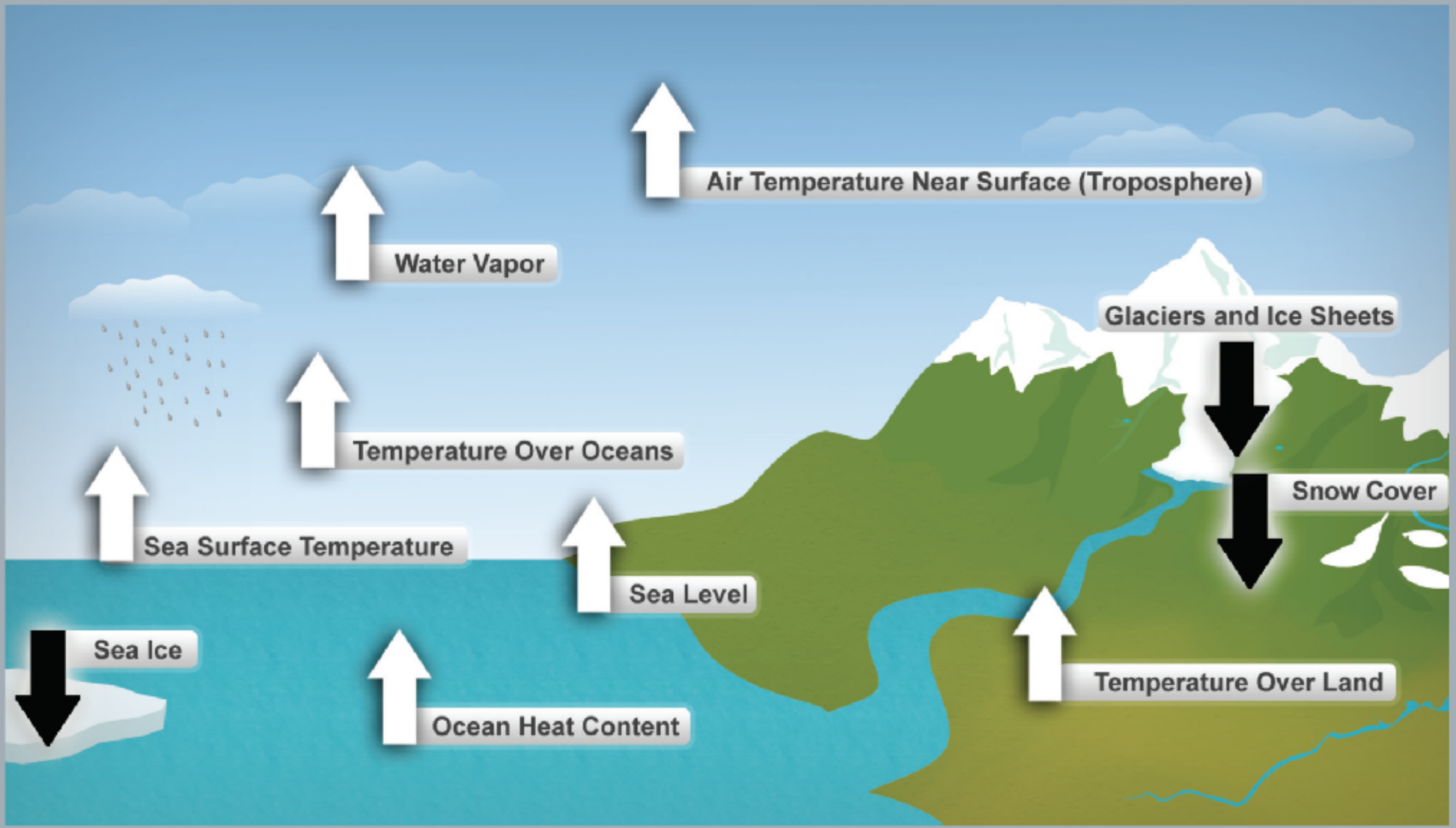
Overview of Findings of the U.S. National Climate Assessment, 2017

1. Global climate is changing, and this is apparent across the United States in a wide range of observations. The global warming of the past 50 years is primarily due to human activities, predominantly the burning of fossil fuels.

Ten Indicators of a Warming World



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Climate Observations

Increases in…

- green-house gas concentration in the atmosphere
- average land-surface temperature
- average sea-surface temperature
- average marine-atmosphere temperature
- specific humidity
- frequency and intensity of extreme weather
- intensity, frequency, and duration of hurricanes
- frost-free season
- ice melt
- sea level
- ocean acidification

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- volume of continental ice sheets
- extent of sea ice in polar areas
- volume of mountain glaciers
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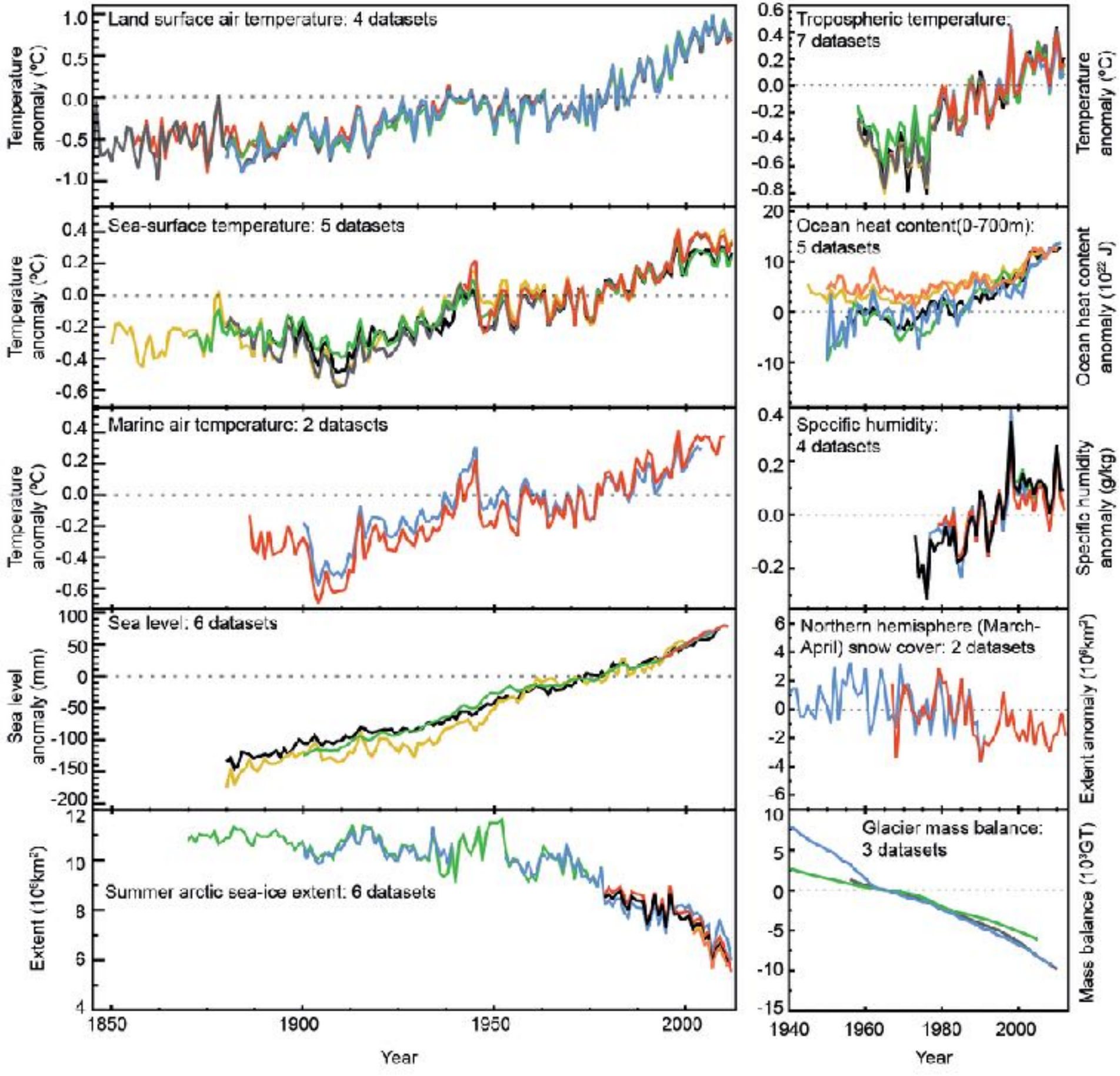

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CLIMATE TRENDS

These two pages present the Key Messages from the "Our Changing Climate" chapter of the full report. They pertain to Report Findings 1, 2, and 3, evidence for which appears on the following pages.

Global climate is changing and this change is apparent across a wide range of observations. The global warming of the past 50 years is primarily due to human activities. Global climate is projected to continue to change over this century and beyond. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases emitted globally, and how sensitive the Earth's climate is to those emissions.

Temperature

U.S. average temperature has increased by 1.3°F to 1.9°F since record keeping began in 1895; most of this increase has occurred since about 1970. The most recent decade was the nation's warmest on record. Temperatures in the United States are expected to continue to rise. Because human-induced warming is superimposed on a naturally varying climate, the temperature rise has not been, and will not be, uniform or smooth across the country or over time.

Extreme Weather

There have been changes in some types of extreme weather events over the last several decades. Heat waves have become more frequent and intense, especially in the West. Cold waves have become less frequent and intense across the nation. There have been regional trends in floods and droughts. Droughts in the Southwest and heat waves everywhere are projected to become more intense, and cold waves less intense everywhere.

Hurricanes

The intensity, frequency, and duration of North Atlantic hurricanes, as well as the frequency of the strongest (Category 4 and 5) hurricanes, have all increased since the early 1980s. The relative contributions of human and natural causes to these increases are still uncertain. Hurricane-associated storm intensity and rainfall rates are projected to increase as the climate continues to warm.

Severe Storms

Winter storms have increased in frequency and intensity since the 1950s, and their tracks have shifted northward over the United States. Other trends in severe storms, including the intensity and frequency of tornadoes, hail, and damaging thunderstorm winds, are uncertain and are being studied intensively.

Precipitation

Average U.S. precipitation has increased since 1900, but some areas have had increases greater than the national average, and some areas have had decreases. More winter and spring precipitation is projected for the northern United States, and less for the Southwest, over this century.

Heavy Downpours

Heavy downpours are increasing nationally, especially over the last three to five decades. Largest increases are in the Midwest and Northeast. Increases in the frequency and intensity of extreme precipitation events are projected for all U.S. regions.

Frost-free Season

The length of the frost-free season (and the corresponding growing season) has been increasing nationally since the 1980s, with the largest increases occurring in the western United States, affecting ecosystems and agriculture. Across the United States, the growing season is projected to continue to lengthen.

Ice Melt

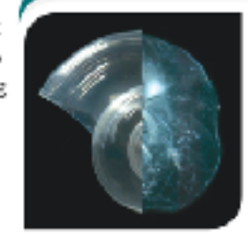
Rising temperatures are reducing ice volume and surface extent on land, lakes, and sea. This loss of ice is expected to continue. The Arctic Ocean is expected to become essentially ice free in summer before mid-century.

Sea Level

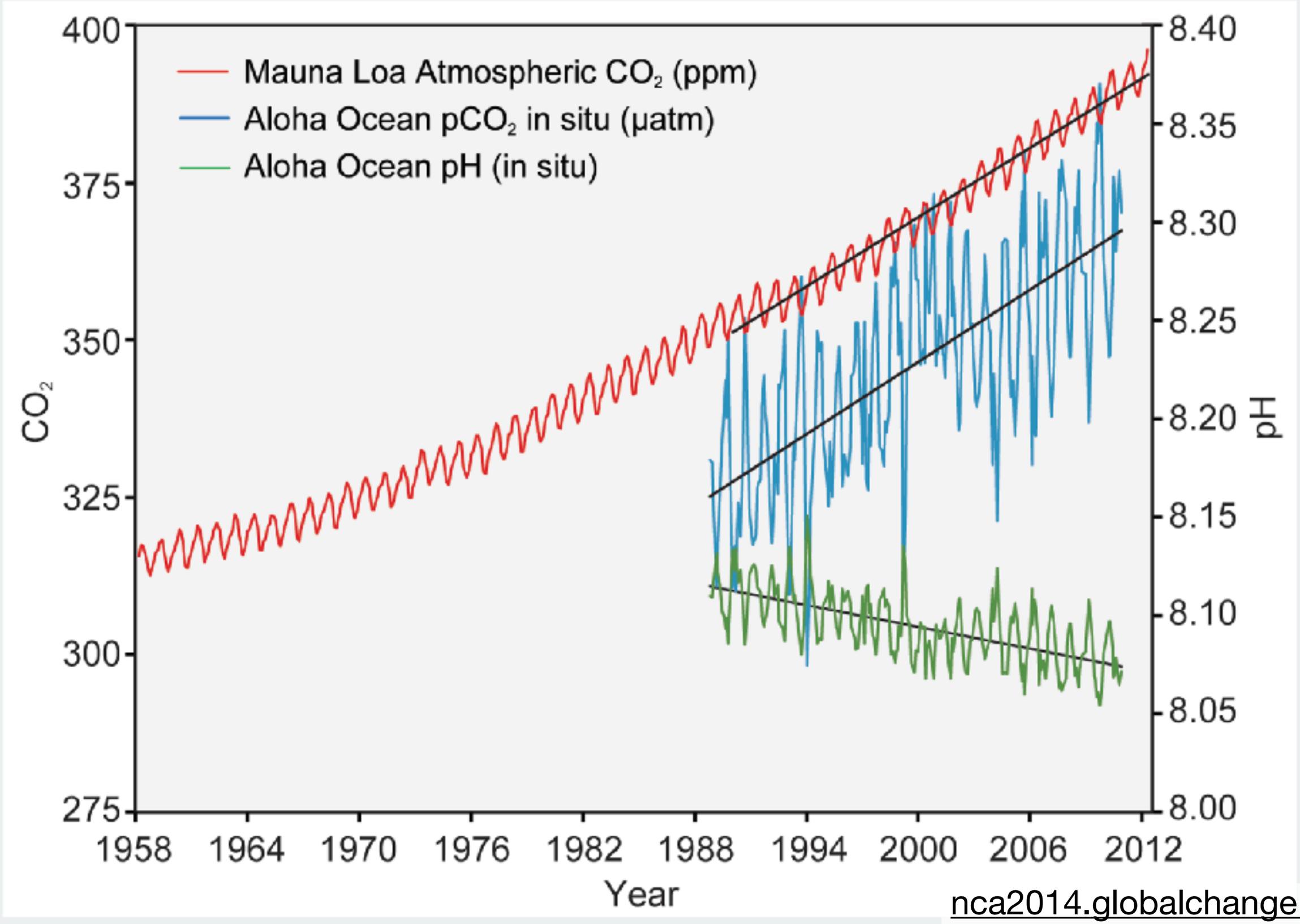
Global sea level has risen by about 8 inches since reliable record keeping began in 1880. It is projected to rise another 1 to 4 feet by 2100.

Ocean Acidification

The oceans are currently absorbing about a quarter of the carbon dioxide emitted to the atmosphere annually and are becoming more acidic as a result, leading to concerns about intensifying impacts on marine ecosystems. See page 60.



As Oceans Absorb CO_2 They Become More Acidic



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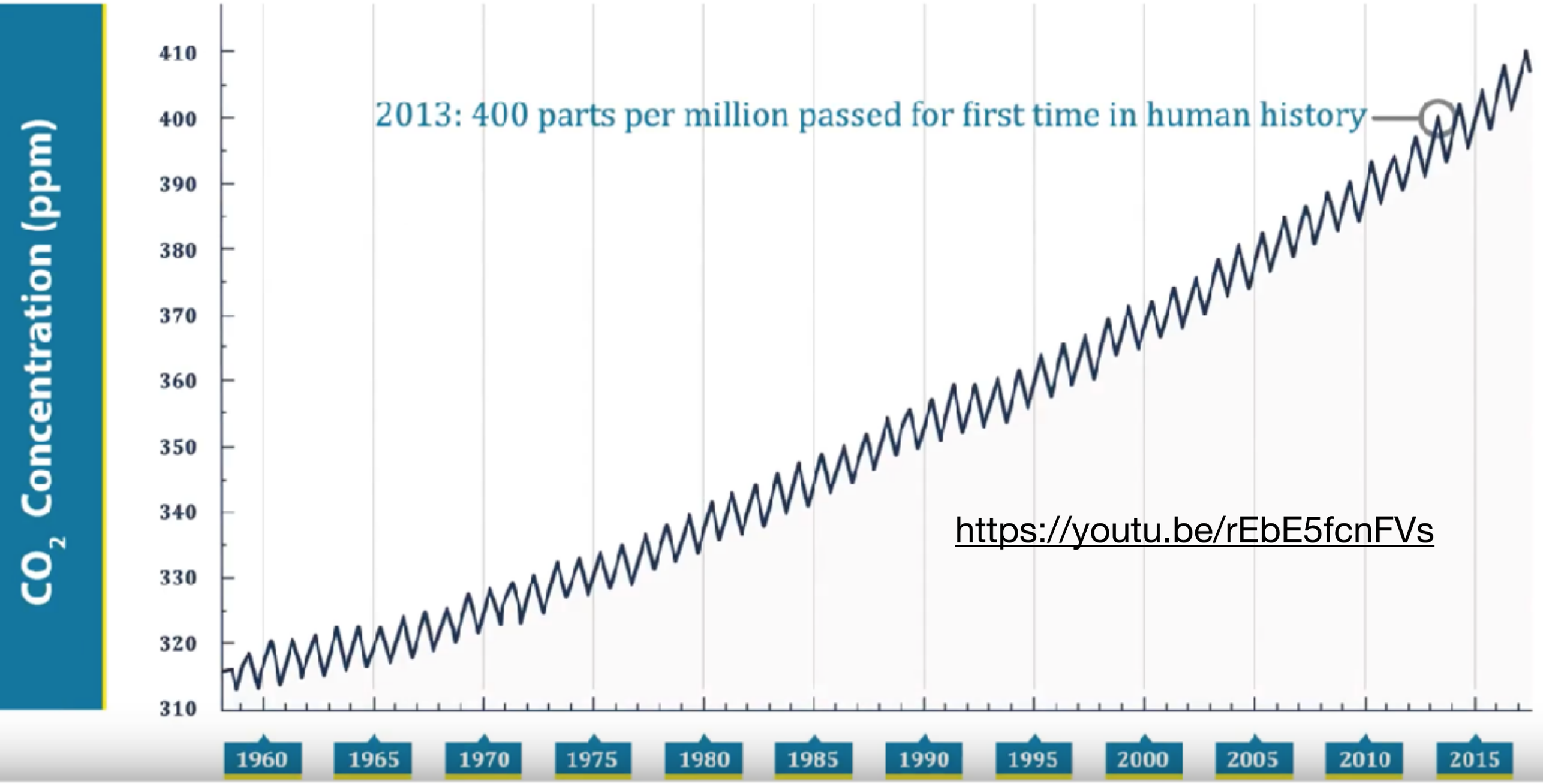
CARBON DIOXIDE CONCENTRATION AT MAUNA LOA OBSERVATORY



https://youtu.be/rEbE5fcnFVs

https://scripps.ucsd.edu/programs/keelingcurve/

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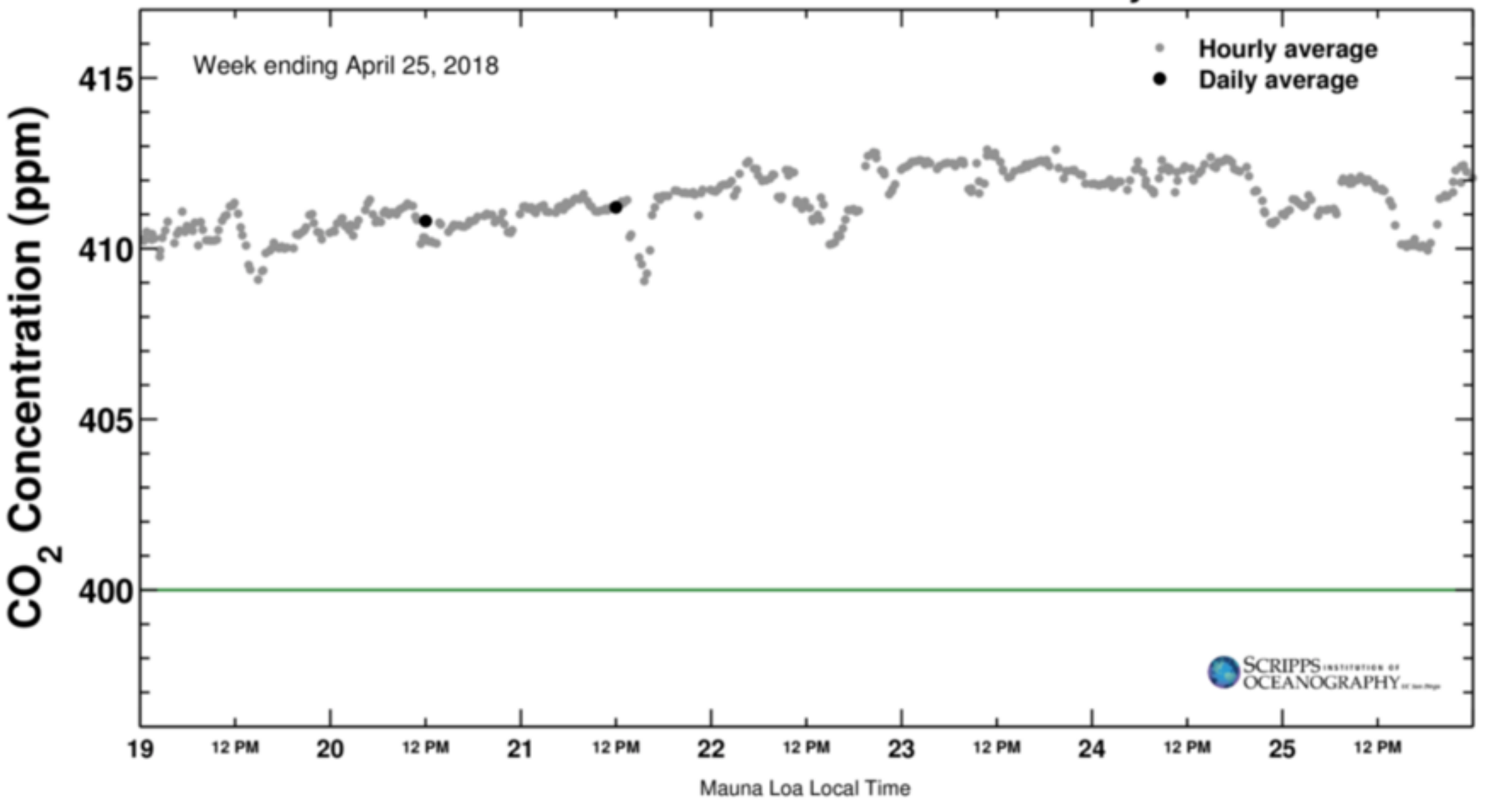
THE KEELING CURVE

Latest CO_2 reading
April 21, 2018

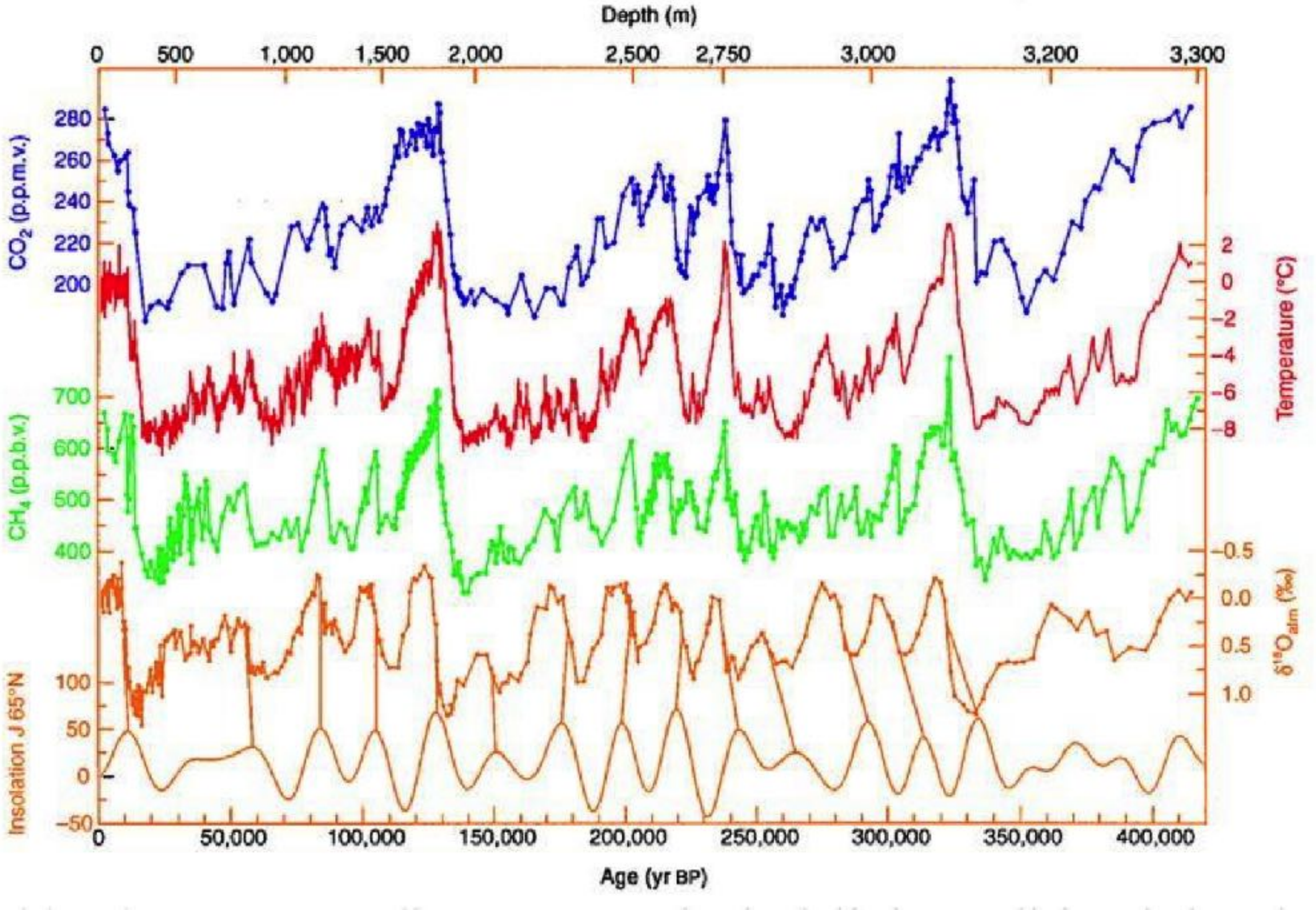
411.21 ppm



One Week | One Month | Six Months | One Year | Two Years | Full Record | 1700-present | 10,000 years | 800,000 years

https://scripps.ucsd.edu/programs/keelingcurve/

Climate Data From Deep Ice Cores (Greenland & Antarctica)



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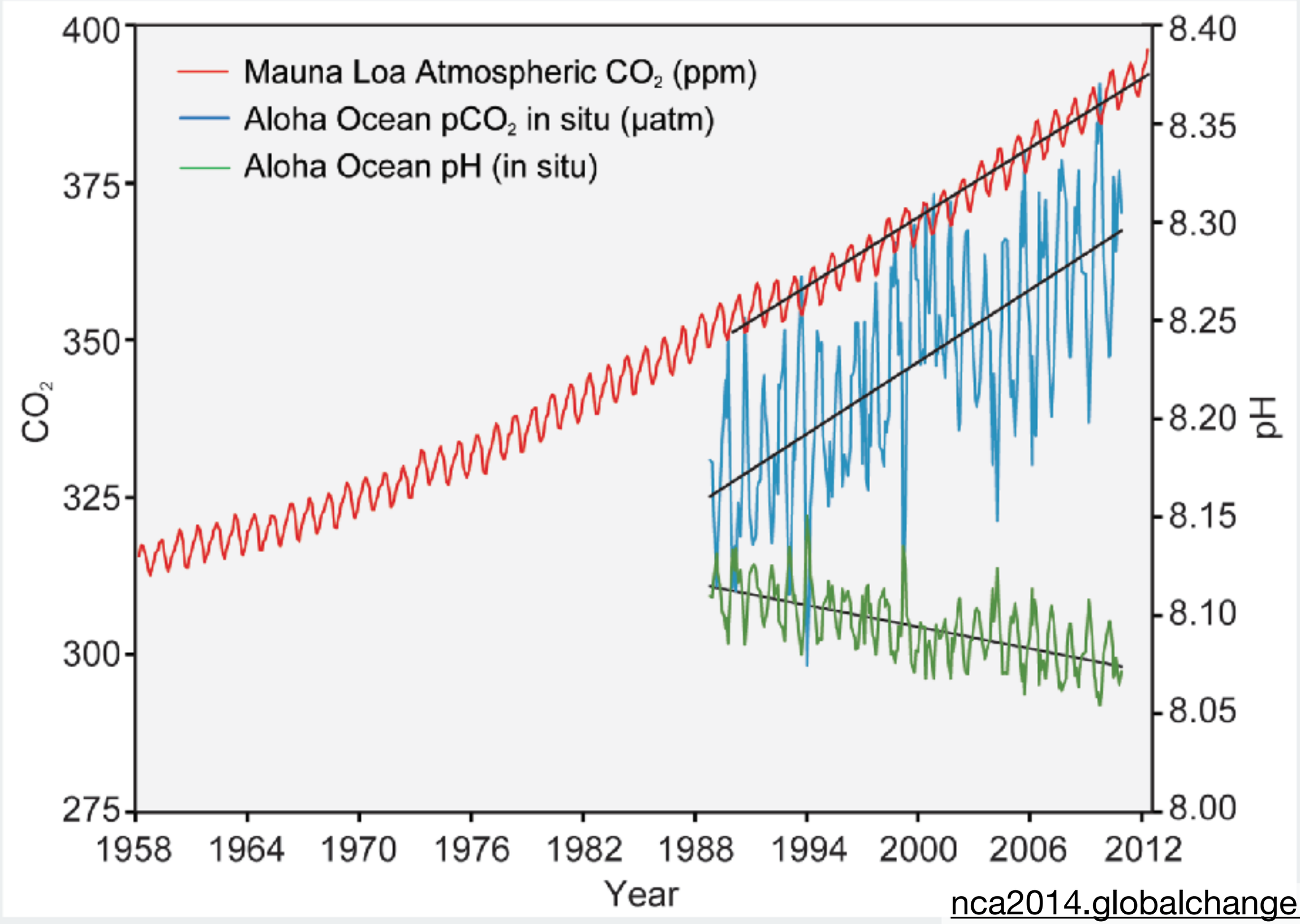

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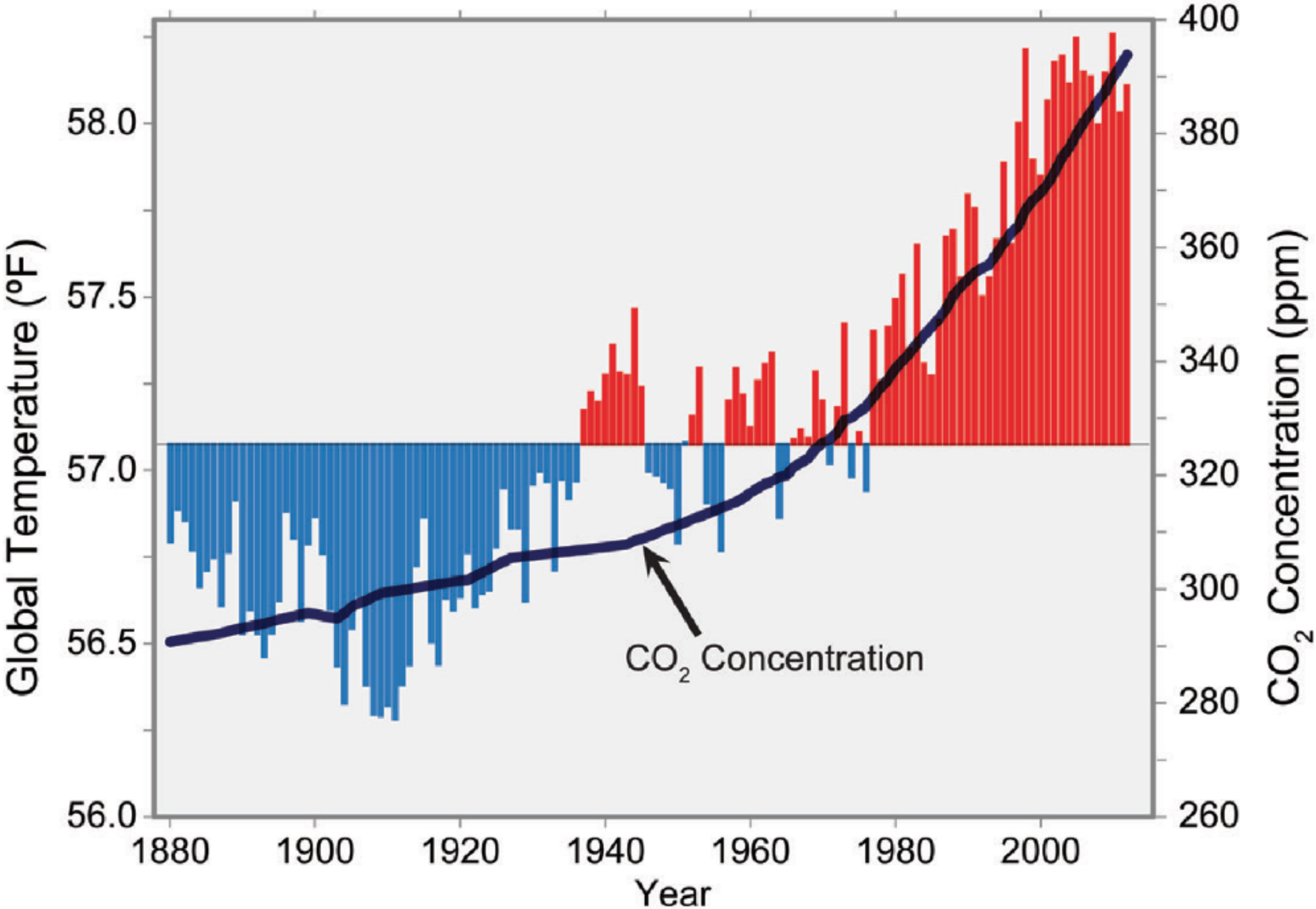

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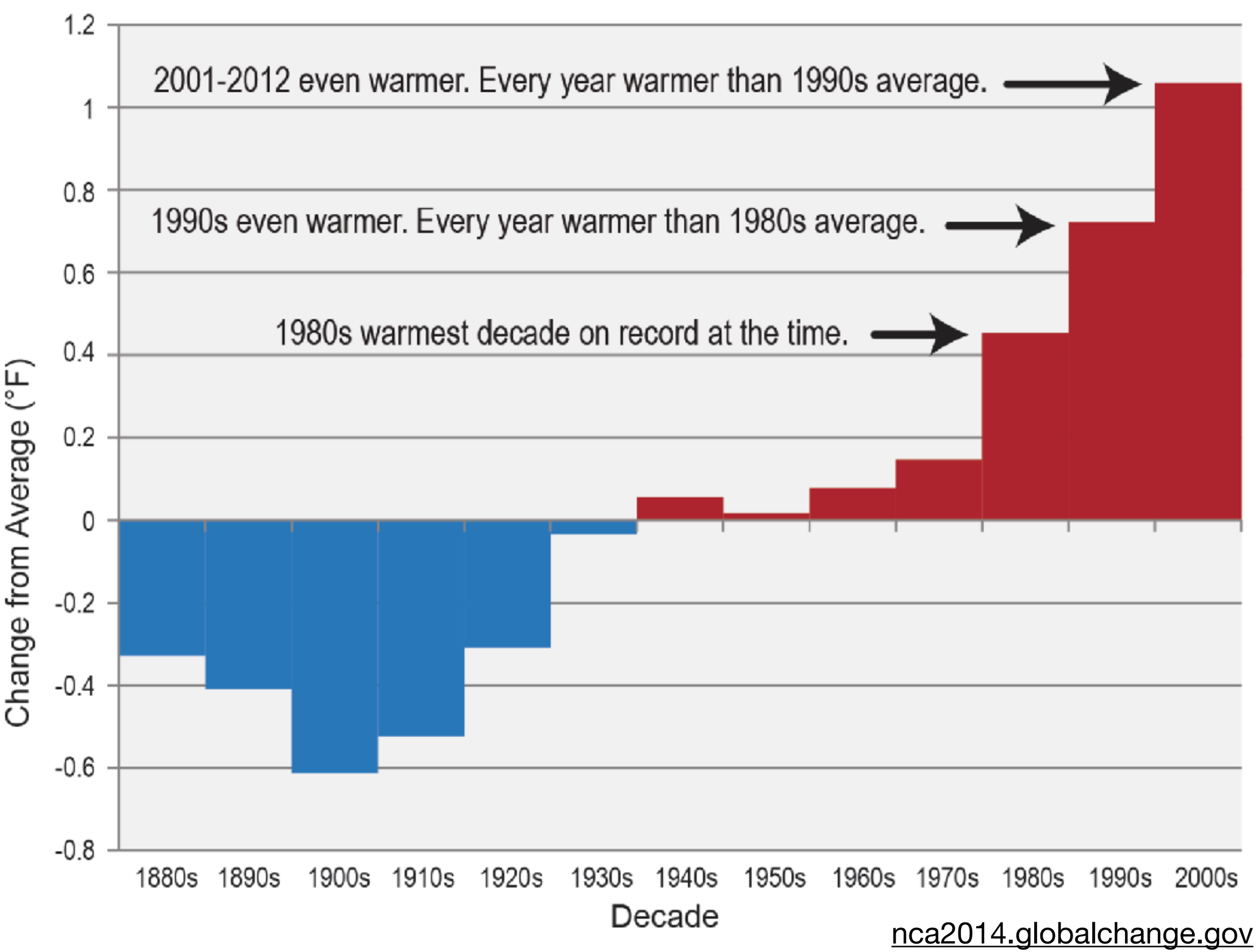

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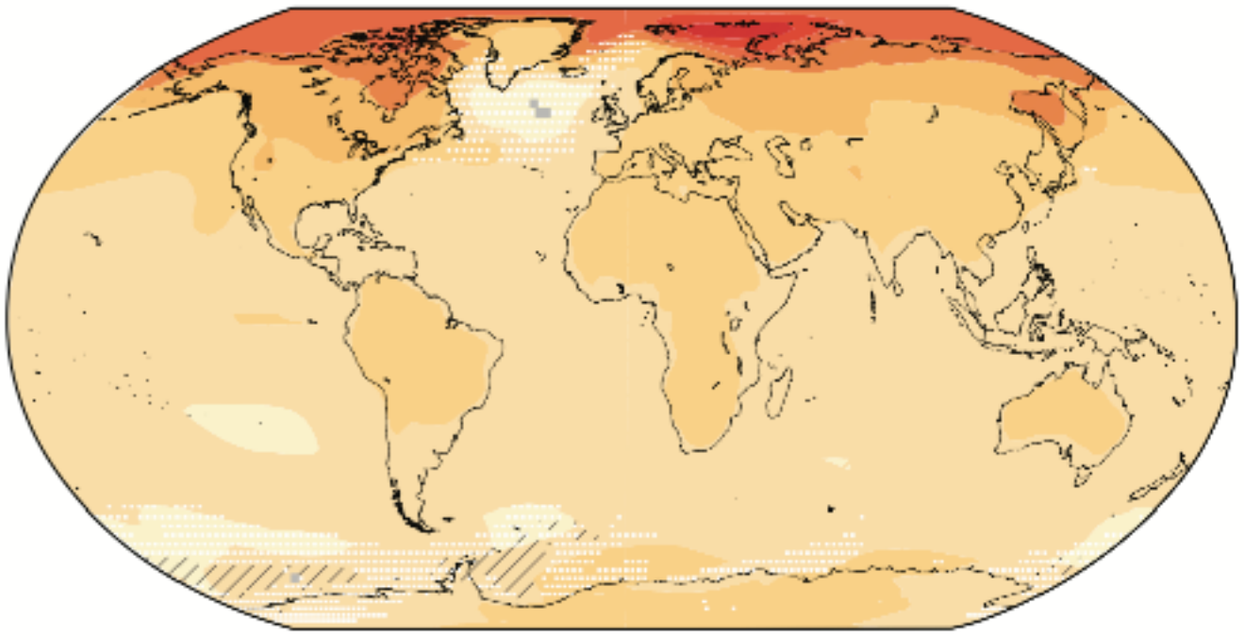
Projected Temperature Change

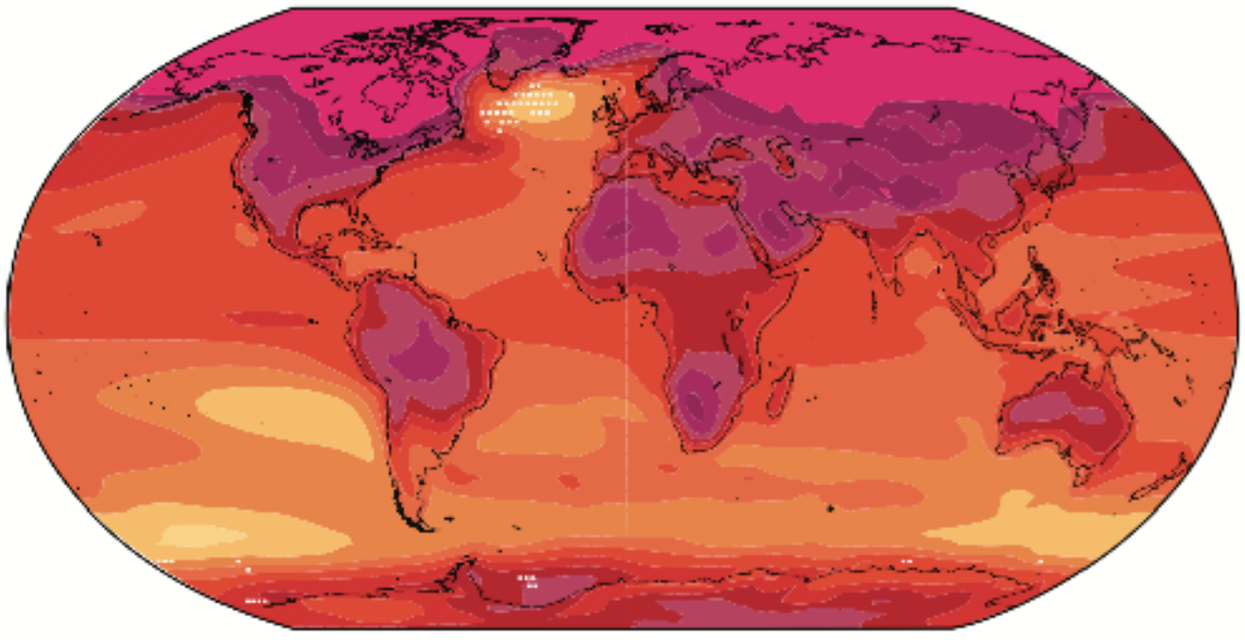
Difference from 1986–2005 mean (°C)

Solid Color	Very strong agreement	White Dots	Strong agreement
Gray	Divergent changes	Diagonal Lines	Little or no change

RCP2.6 2081–2100



RCP8.5 2081–2100



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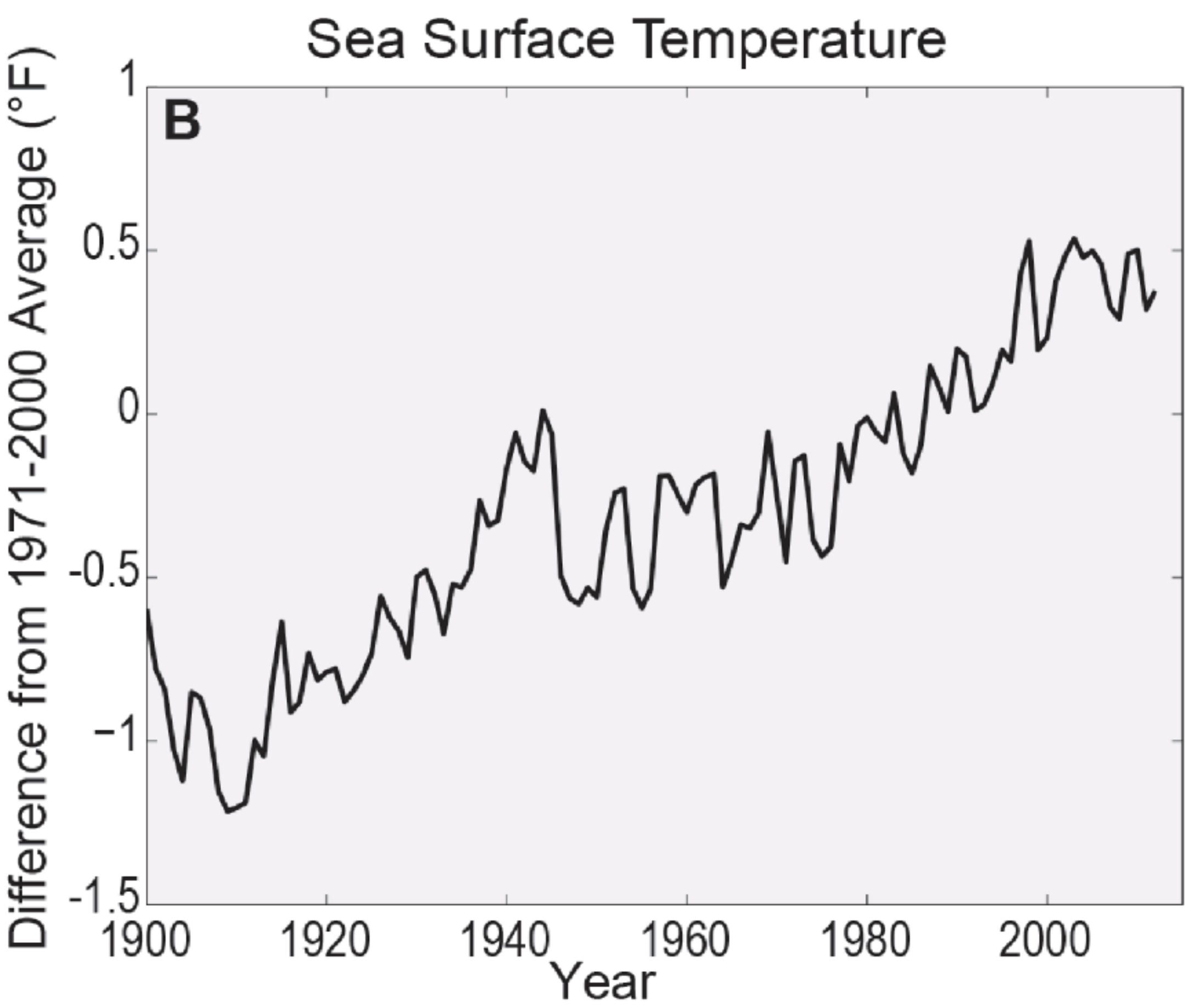

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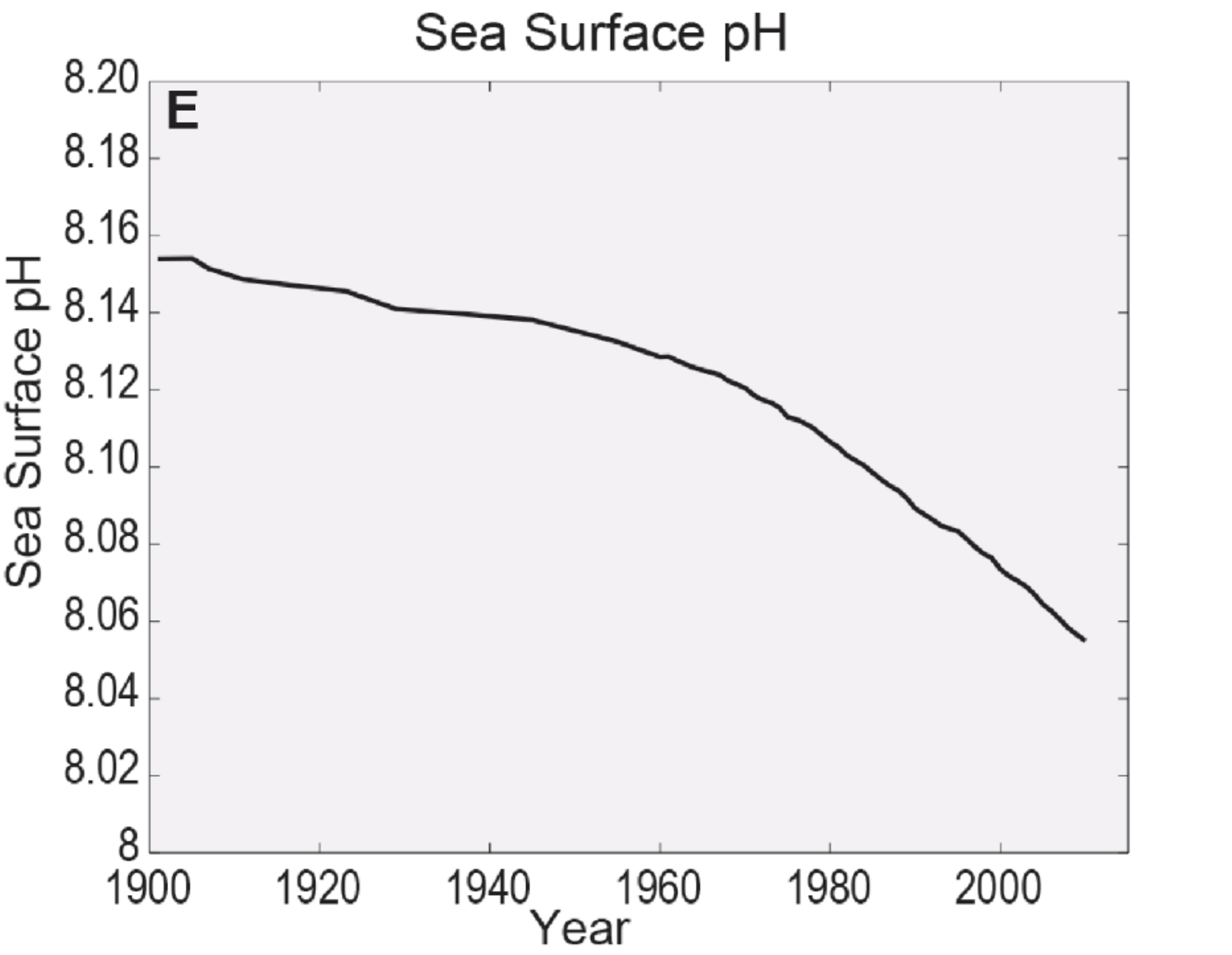

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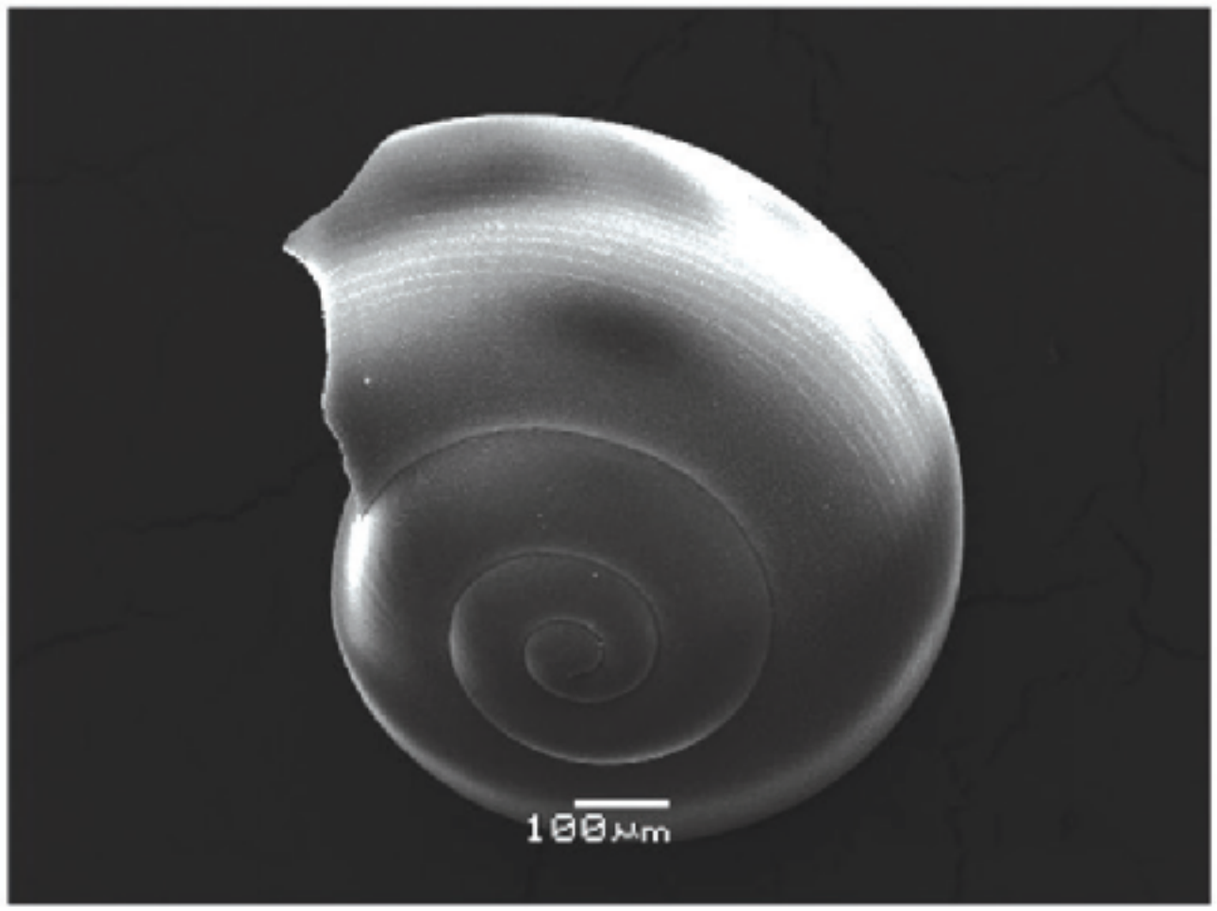
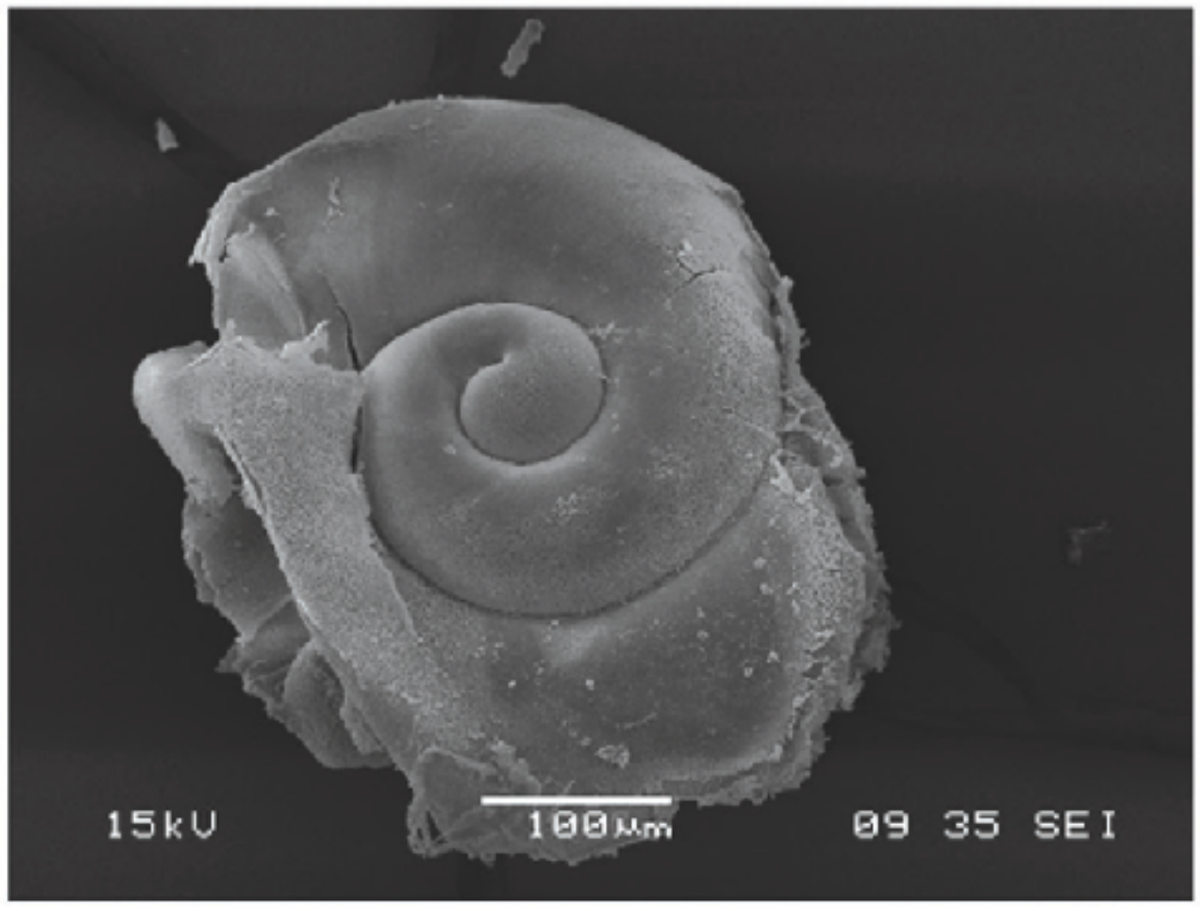
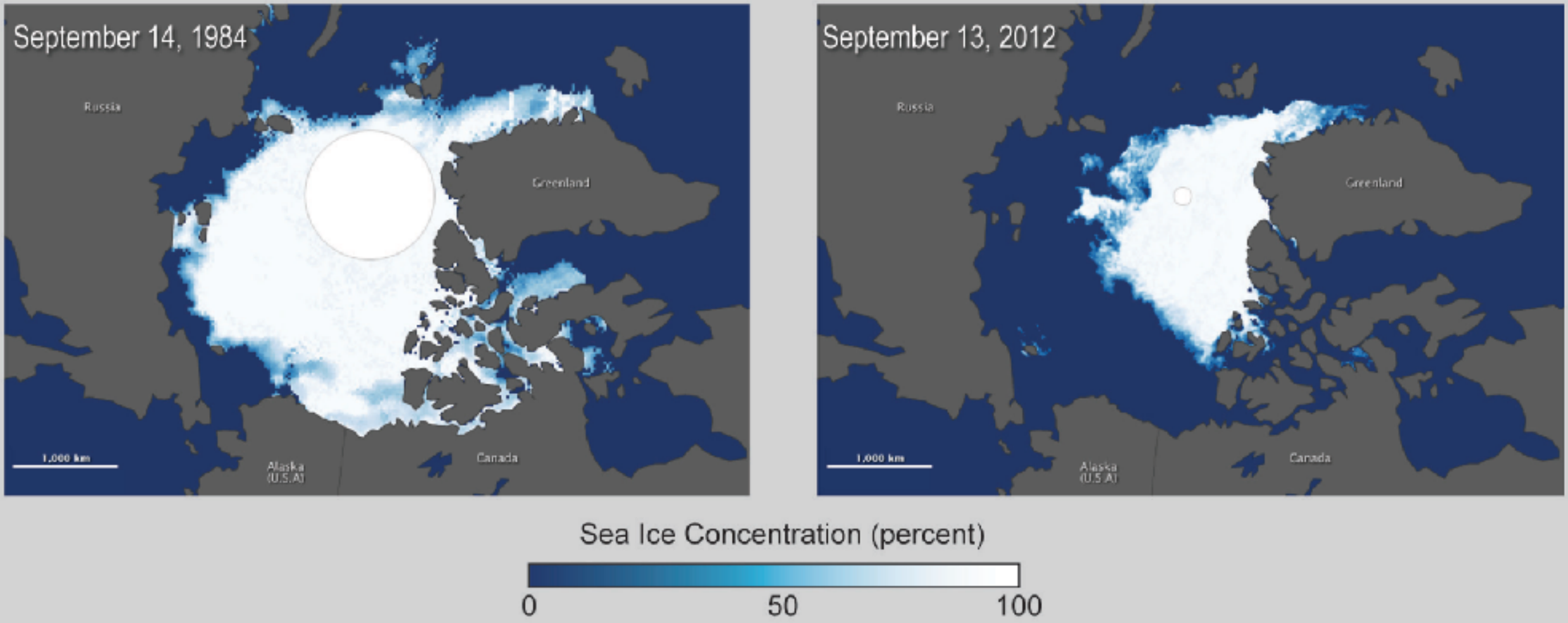
Shells Dissolve in Acidified Ocean Water



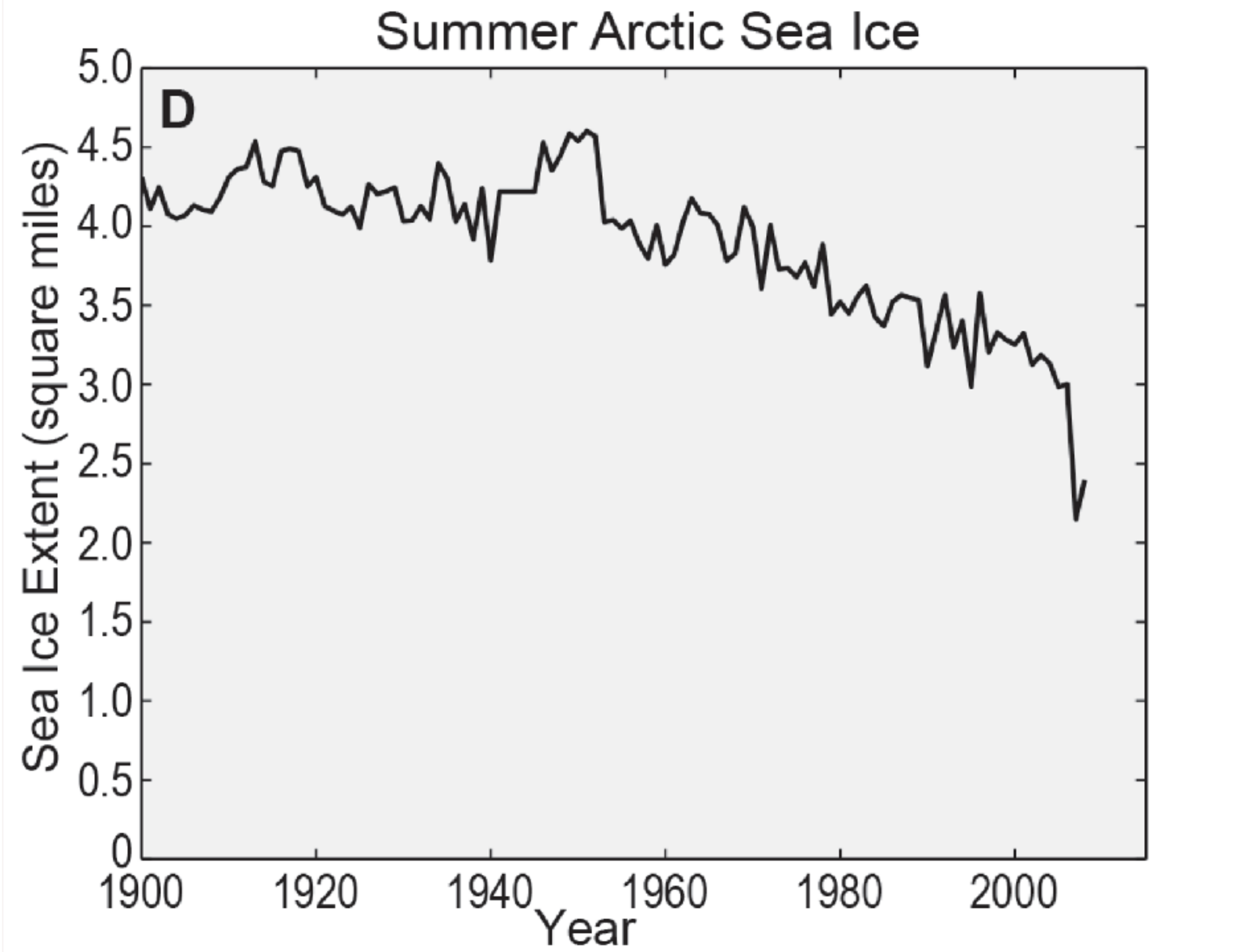


Pteropods, or “sea butterflies,” are eaten by a variety of marine species ranging from tiny krill to salmon to whales. The photos show what happens to a pteropod’s shell in seawater that is too acidic. On the left is a shell from a live pteropod from a region in the Southern Ocean where acidity is not too high. The shell on the right is from a pteropod in a region where the water is more acidic. (Figure source: (left) Bednaršek et al. 2012[e] (right) Nina Bednaršek).

Arctic Sea Ice Decline



The retreat of sea ice has occurred faster than climate models had predicted. Image on left shows Arctic minimum sea ice extent in 1984, which was about 2.59 million square miles, the average minimum extent for 1979-2000. Image on right shows that the extent of sea ice had dropped to 1.32 million square miles at the end of summer 2012. The dramatic loss of Arctic sea ice increases warming and has many other impacts on the region. Marine mammals including polar bears and many seal species depend on sea ice for nearly all aspects of their existence. Alaska Native coastal communities rely on sea ice for many reasons, including its role as a buffer against coastal erosion from storms and as a platform for hunting. (Figure source: NASA Earth Observatory 2012[8]).



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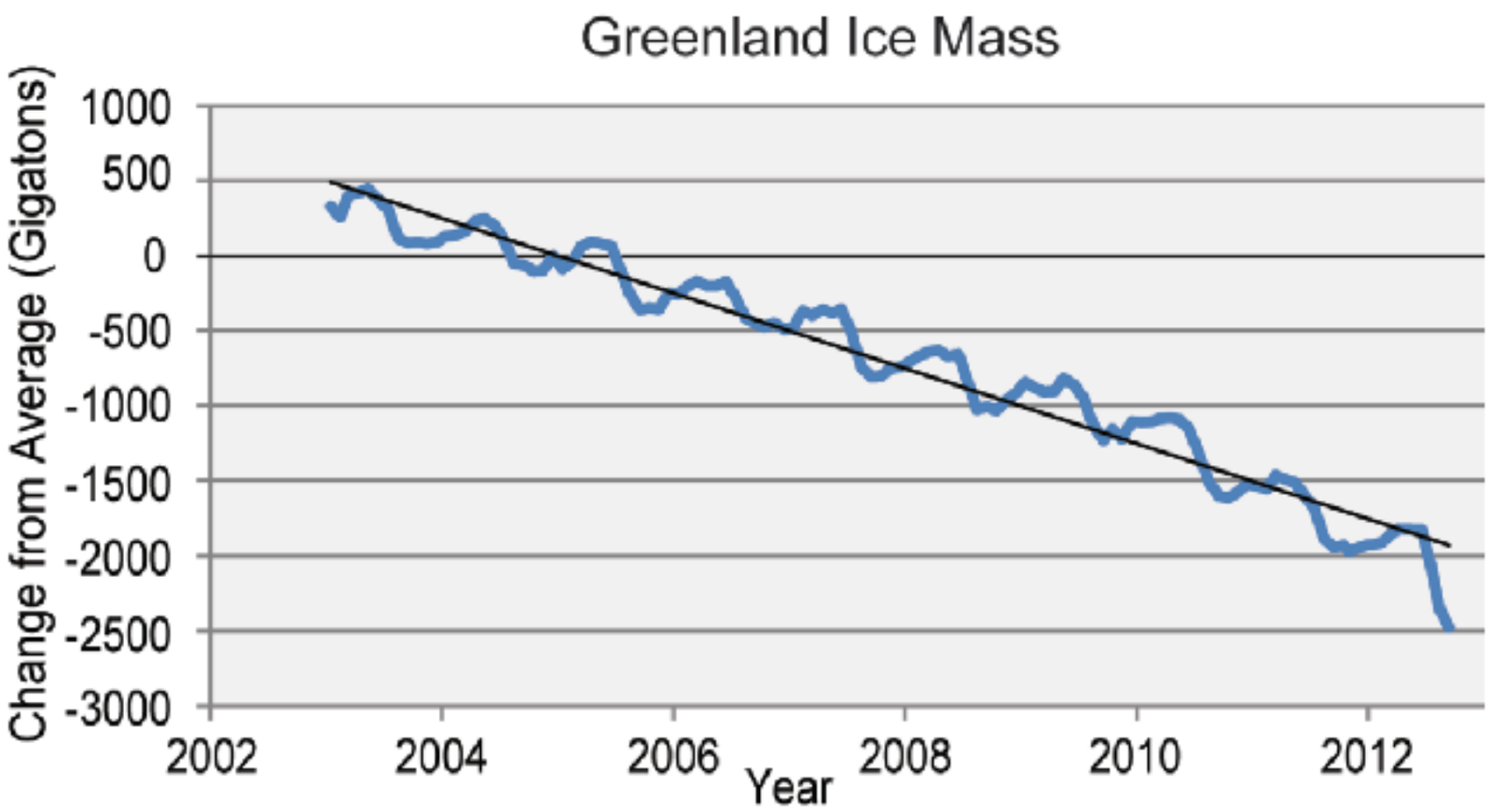

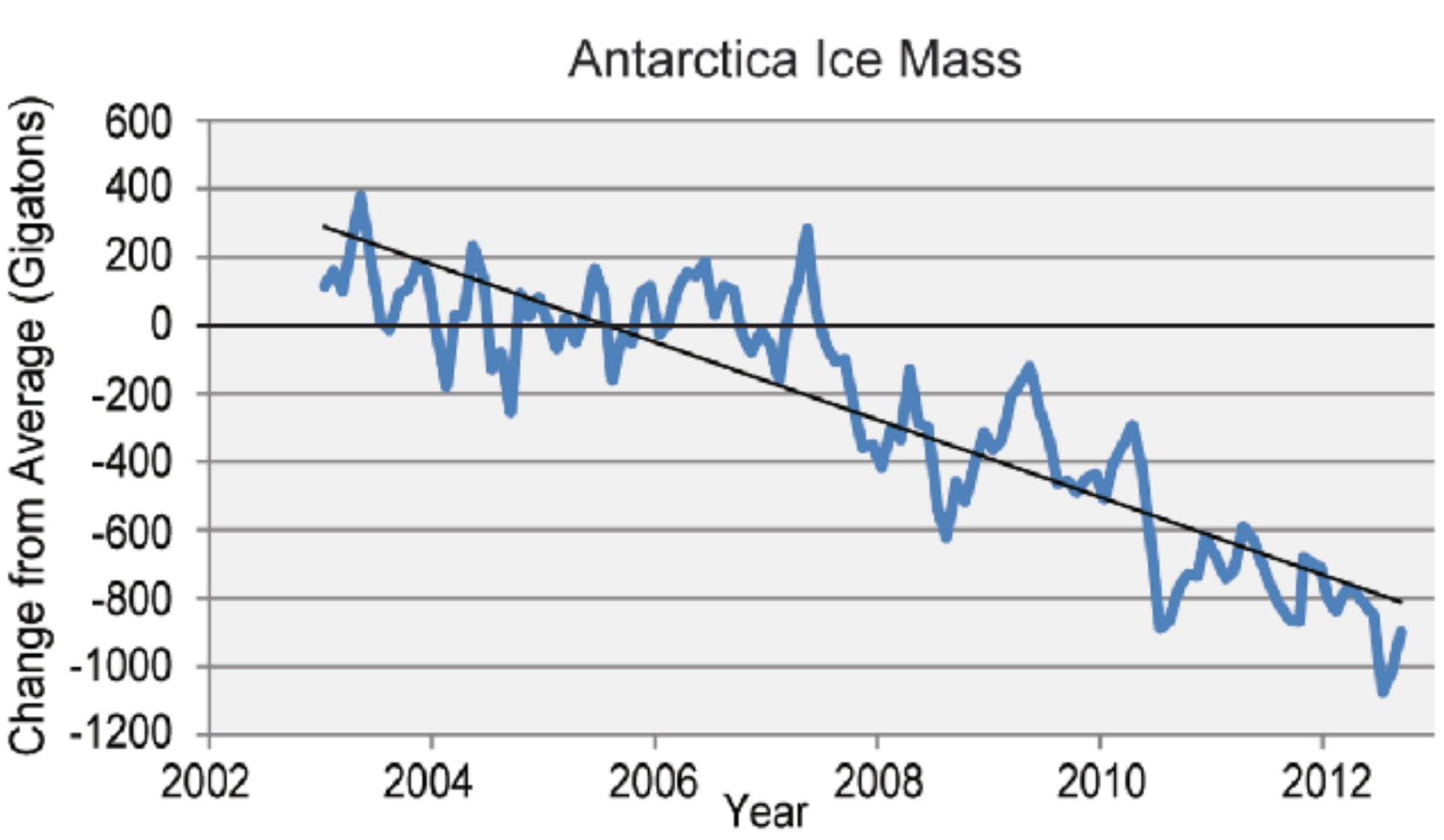

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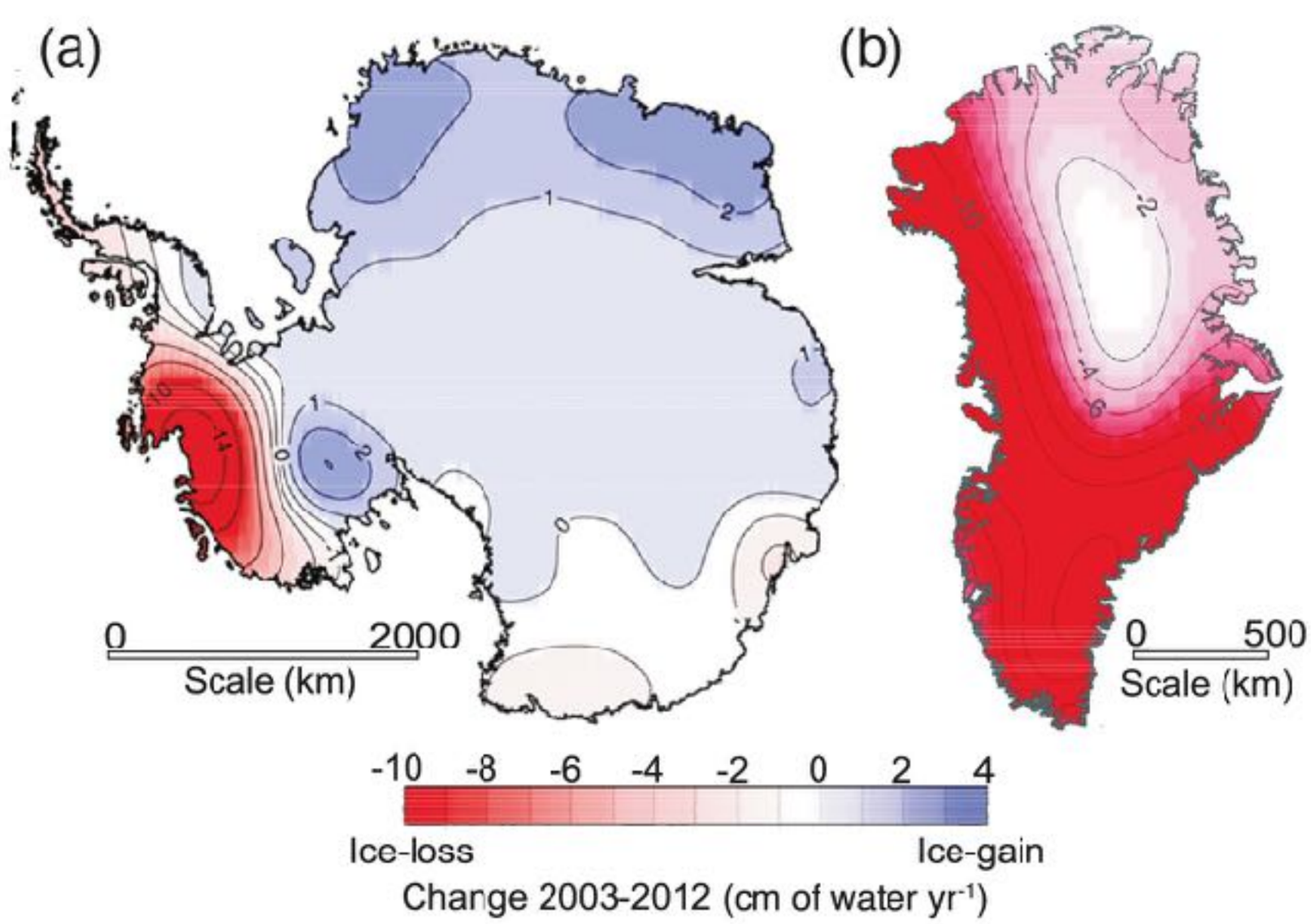

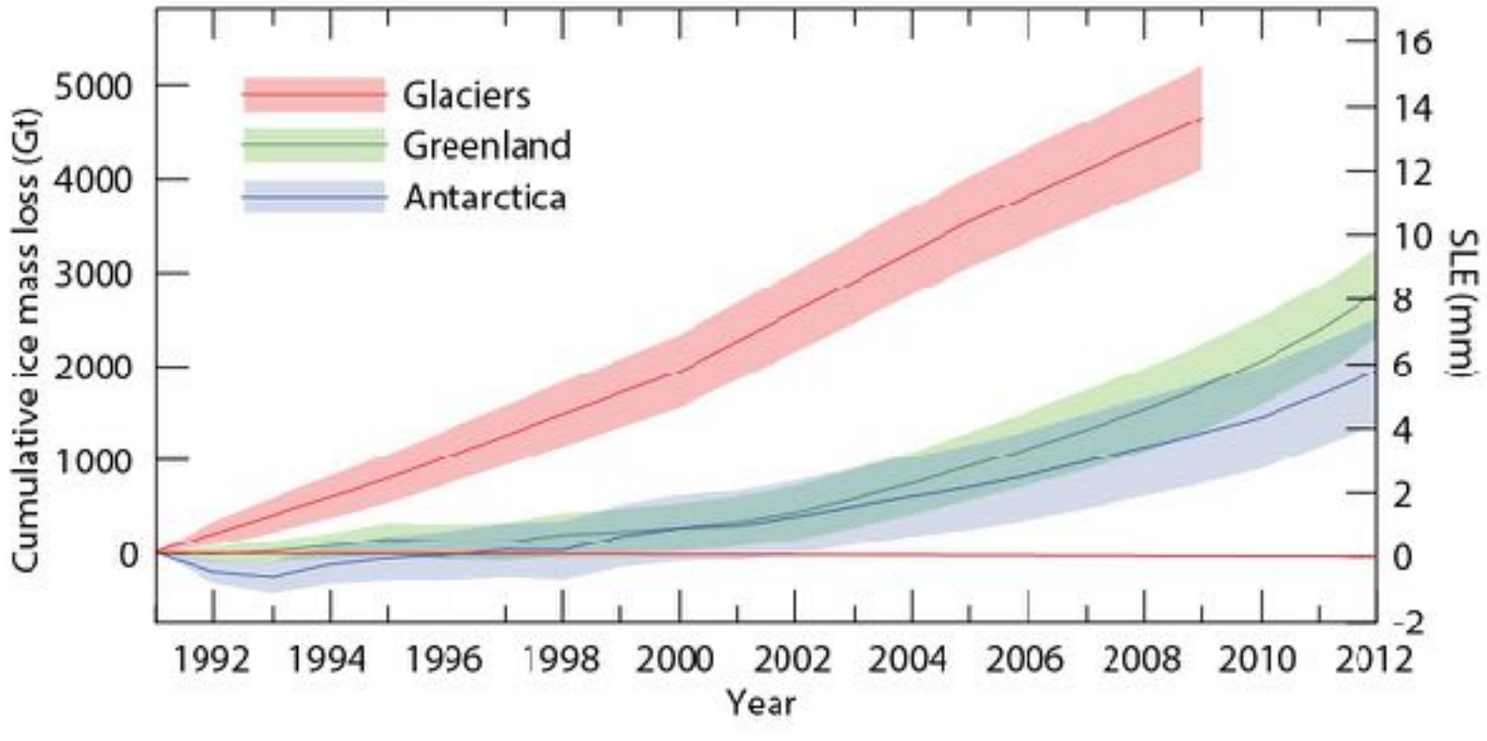

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On the left is a photograph of Muir Glacier in Alaska taken on August 13, 1941; on the right, a photograph taken from the same vantage point on August 31, 2004. Total glacial mass has declined sharply around the globe, adding to sea level rise. (Left photo by glaciologist William O. Field; right photo by geologist Bruce F. Molnia of the United States Geological Survey.)

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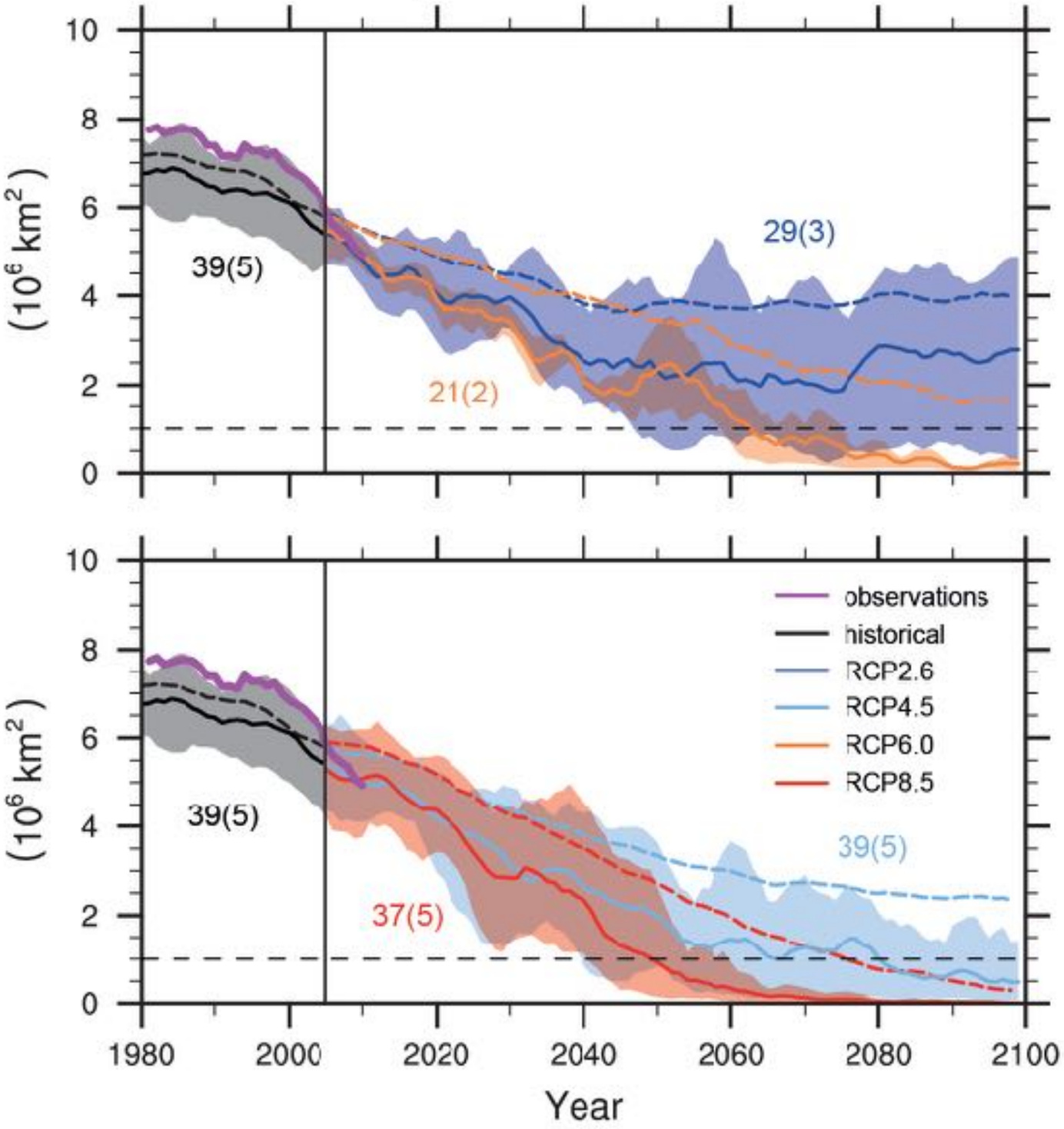

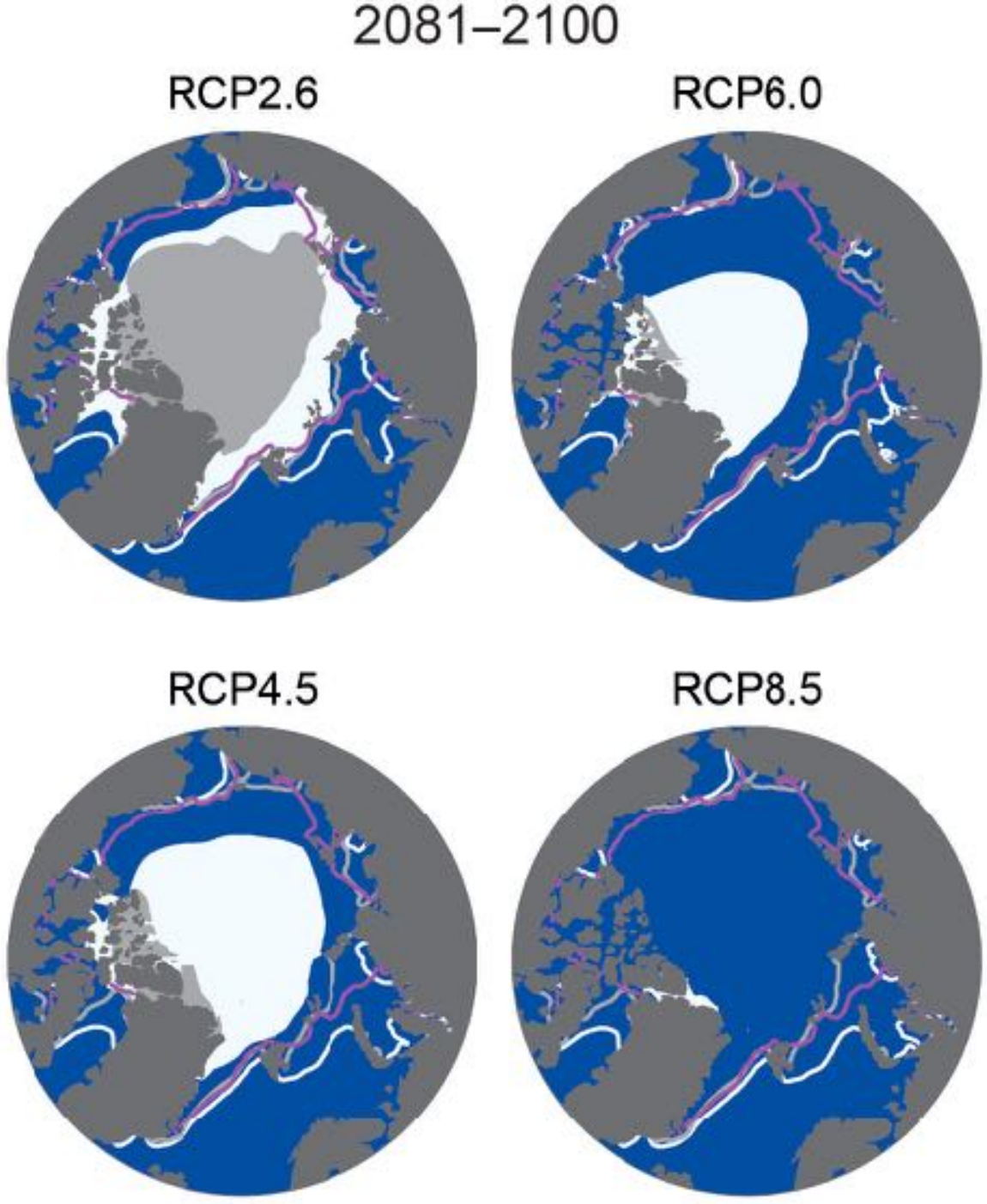

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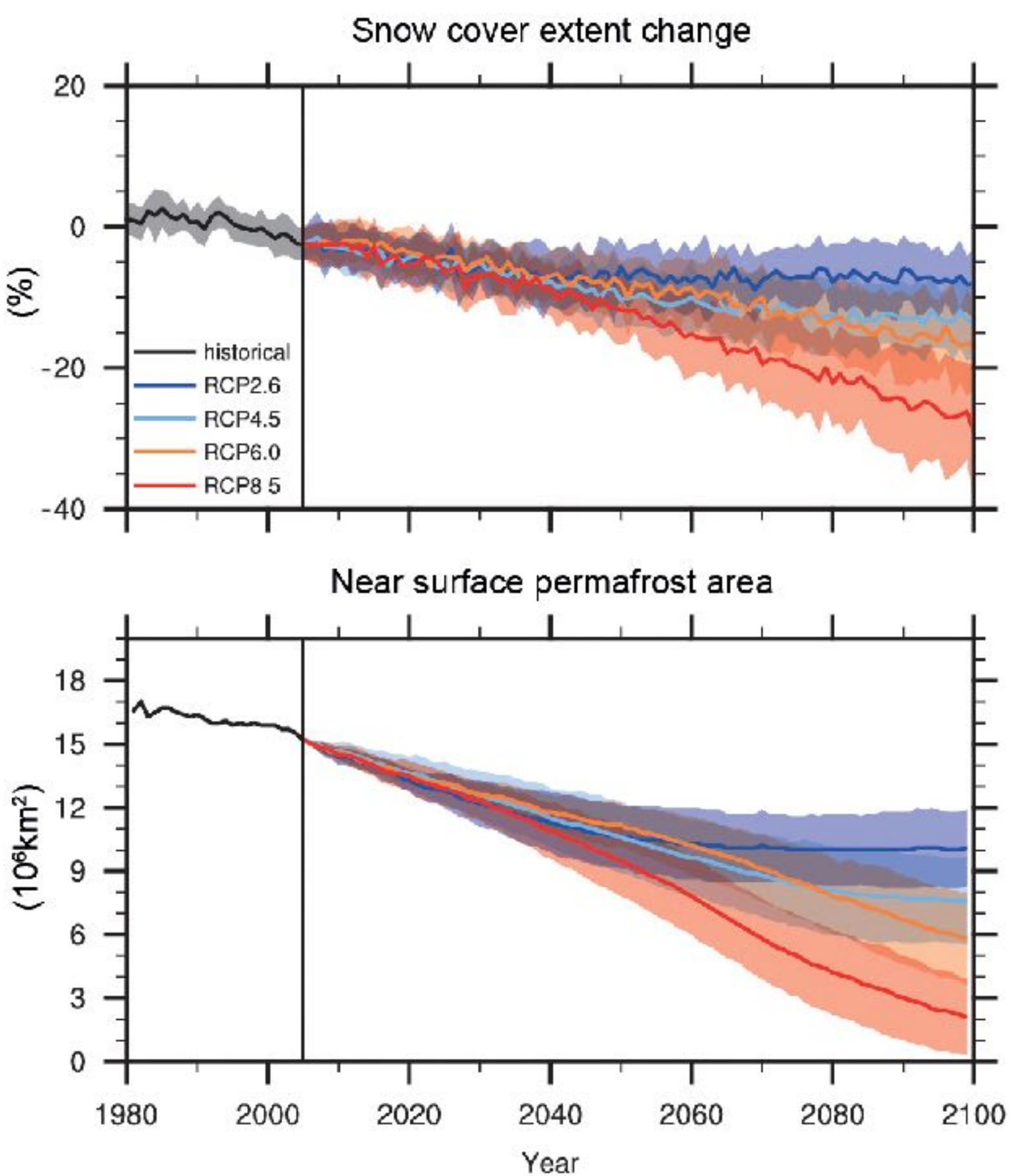

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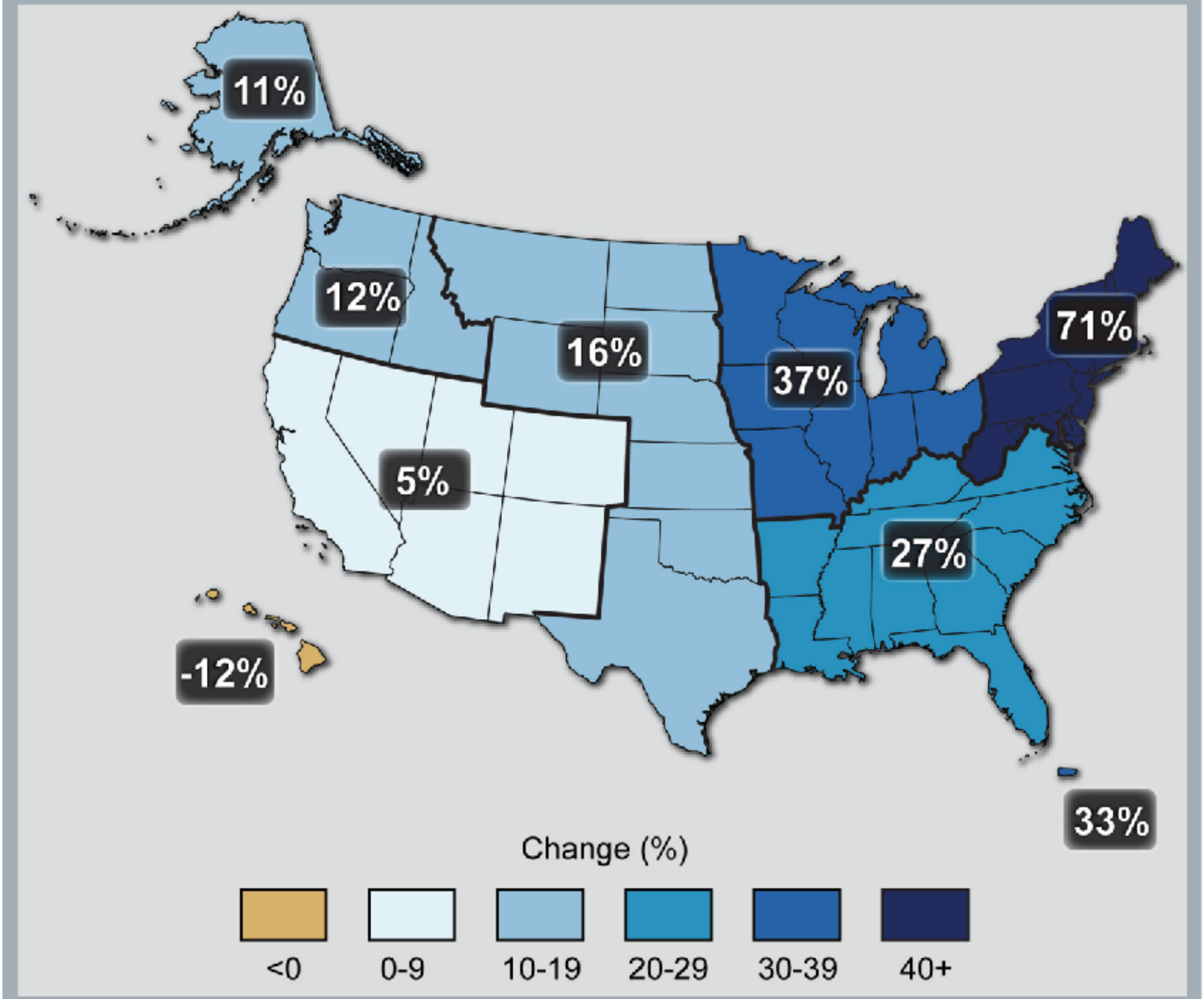
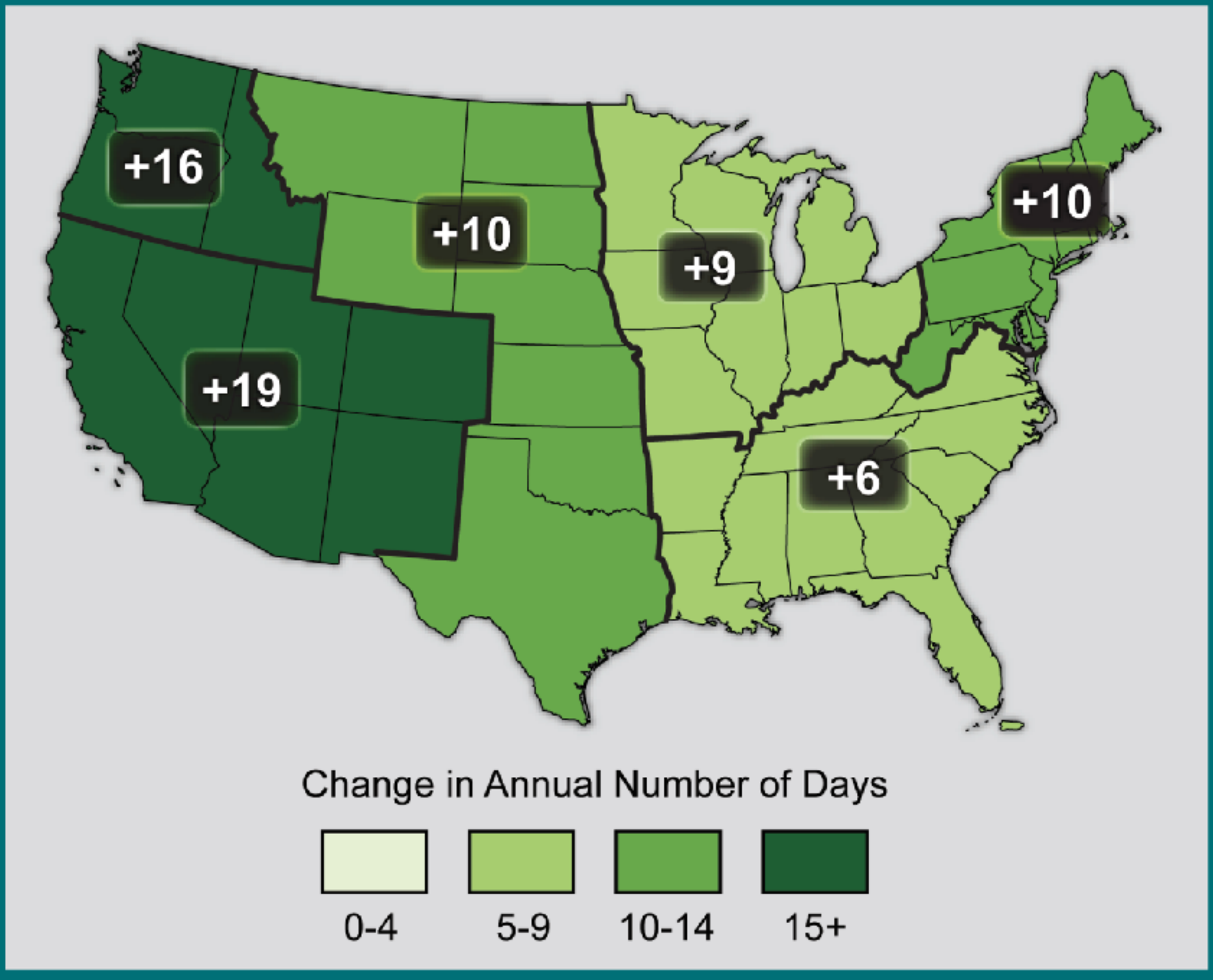
Observed Change in Very Heavy Precipitation



Observed Increases in Frost-Free Season



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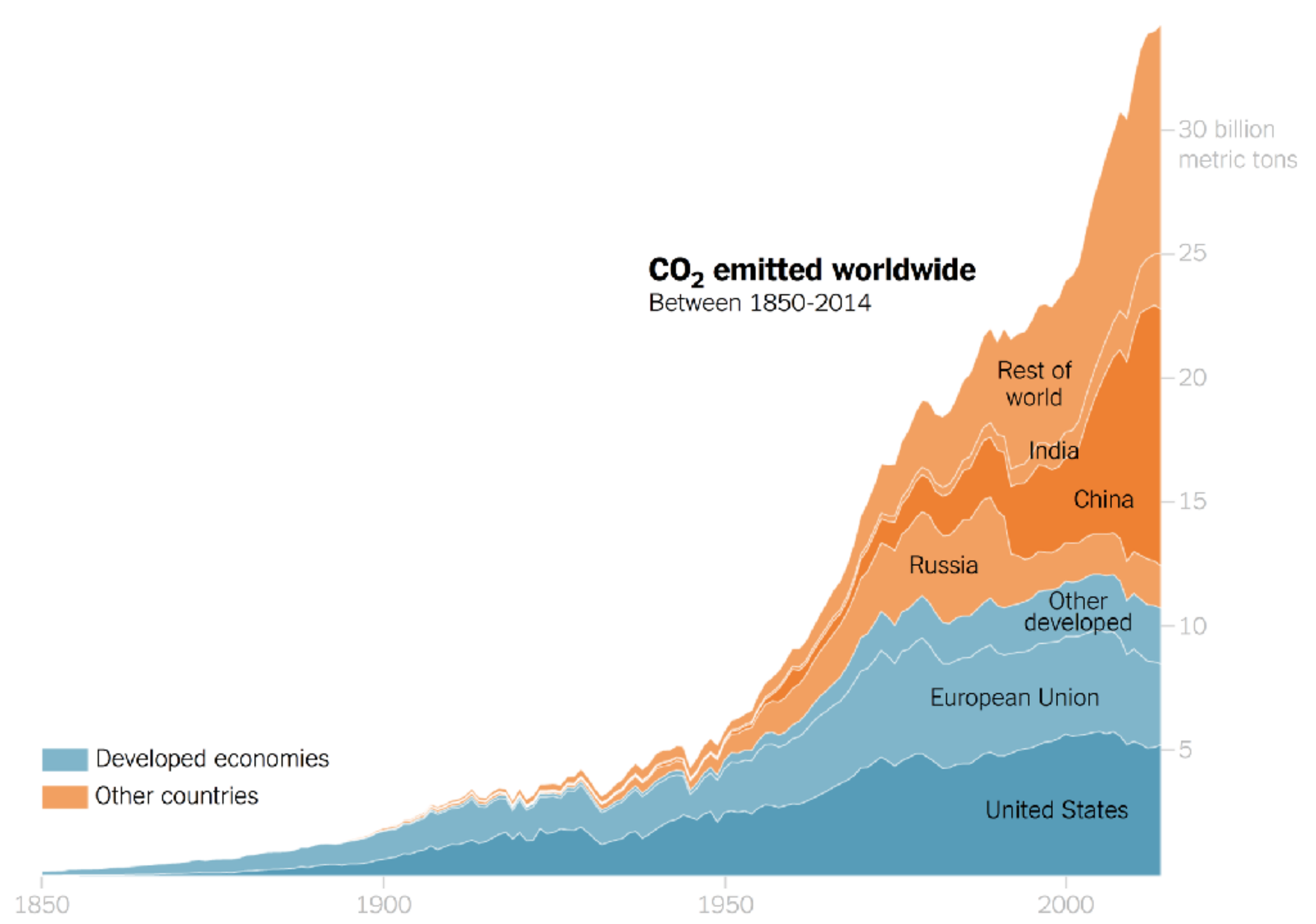
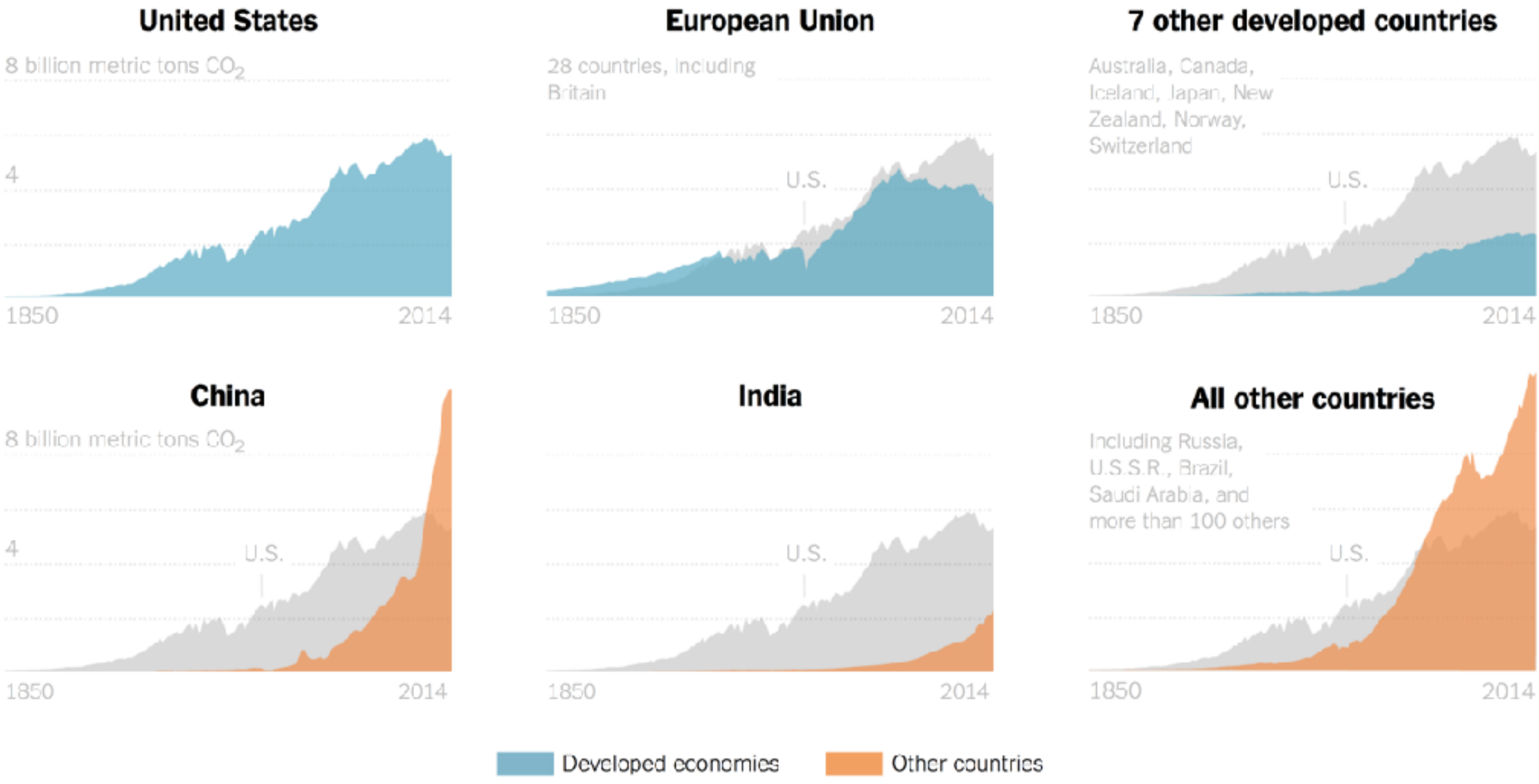
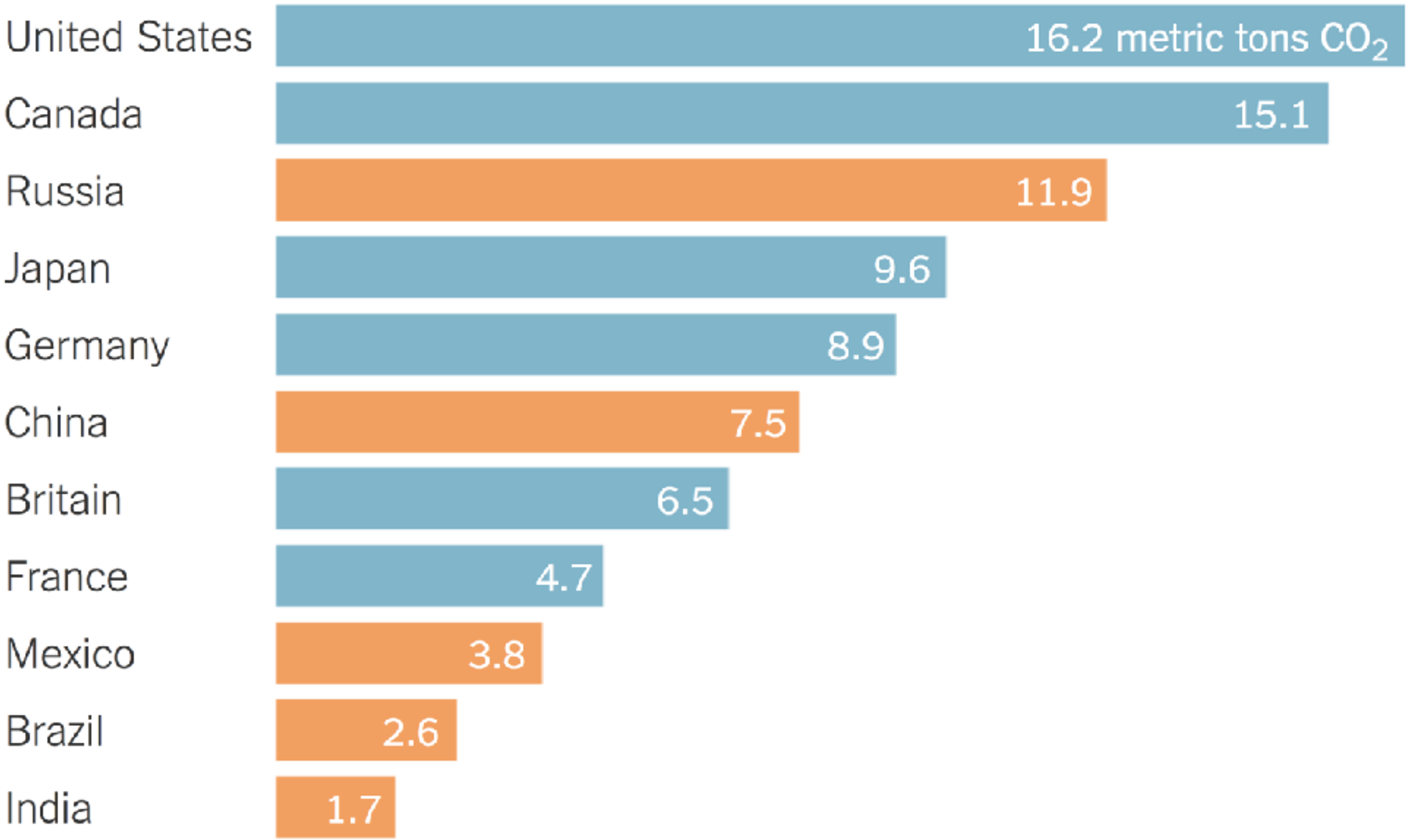


Justin Gillis and Nadja Popovich, NY Times, June 1, 2017



Justin Gillis and Nadja Popovich, NY Times, June 1, 2017

Per person carbon emissions in 2014



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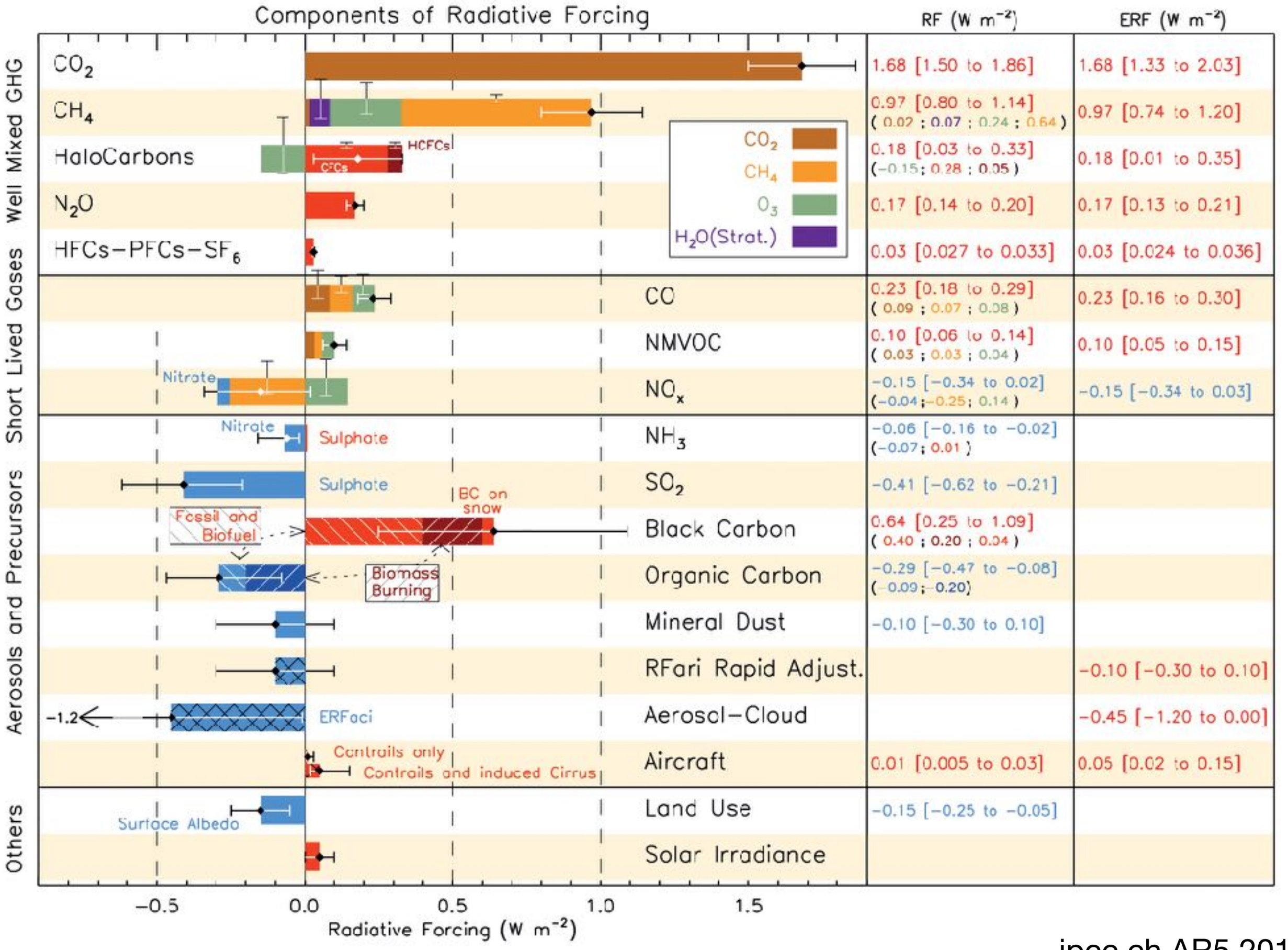

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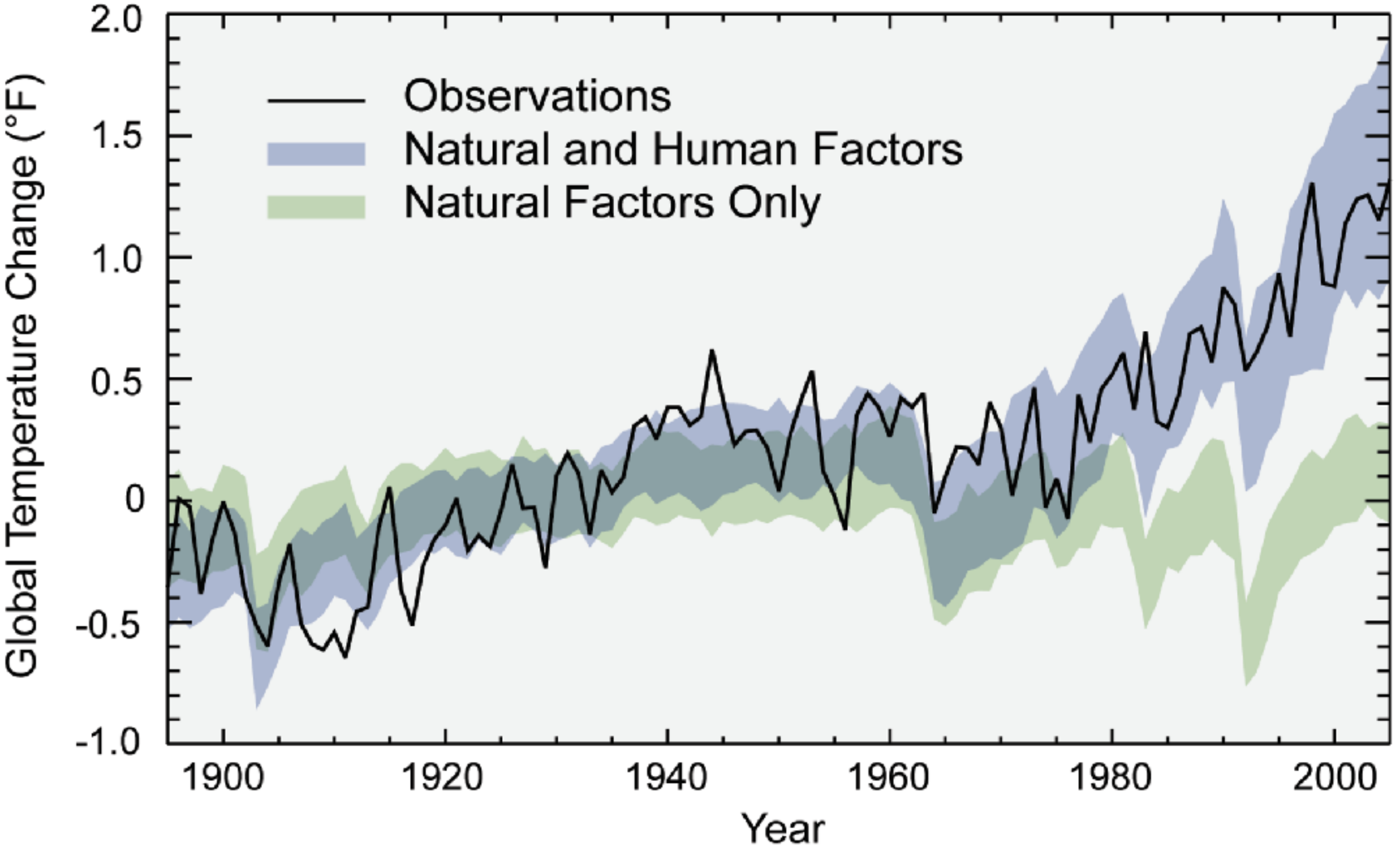

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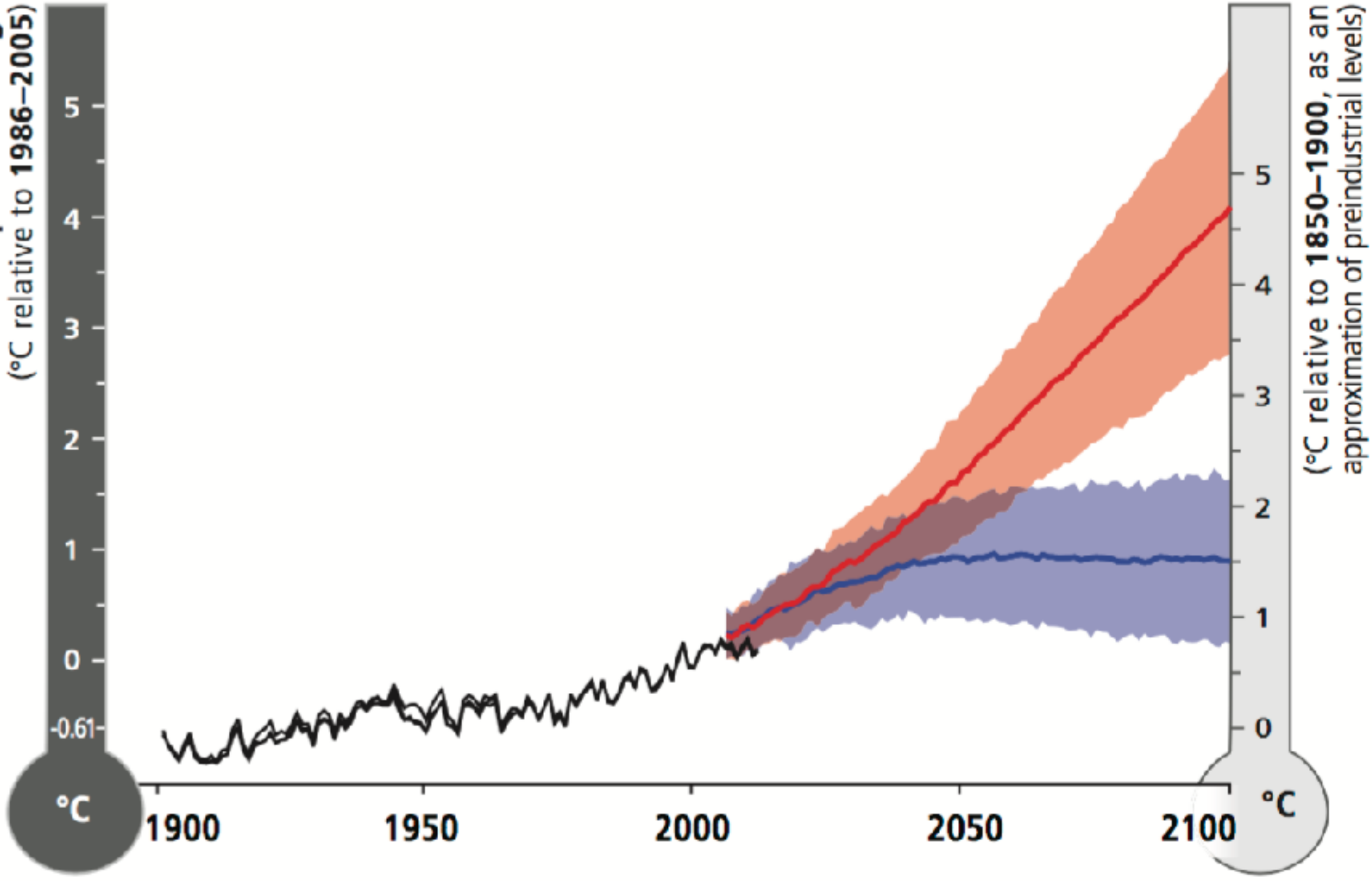

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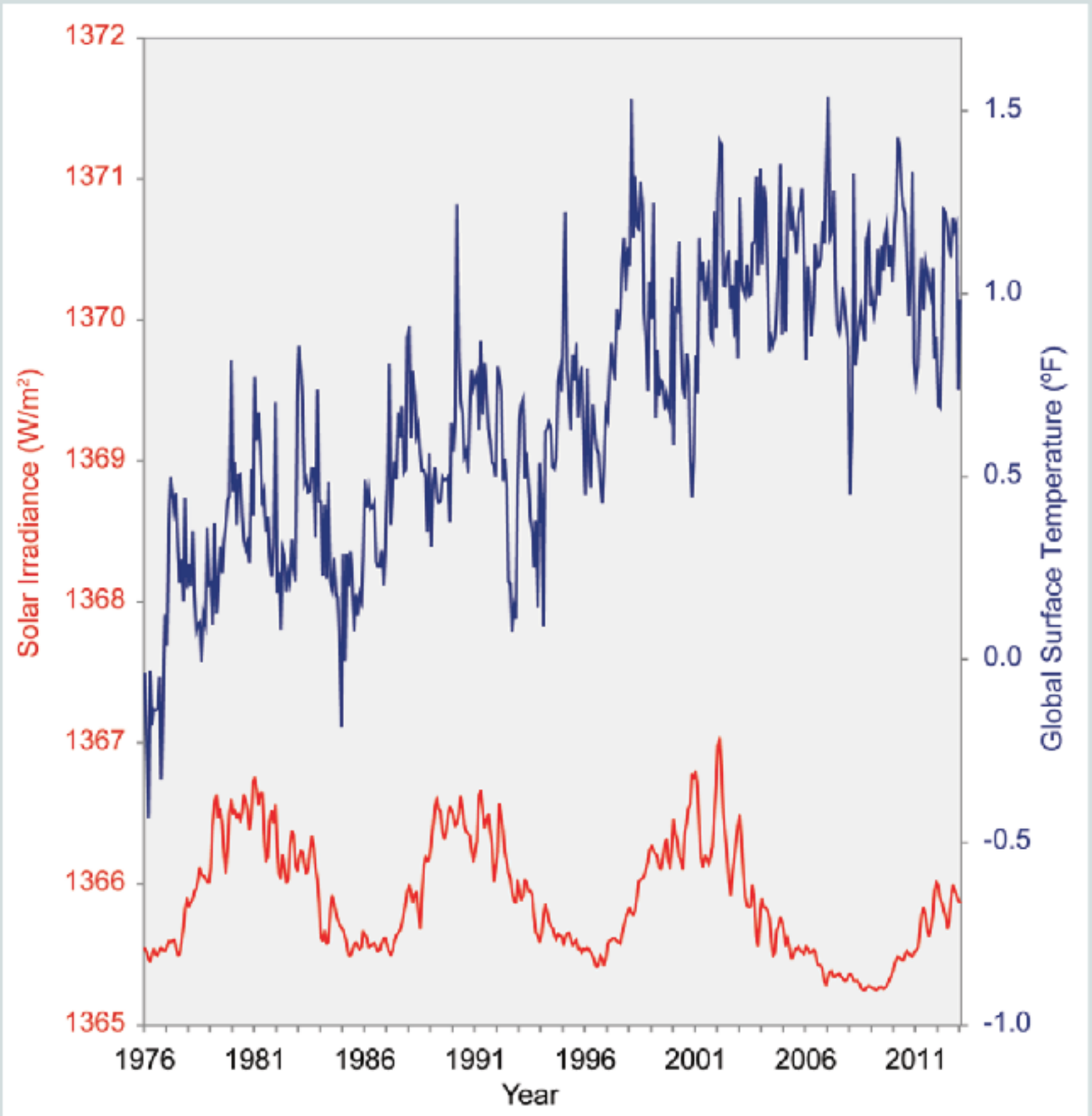
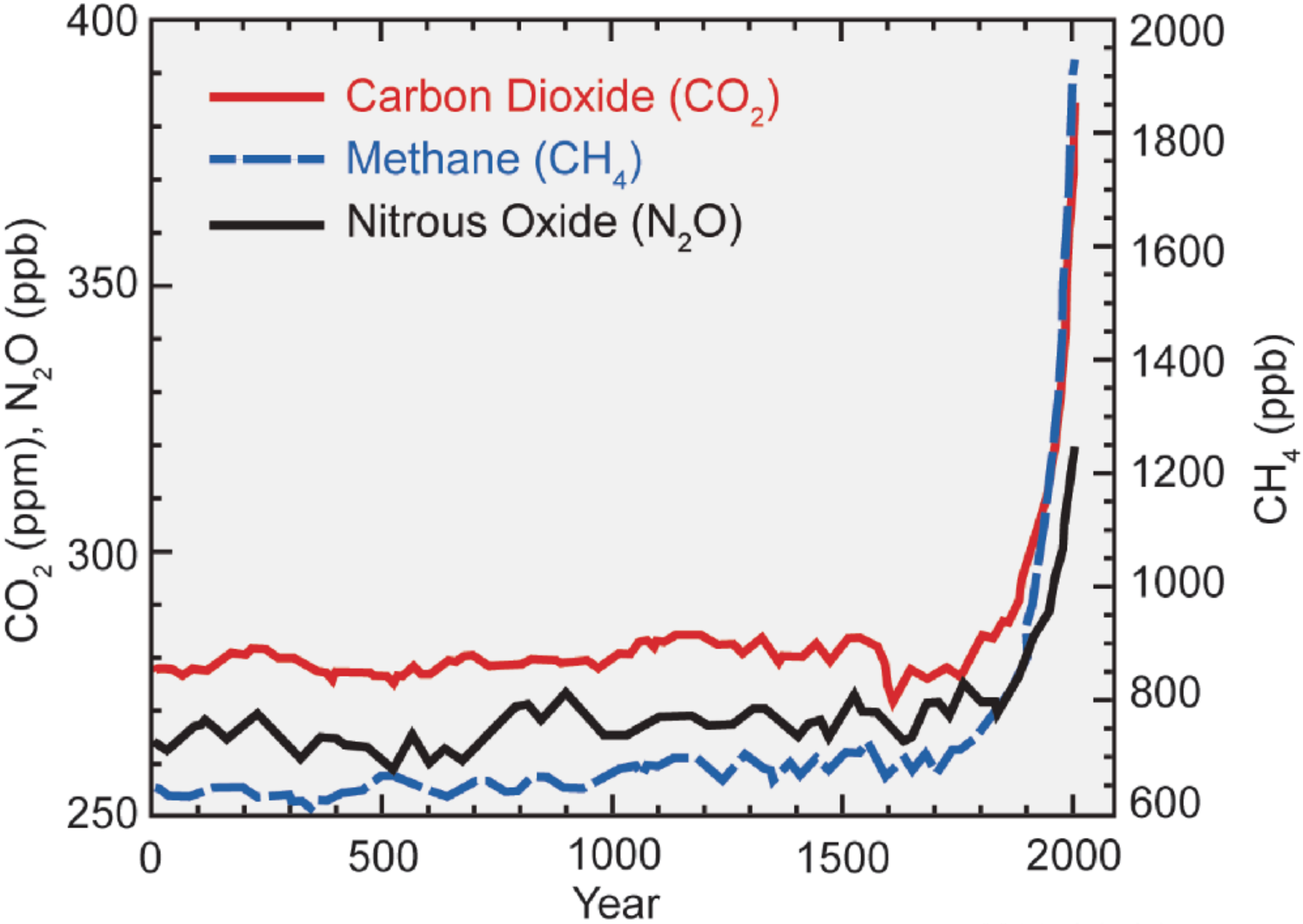
Measurements of Surface Temperature and Sun's Energy





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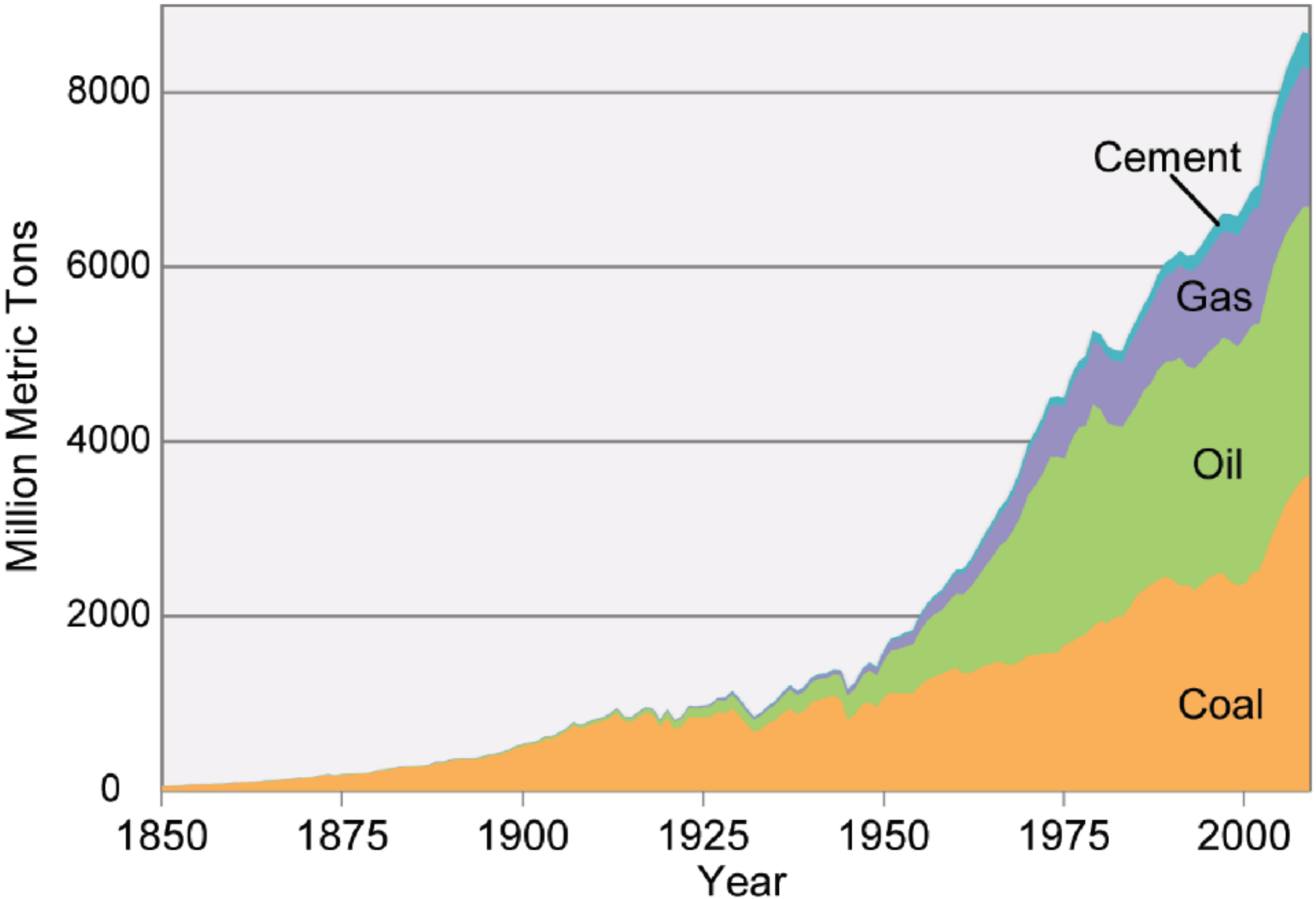
Carbon Emissions in the Industrial Age



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Oil used for transportation and coal used for electricity generation are the largest contributors to the rise in carbon dioxide that is the primary driver of recent climate change.

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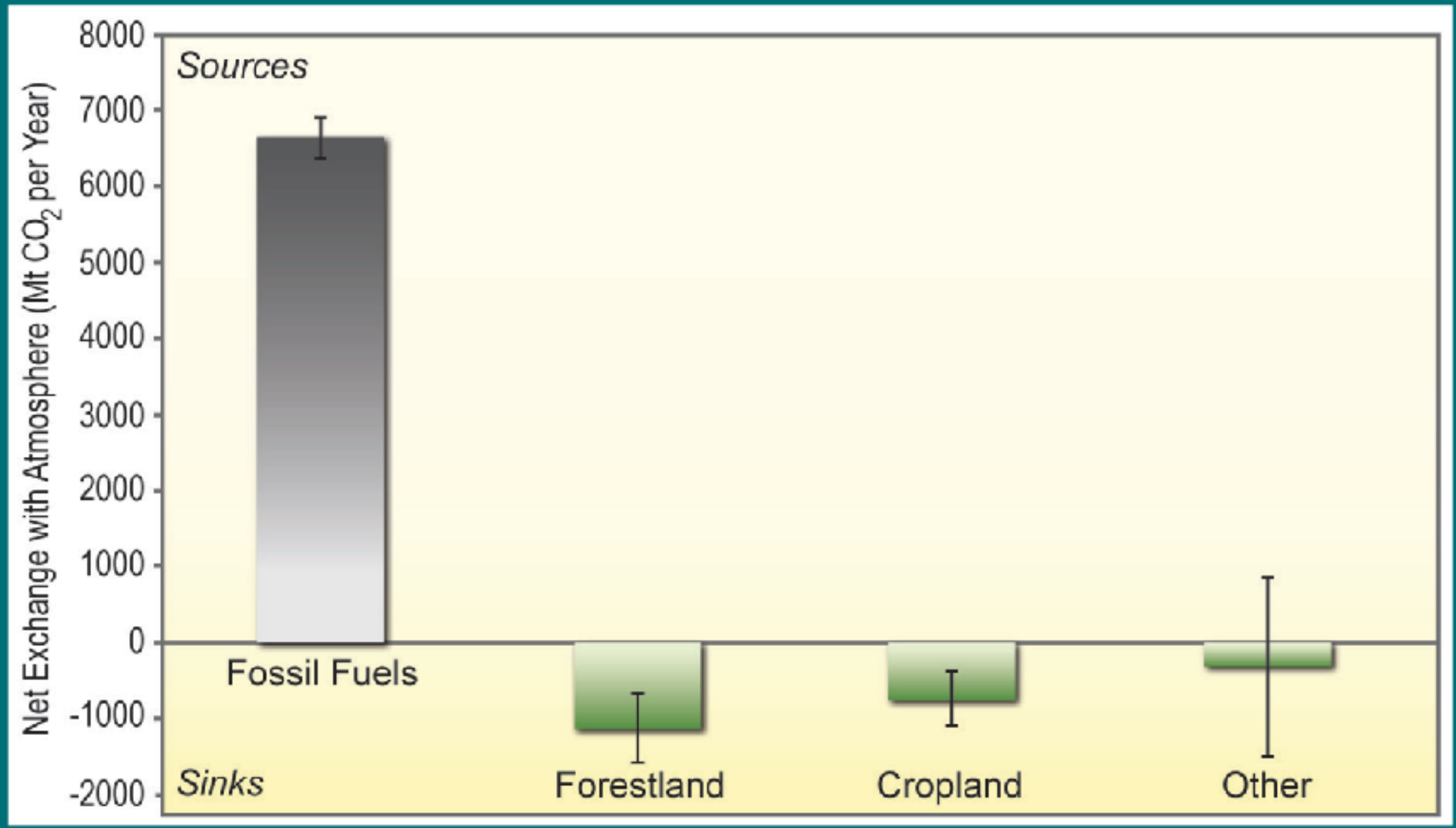
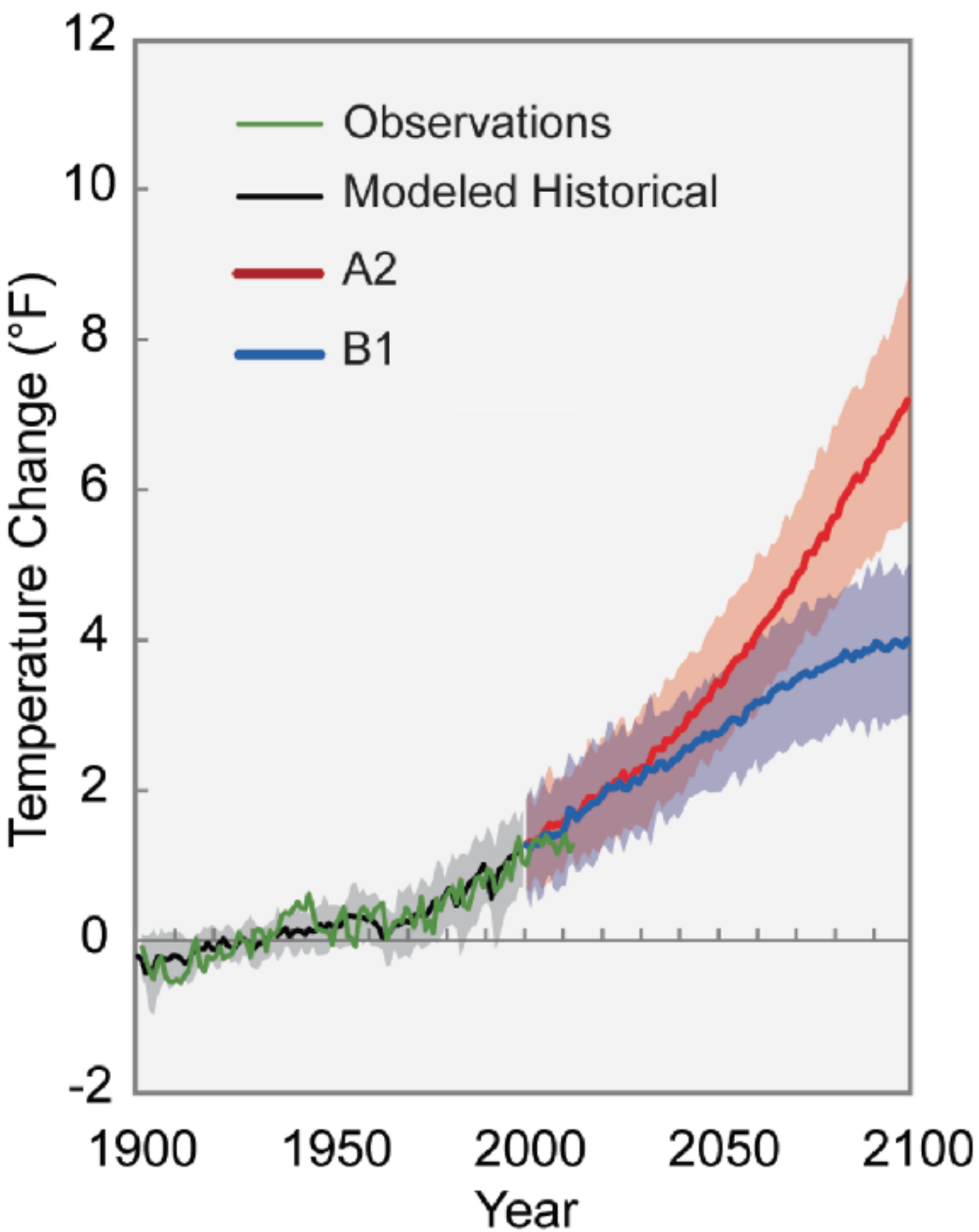
Major North American Carbon Dioxide Sources and Sinks



The release of carbon dioxide from fossil fuel burning in North America (shown here for 2010) vastly exceeds the amount that is taken up and temporarily stored in forests, crops, and other ecosystems (shown here is the annual average for 2000-2006). (Figure source: King et al. 2012[4]).



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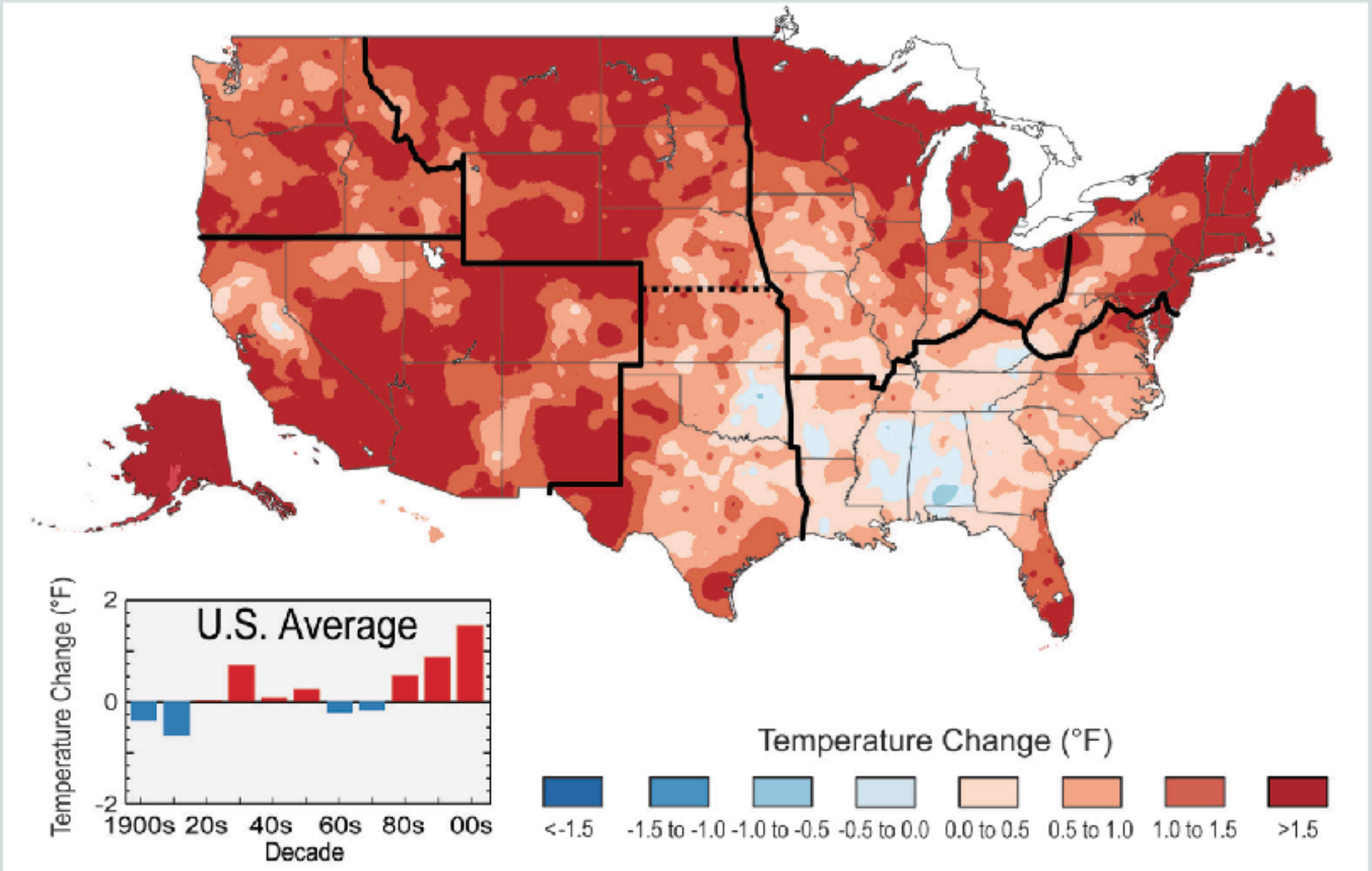
Observed U.S. Temperature Change



The colors on the map show temperature changes over the past 22 years (1991-2012) compared to the 1901-1960 average for the contiguous U.S., and to the 1951-1980 average for Alaska and Hawai'i. The bars on the graph show the average temperature changes for the U.S. by decade for 1901-2012 (relative to the 1901-1960 average). The far right bar (2000s decade) includes 2011 and 2012. The period from 2001 to 2012 was warmer than any previous decade in every region. (Figure source: NOAA NCDC / CICS-NC).

2. Some extreme weather and climate events have increased in recent decades, and new and stronger evidence confirms that some of these increases are related to human activities.

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3. Human-induced climate change is projected to continue, and it will accelerate significantly if global emissions of heat-trapping gases continue to increase.

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4. Impacts related to climate change are already evident in many sectors and are expected to become increasingly disruptive across the nation throughout this century and beyond.

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5. Climate change threatens human health and well-being in many ways, including through more extreme weather events and wildfire, decreased air quality, and diseases transmitted by insects, food, and water.

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6. Infrastructure is being damaged by sea level rise, heavy downpours, and extreme heat; damages are projected to increase with continued climate change.

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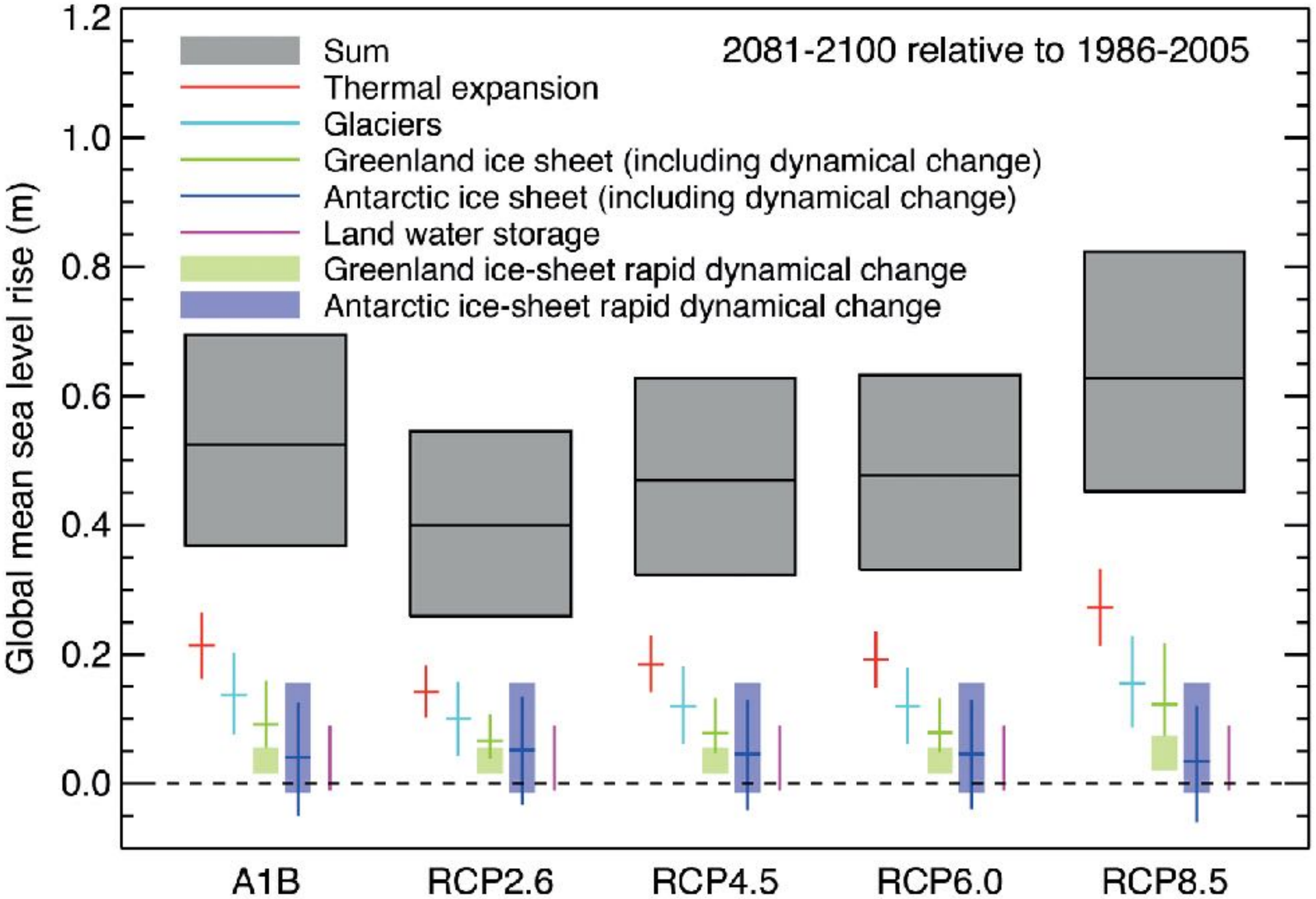

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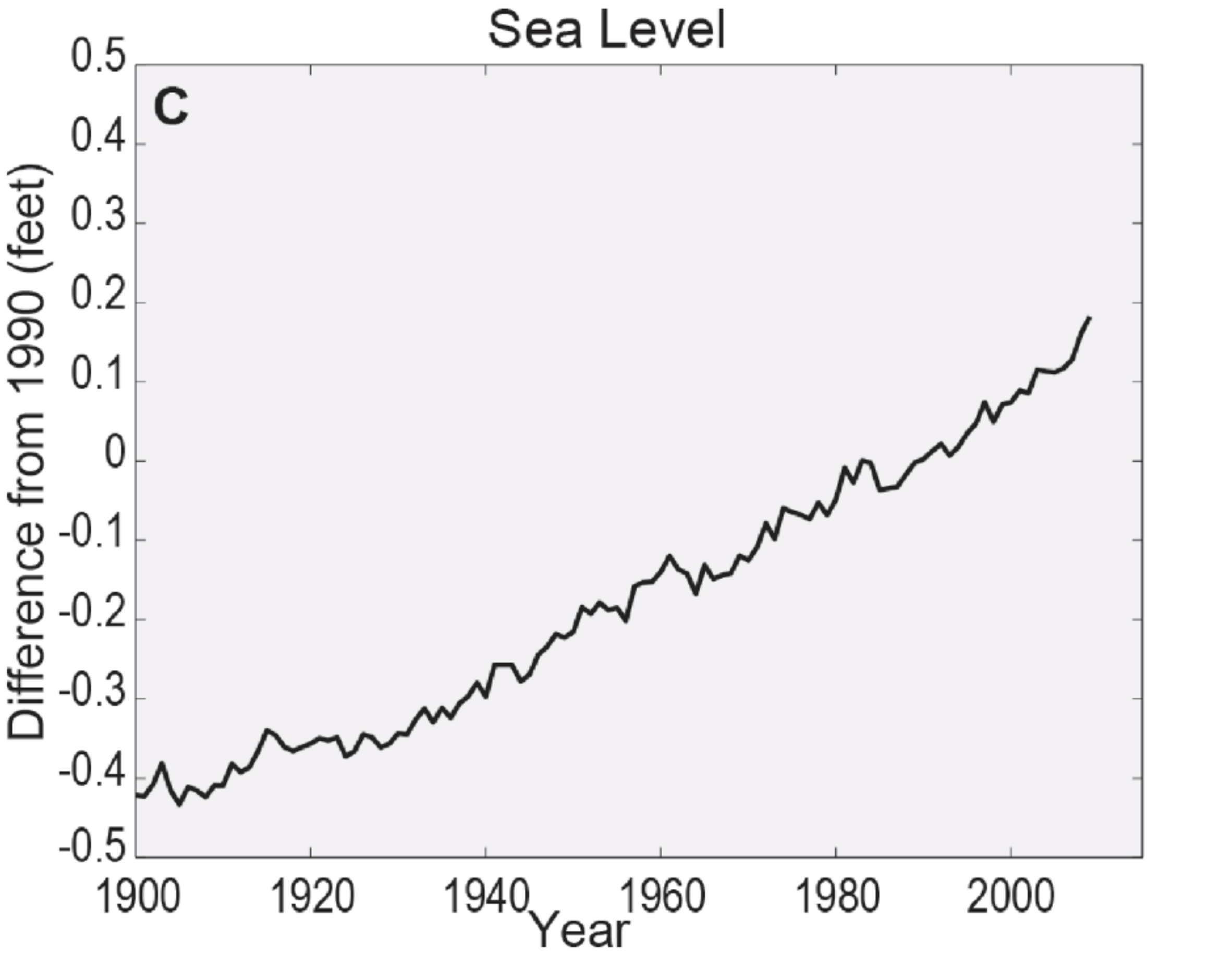

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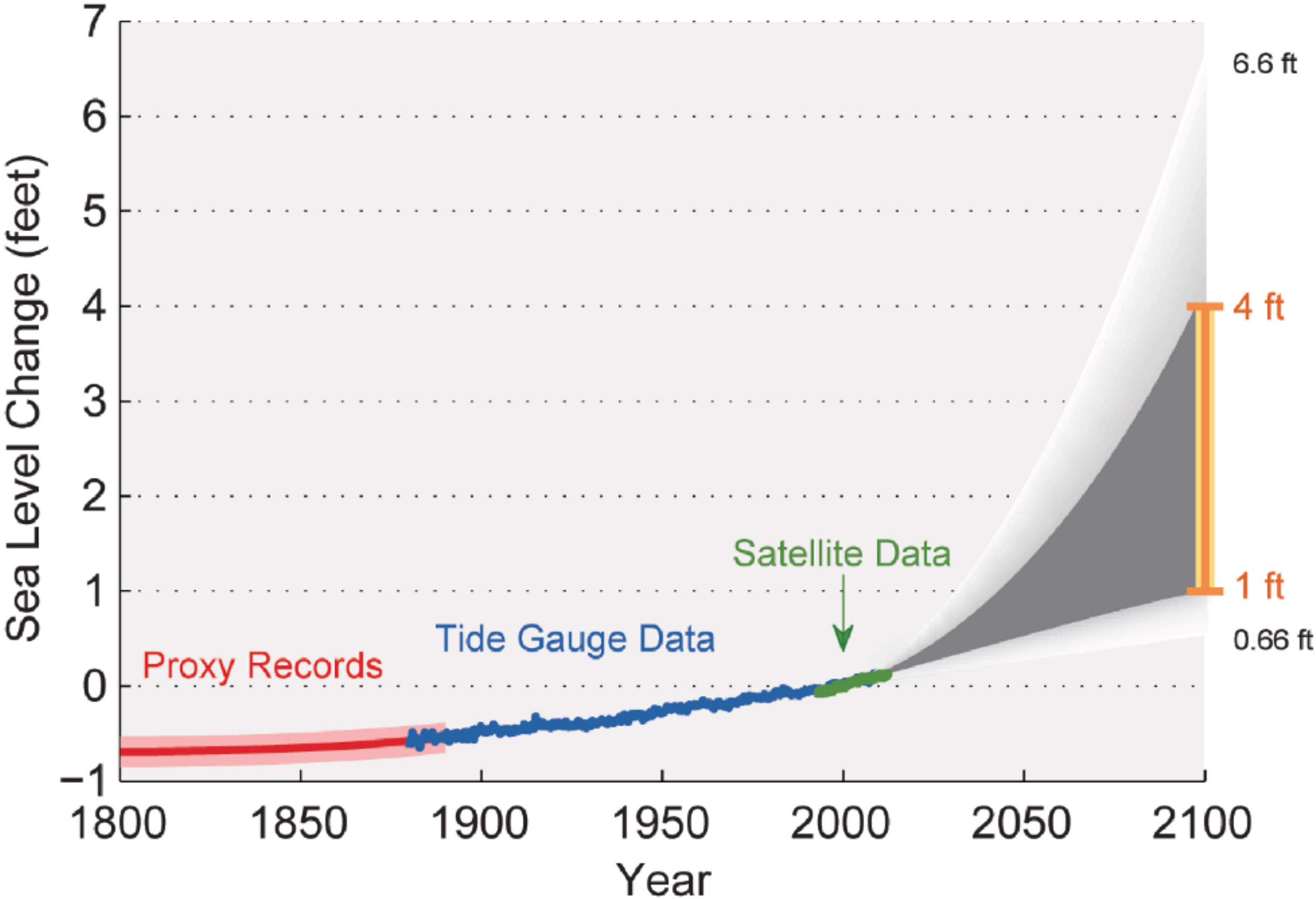

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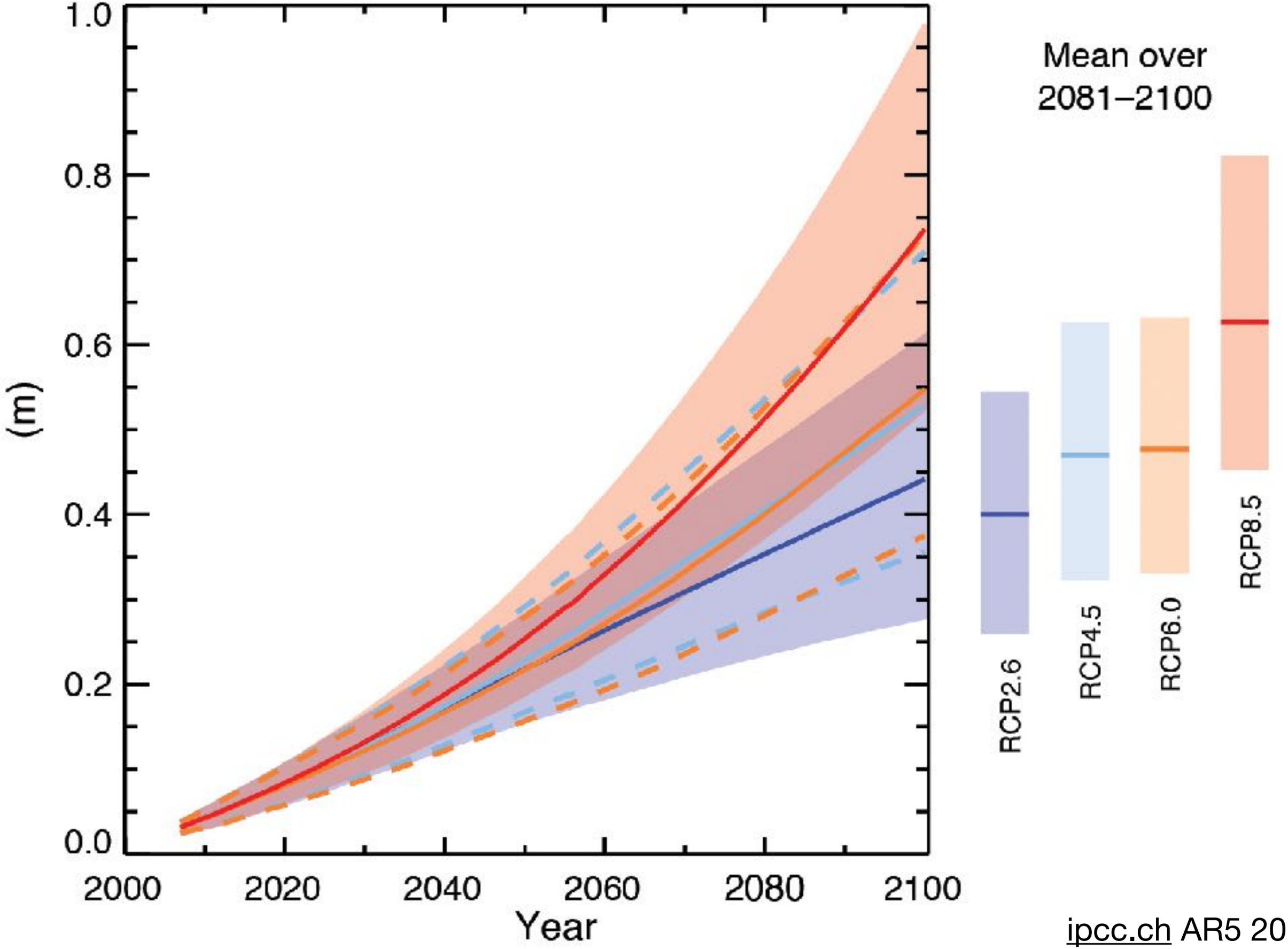
Global mean sea level rise



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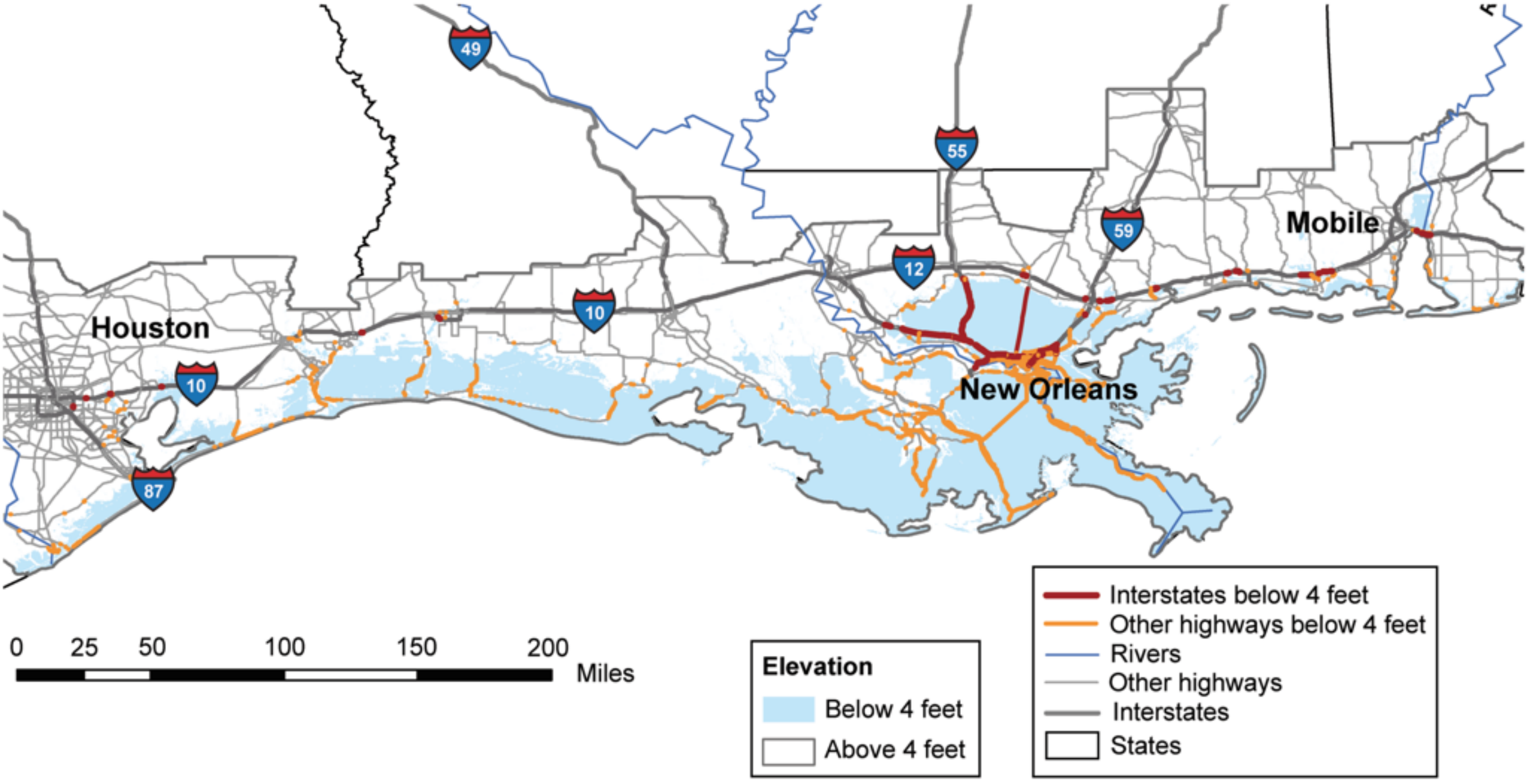

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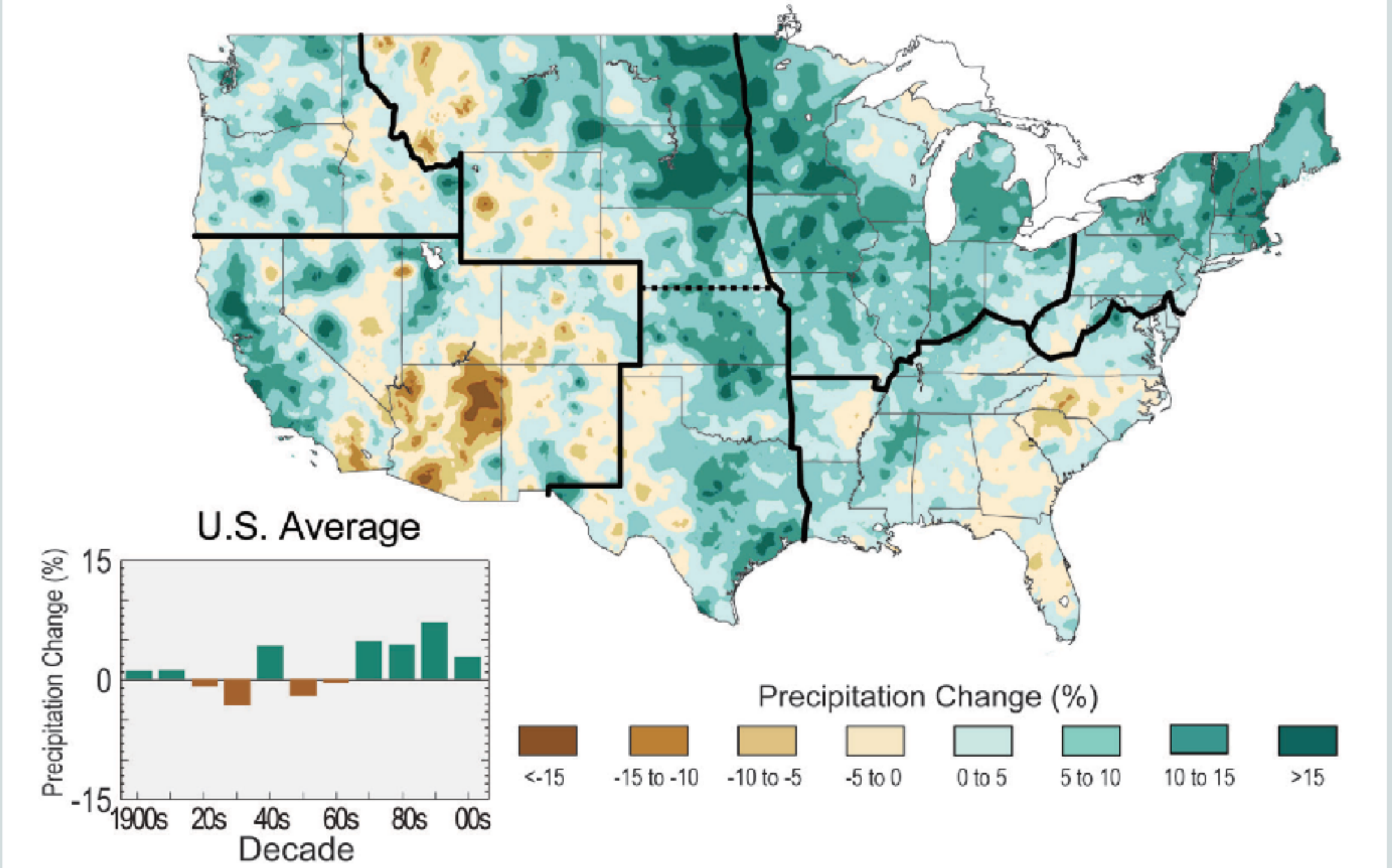
Observed U.S. Precipitation Change



The colors on the map show annual total precipitation changes for 1991-2012 compared to the 1901-1960 average, and show wetter conditions in most areas. The bars on the graph show average precipitation differences by decade for 1901-2012 (relative to the 1901-1960 average). The far right bar is for 2001-2012. (Figure source: NOAA NCDC / CICS-NC).

7. Water quality and water supply reliability are jeapardized by climate change in a variety of ways that affect ecosystems and livelihoods.

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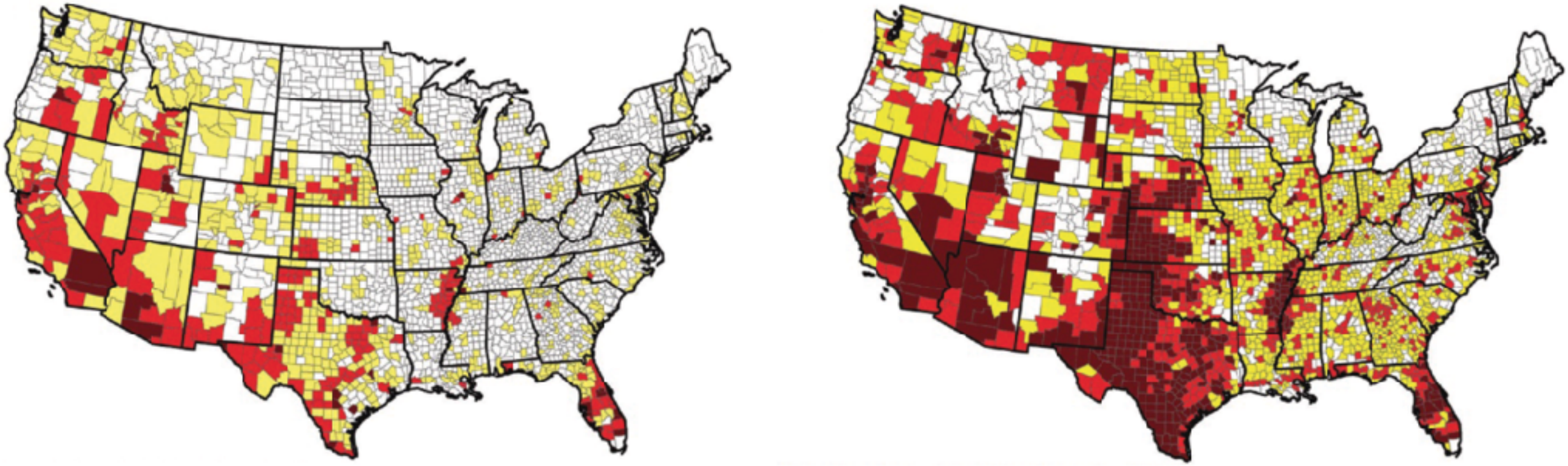
(a) No Climate Change Effects

(b) Climate Change Effects



Water Supply Sustainability Risk Index (2050)

- Extreme (29)
- High (271)
- Moderate (821)
- Low (2020)

Water Supply Sustainability Risk Index (2050)

- Extreme (412)
- High (608)
- Moderate (1192)
- Low (929)

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8. Climate disruptions to agriculture have been increasing and are projected to become more severe over this century.

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9. Climate change poses particular threats to Indigenous Peoples' health, well-being, and ways of life.

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10. Ecosystems and the benefits they provide to society are being affected by climate change. The capacity of ecosystems to buffer the impacts of extreme events like fires, floods, and severe storms is being overwhelmed.

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11. Ocean waters are becoming warmer and more acidic, broadly affecting ocean circulation, chemistry, ecosystems, and marine life.

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12. Planning for adaptation (to address and prepare for impacts) and mitigation (to reduce future climate change, for example by cutting emissions) is becoming more widespread, but current implementation efforts are insufficient to avoid increasingly negative social, environmental, and economic consequences.

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