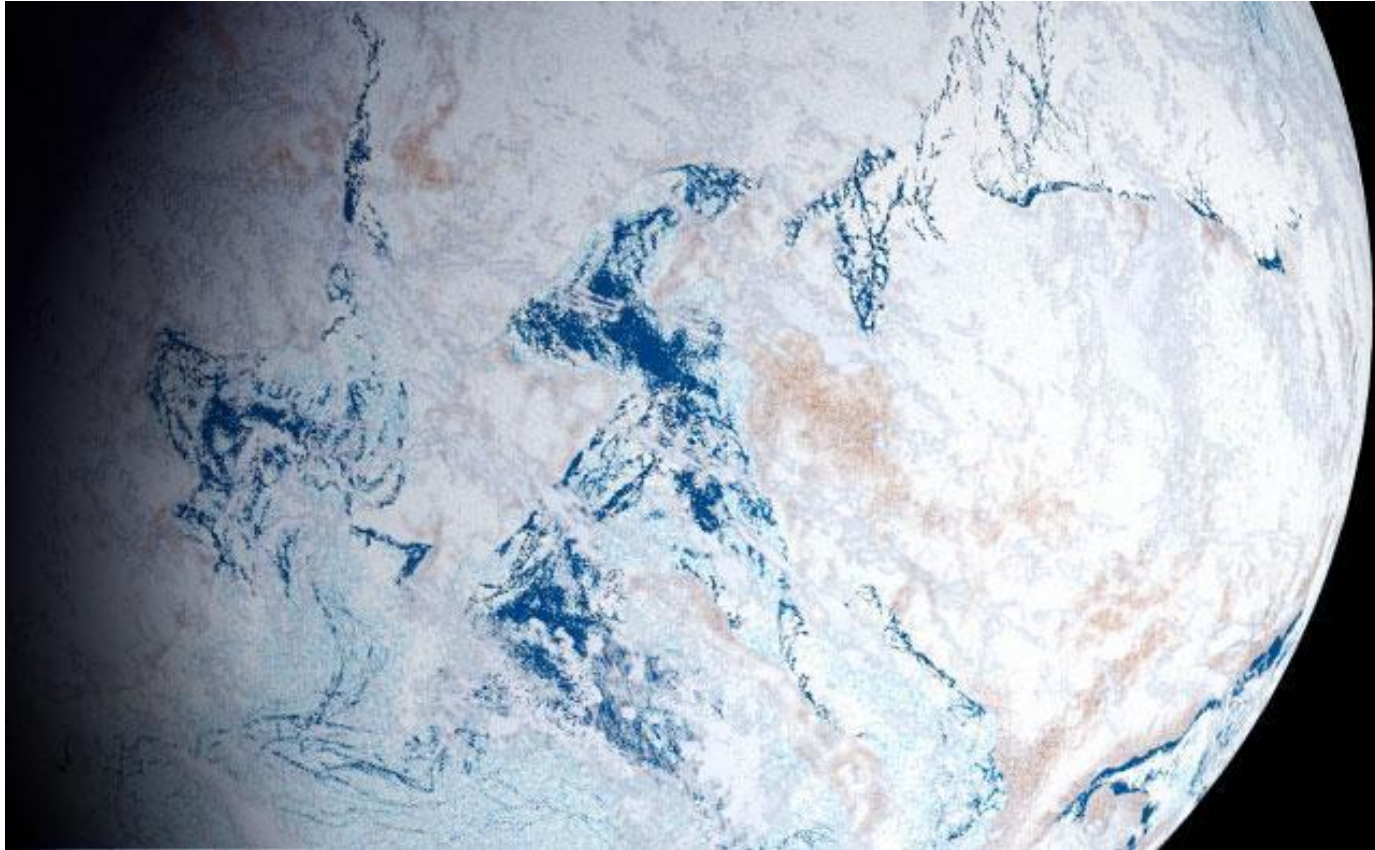
- Earth's climate is always changing
- Climate change always has a cause
- Climate change over the past century or so: It's us
- The Arctic is leading the way

# GSA GEOLOGIC TIME SCALE v. 5.0



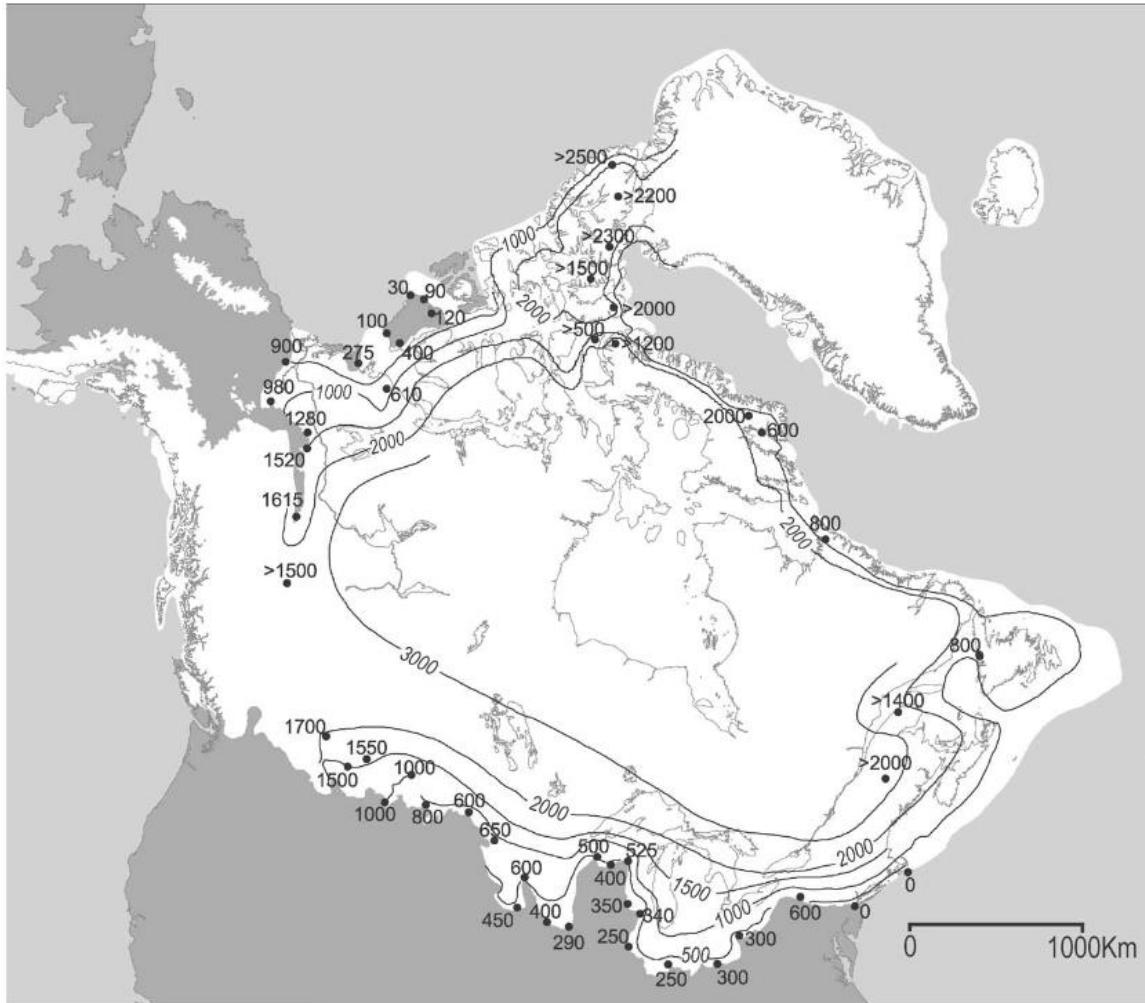
Divisions in the geologic time scale reflect climate changes

# Snowball Earth

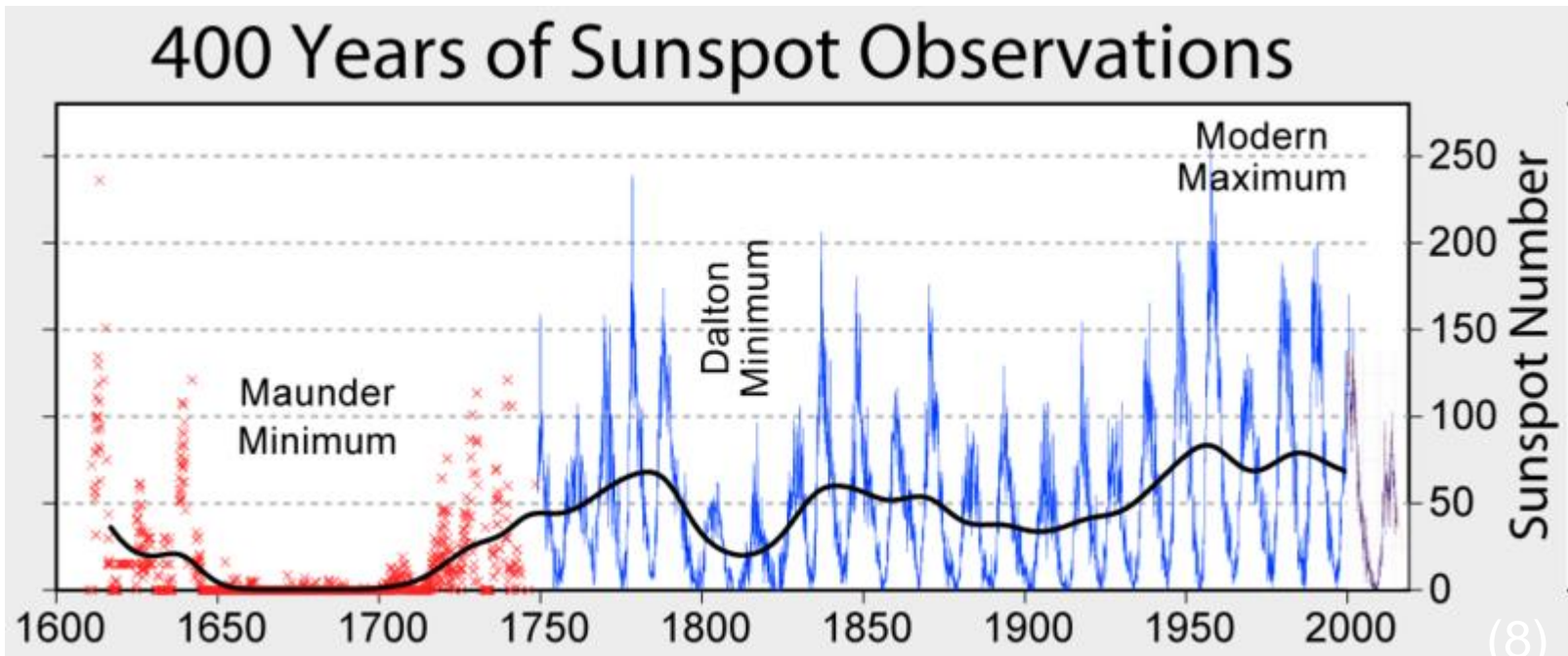


Evidence that the surface became entirely or nearly entirely frozen at least once, perhaps multiple times, sometime earlier than 650 million years ago (the whole planet was Arctic!)

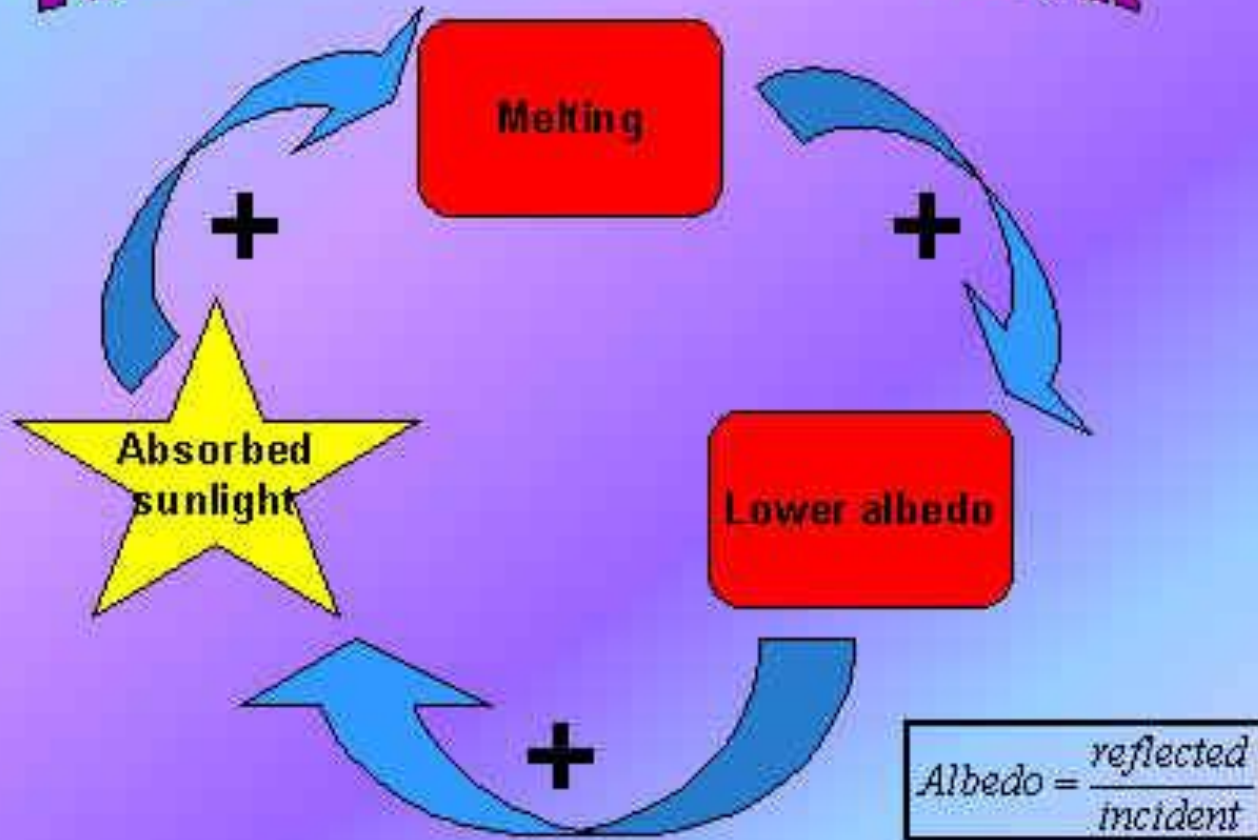
# Laurentide Ice Sheet ~ 25,000 Years Ago



# Solar Variability

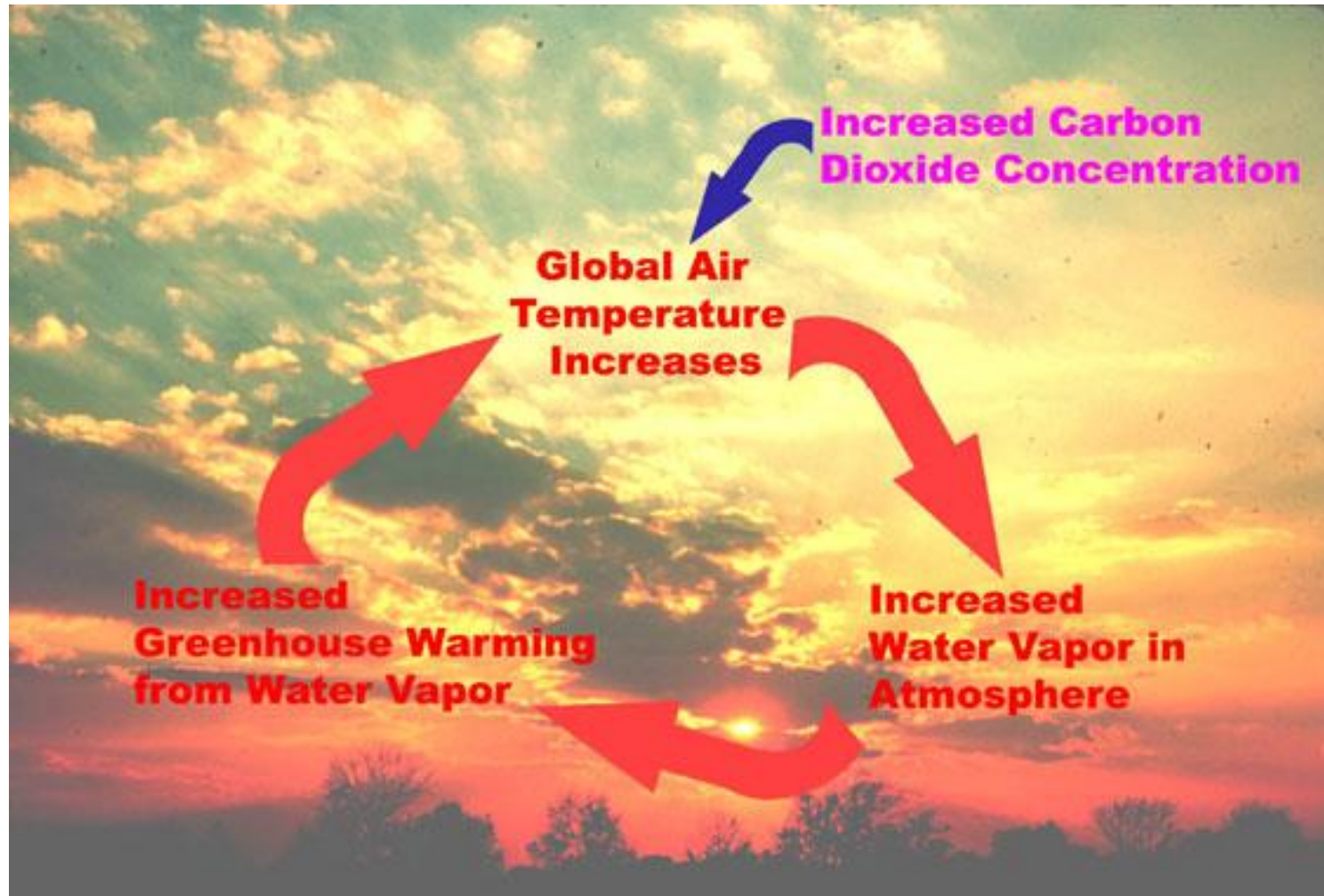


# Ice albedo feedback



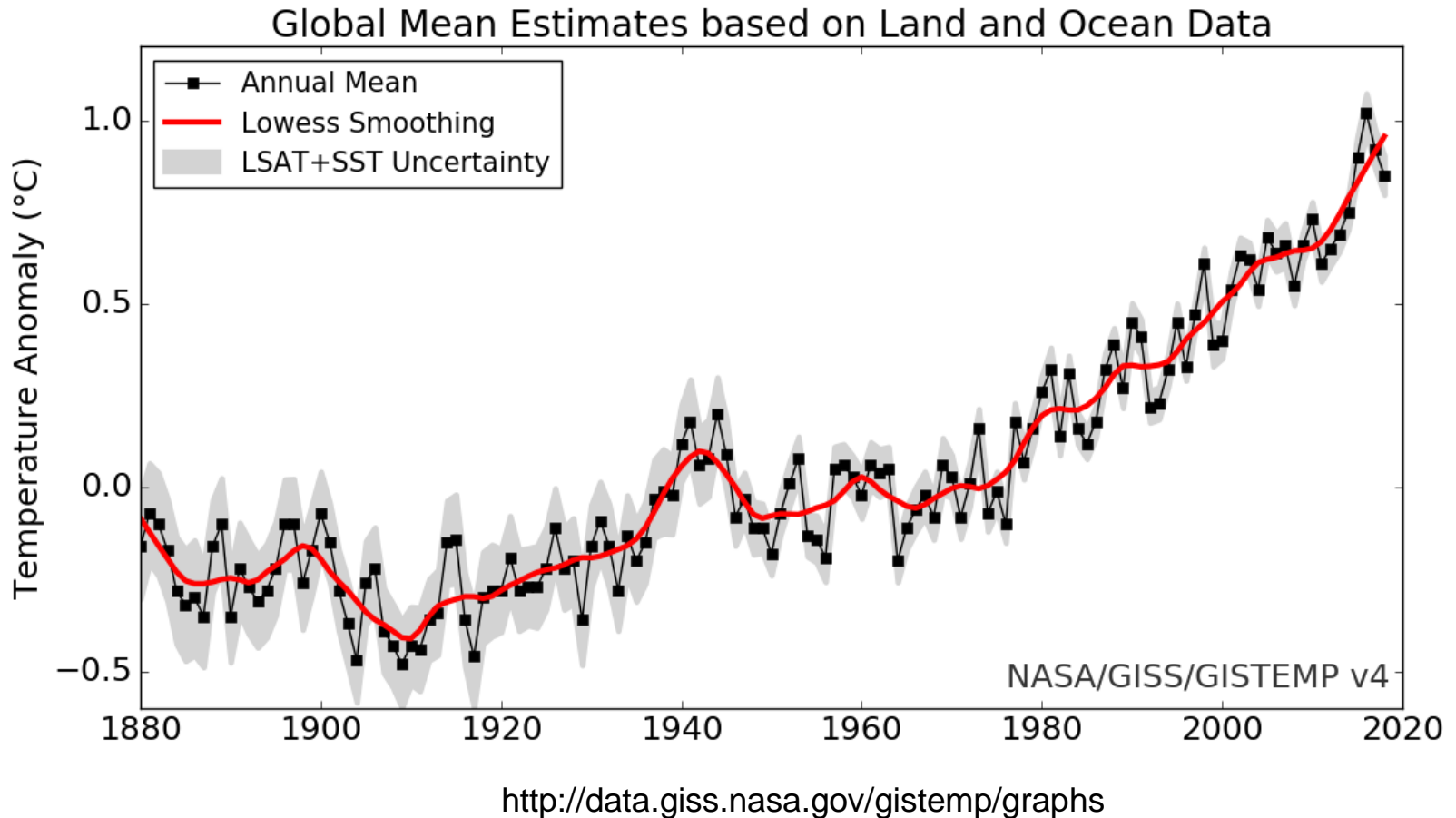


# Water vapor feedback



[http://www.nasa.gov/vision/earth/lookingatearth/warmer\\_humidity.html](http://www.nasa.gov/vision/earth/lookingatearth/warmer_humidity.html)

# Warming over the Instrumental Record

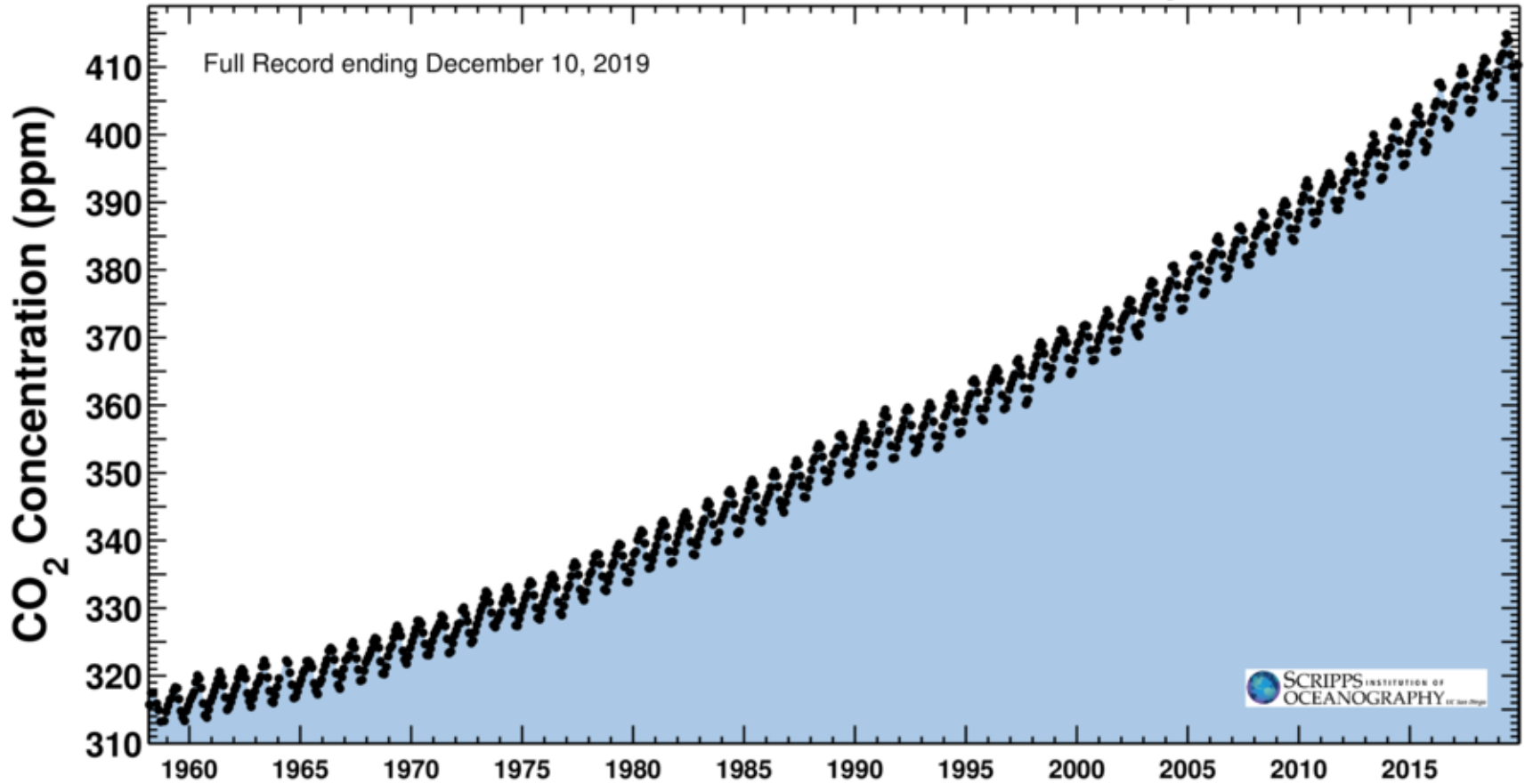


The instrumental record is sufficiently dense to allow us to estimate the global average temperature back to about 1880.

# The Keeling Curve

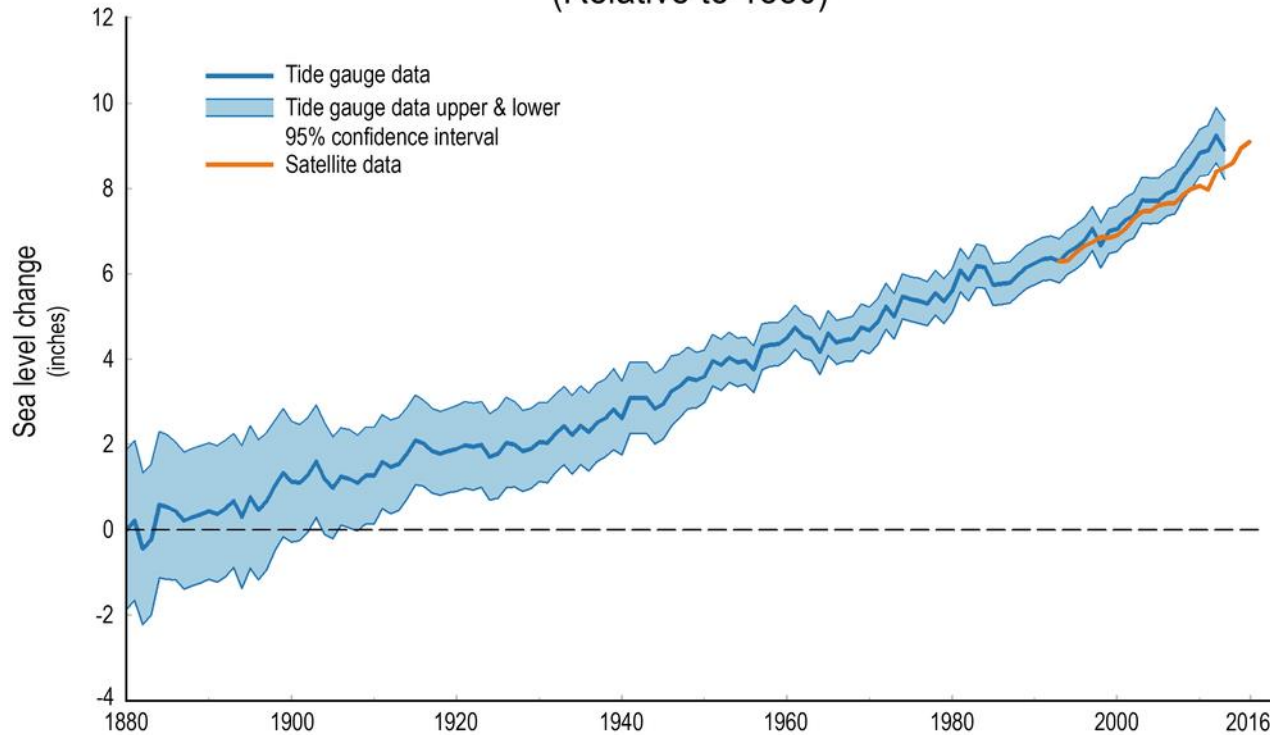
December 10, 2019

Carbon dioxide concentration at Mauna Loa Observatory



# Rising Sea Level

## Global Average Sea Level Change (Relative to 1880)



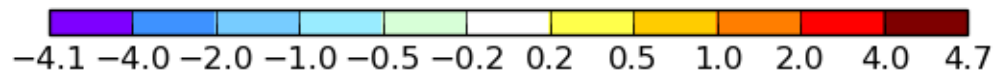
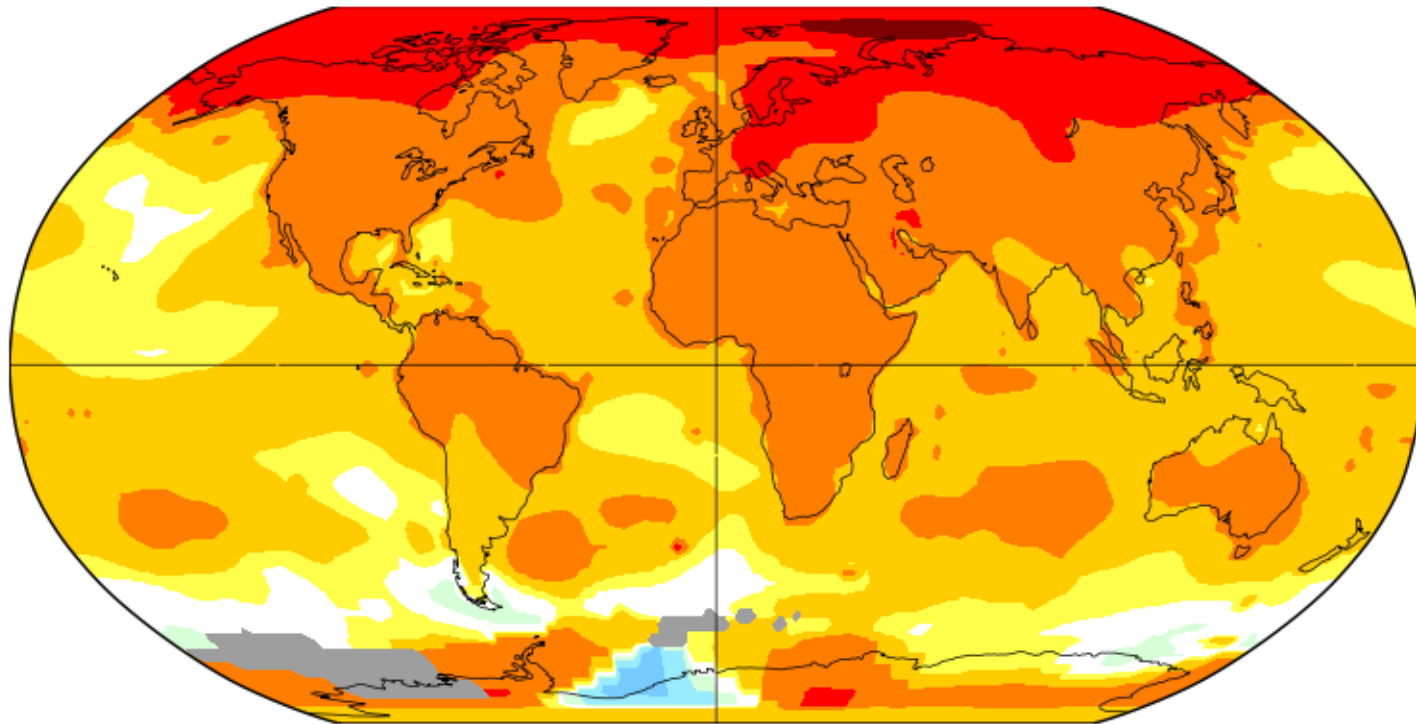
<https://www.globalchange.gov/browse/indicators/global-sea-level-rise>

# Arctic Amplification

Nov-Oct

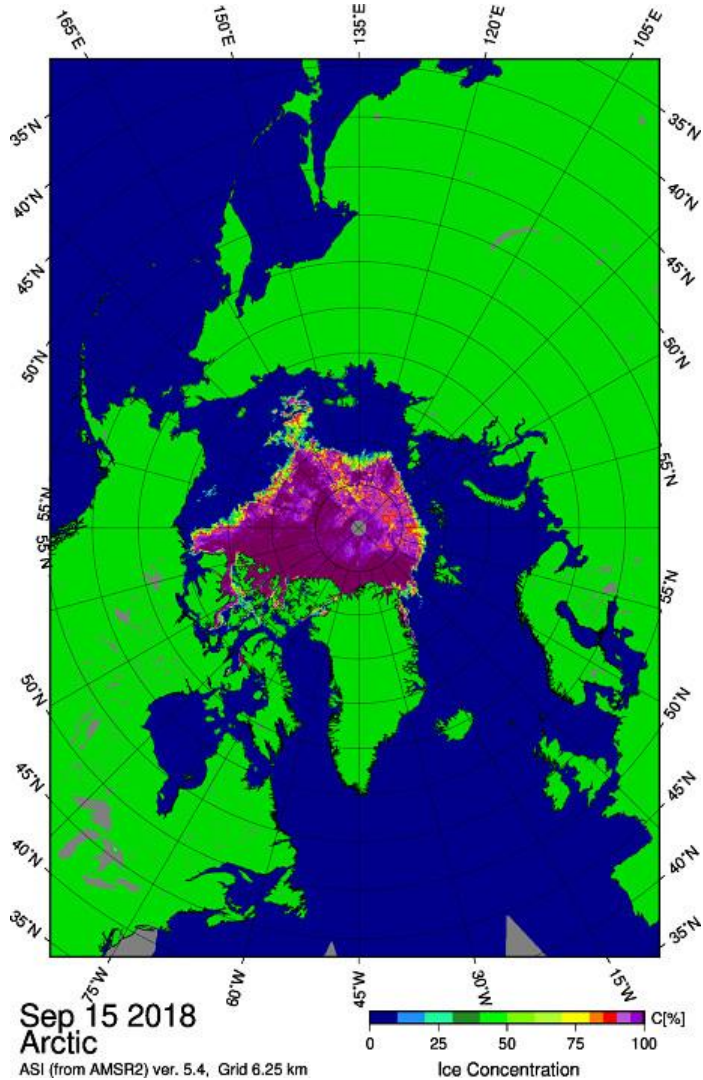
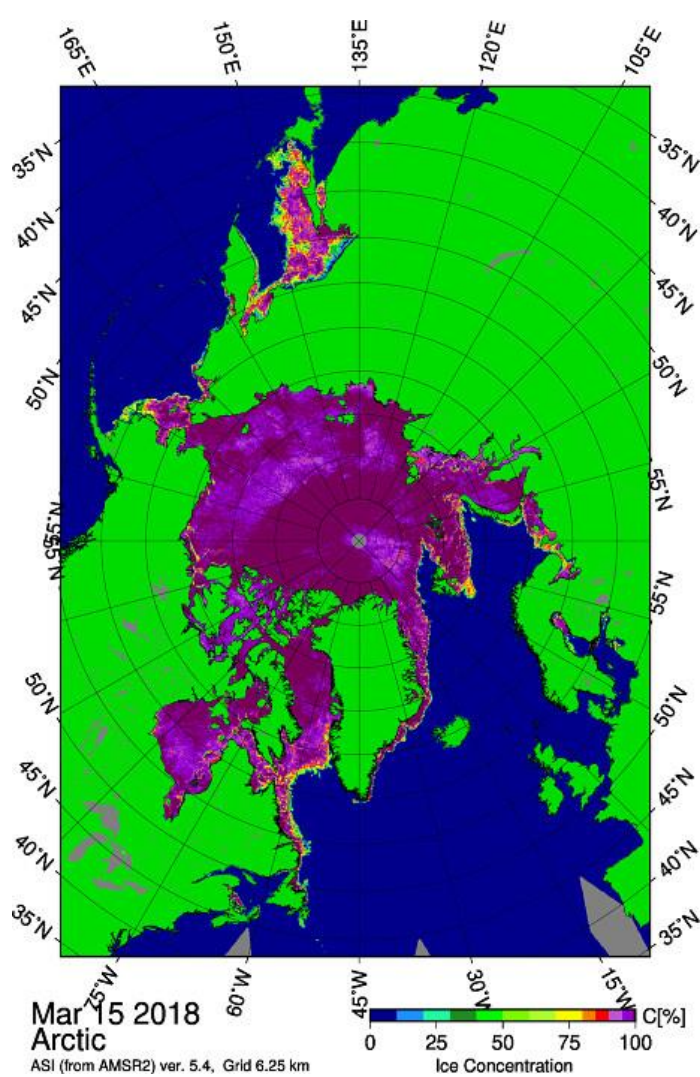
L-OTI (°C) Change 1960-2018

0.98

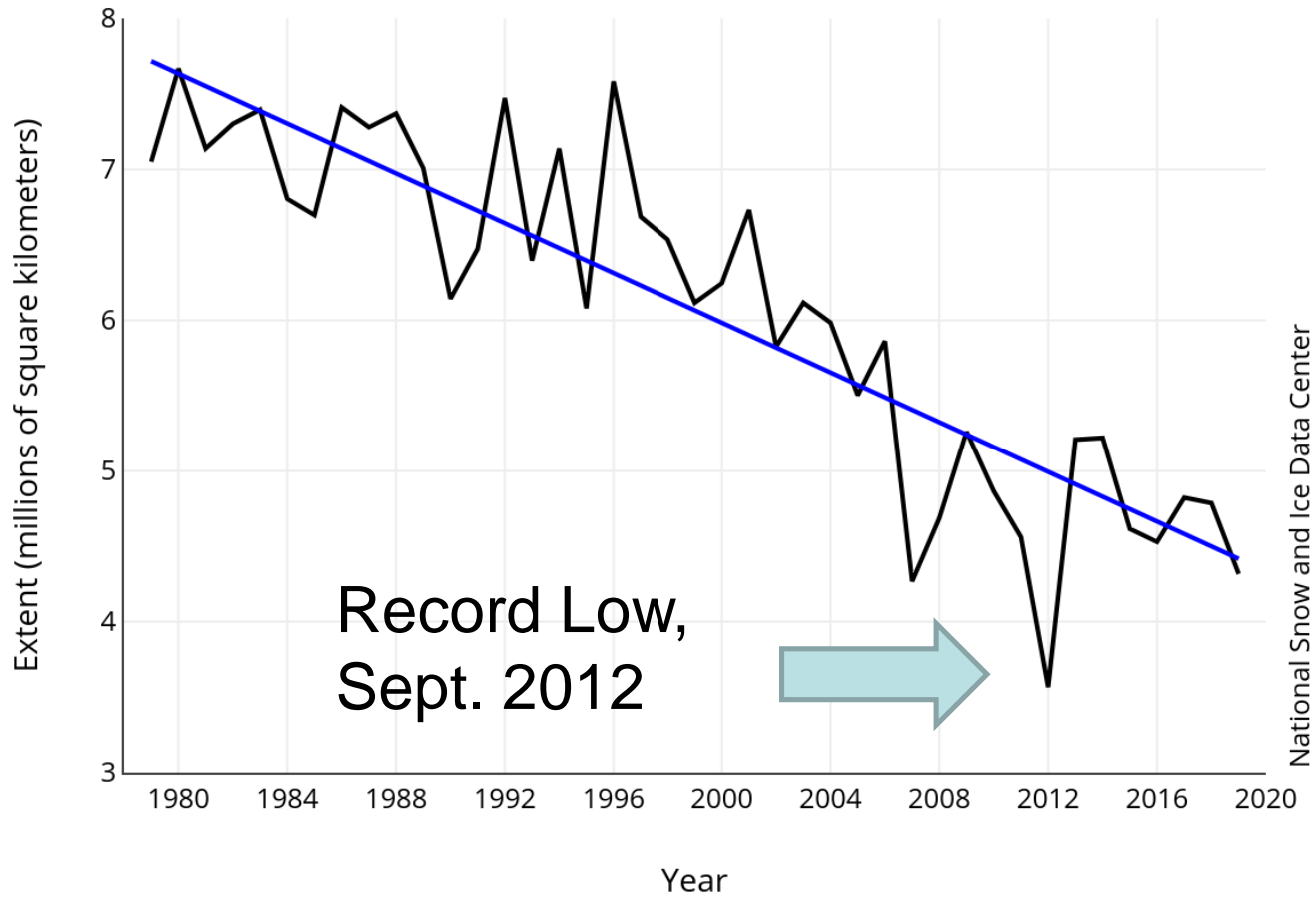


<http://data.giss.nasa.gov/gistemp/graphs/>

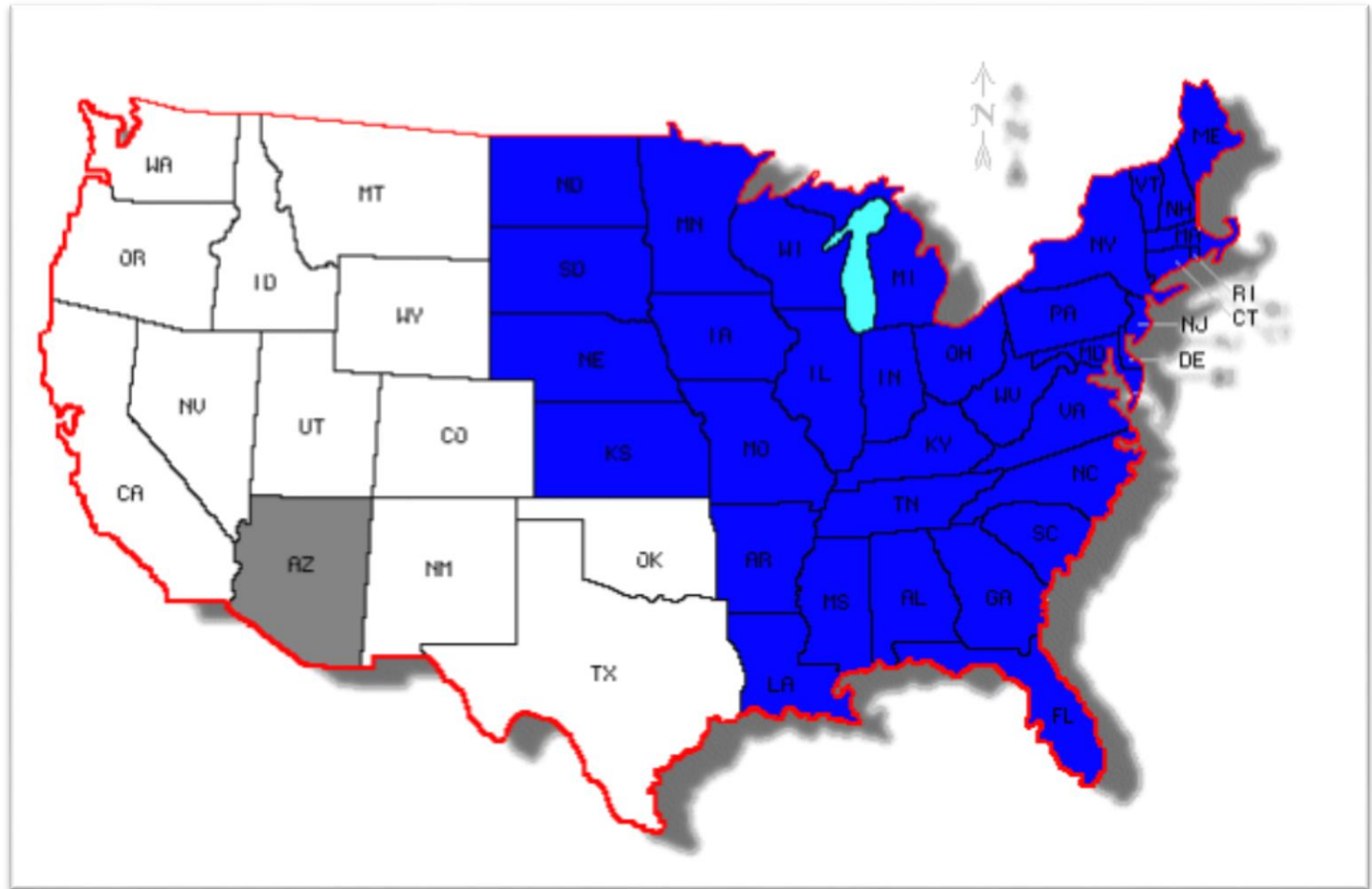
# The Arctic Sea Ice Cover



# September Arctic Sea Ice Extent

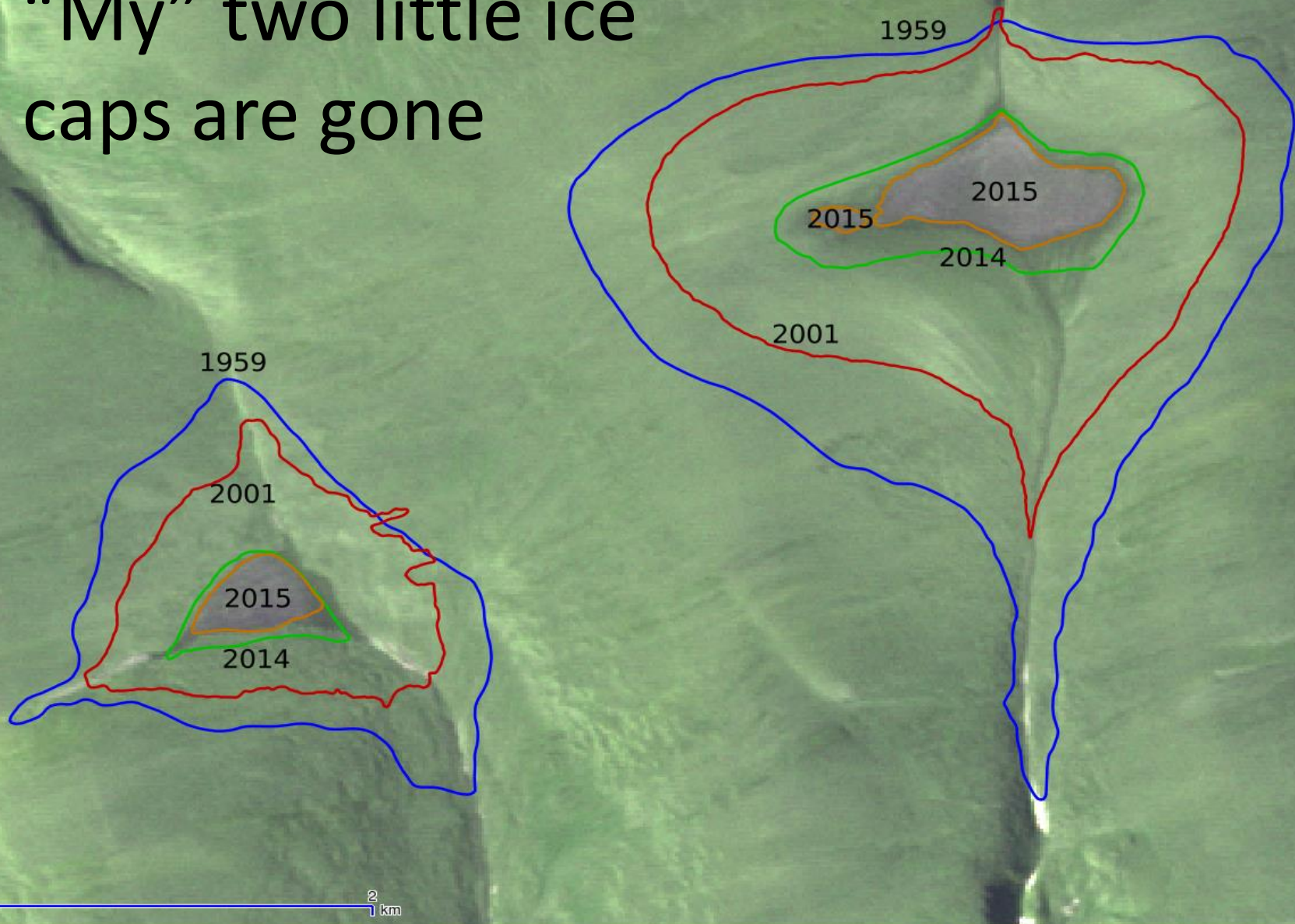


# September Ice Extent: 2012





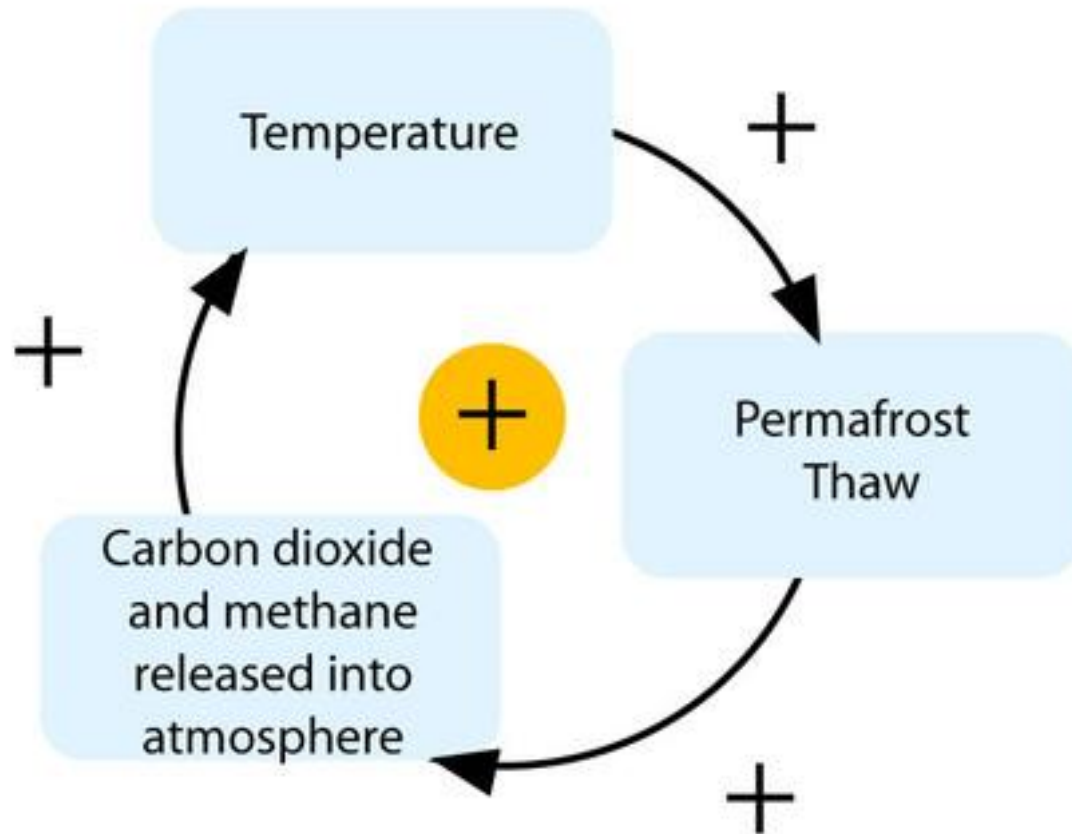
“My” two little ice caps are gone



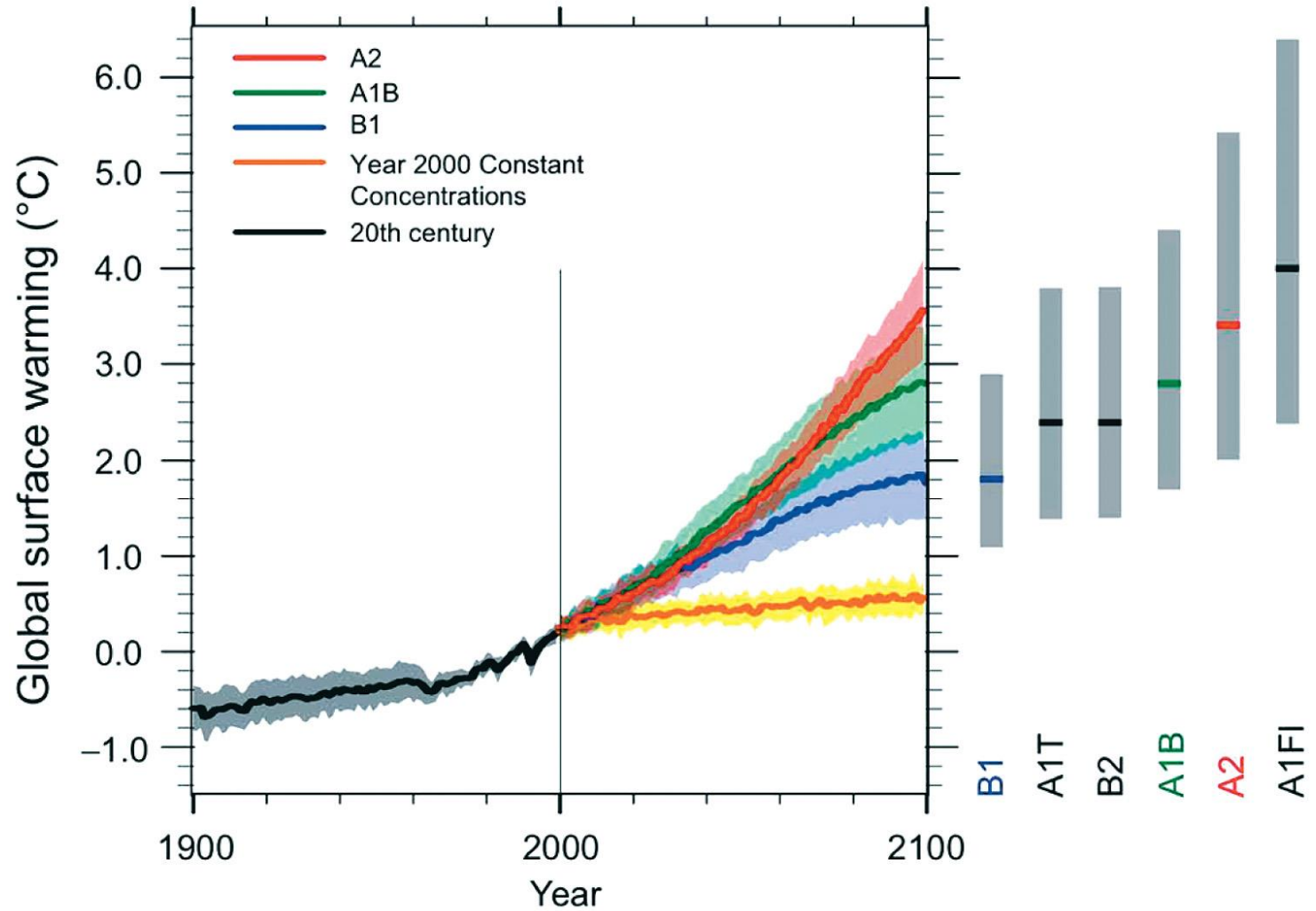
# Thawing Permafrost – Beaufort Sea Coast



# Permafrost Carbon Feedback



# Multi-model Averages and Assessed Ranges for Surface Warming



# Role of Scientists in Education and Science Communication

- NSIDC: We are honest brokers of data and scientific information – we avoid stepping into advocacy
- Too few students are entering college with a basic understanding of physics and mathematics
- Too few students are entering college with adequate writing skills
- Science communication isn't the sort of this one learns in a class (too many armchair authorities) - it takes battlefield experience



Thank You