The Scientific Basis For Climate Change

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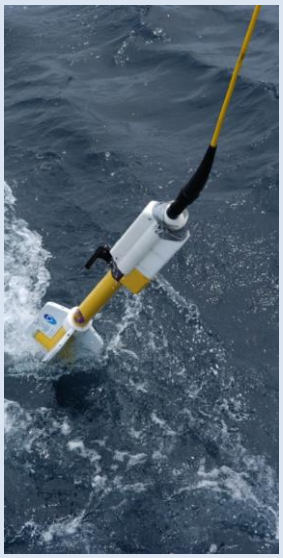
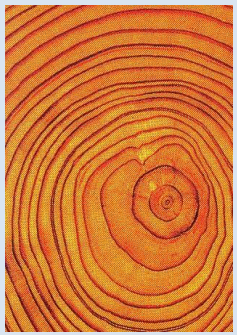
Asheville, NC

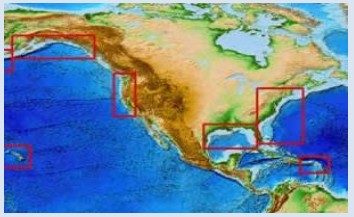
National Centers for Environmental Information
Steward of the Nation's Environmental Information

With data that spans Stone Age to Space Age, from the depths of the ocean to the sun, and across the globe

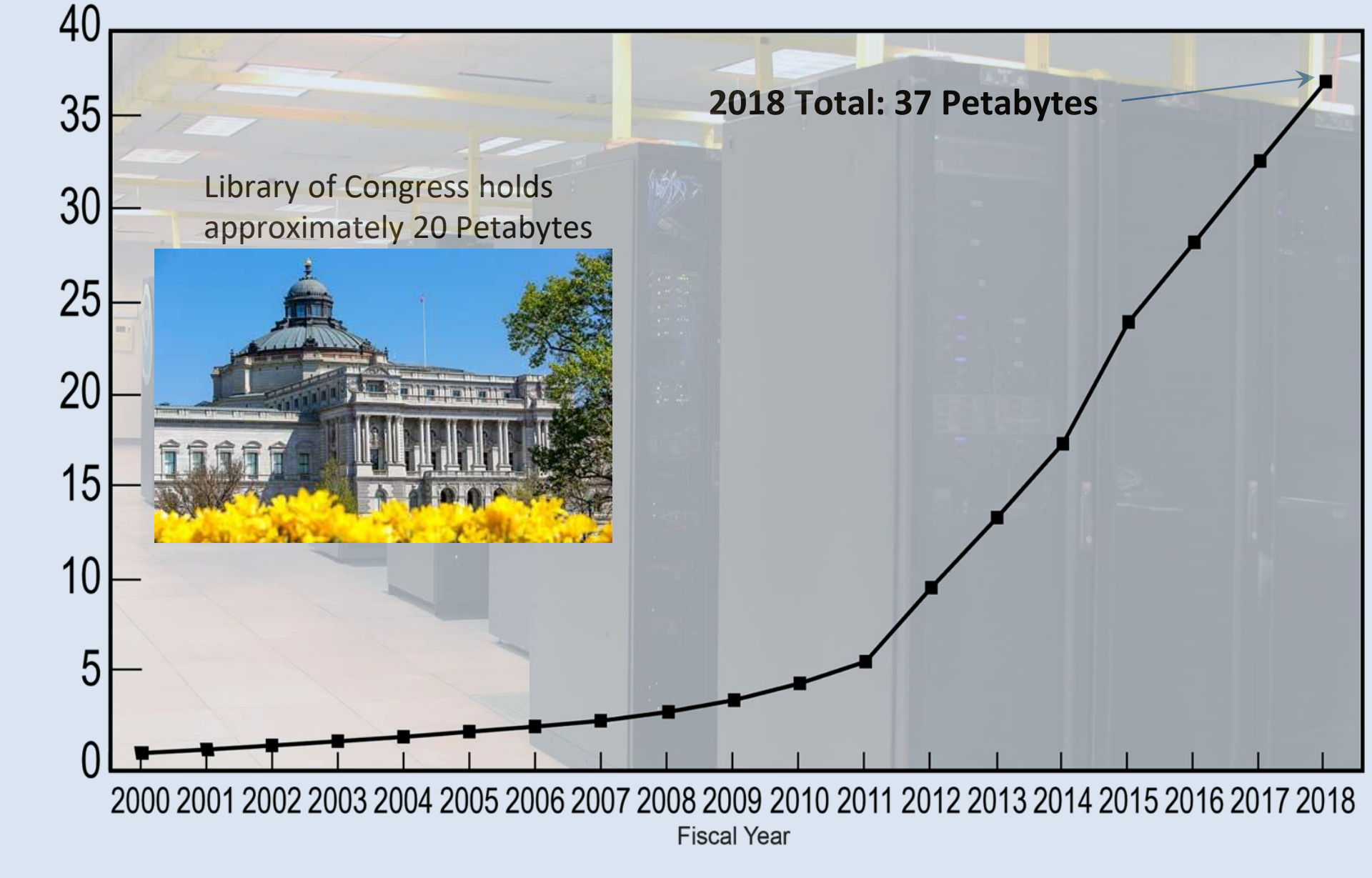





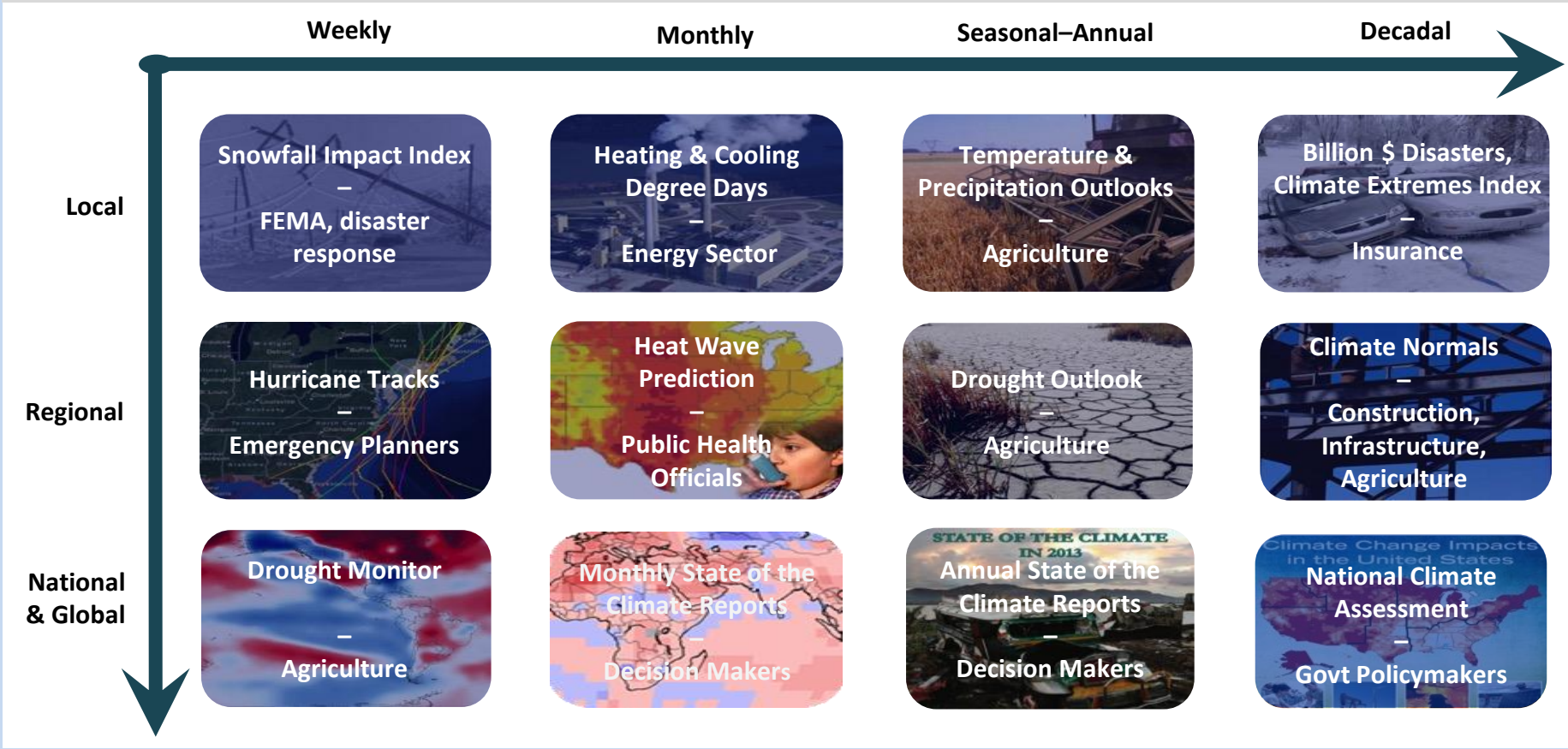



NCEI Environmental Data Archive Volume

Increasing Data Volumes from Station, Model, Radar, and Satellite Sources



Center for Weather and Climate Products



Climate Change: What's the Evidence?

Weather vs. Climate

- **Weather** is local and short-term. It can change day to day, hour to hour, and even minute to minute.
- **Climate** is what the weather is normally like year to year and decade to decade. Climate is usually measured over periods of about 30 years.

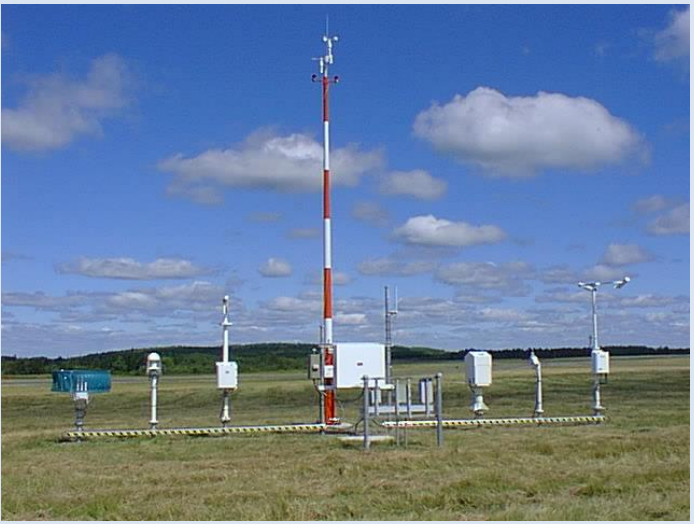
Climate *tells you what clothes to buy and have in your wardrobe.*
Weather *tells you what to wear each day.*

ING Miami Marathon and Half Marathon
January 2008 Florida

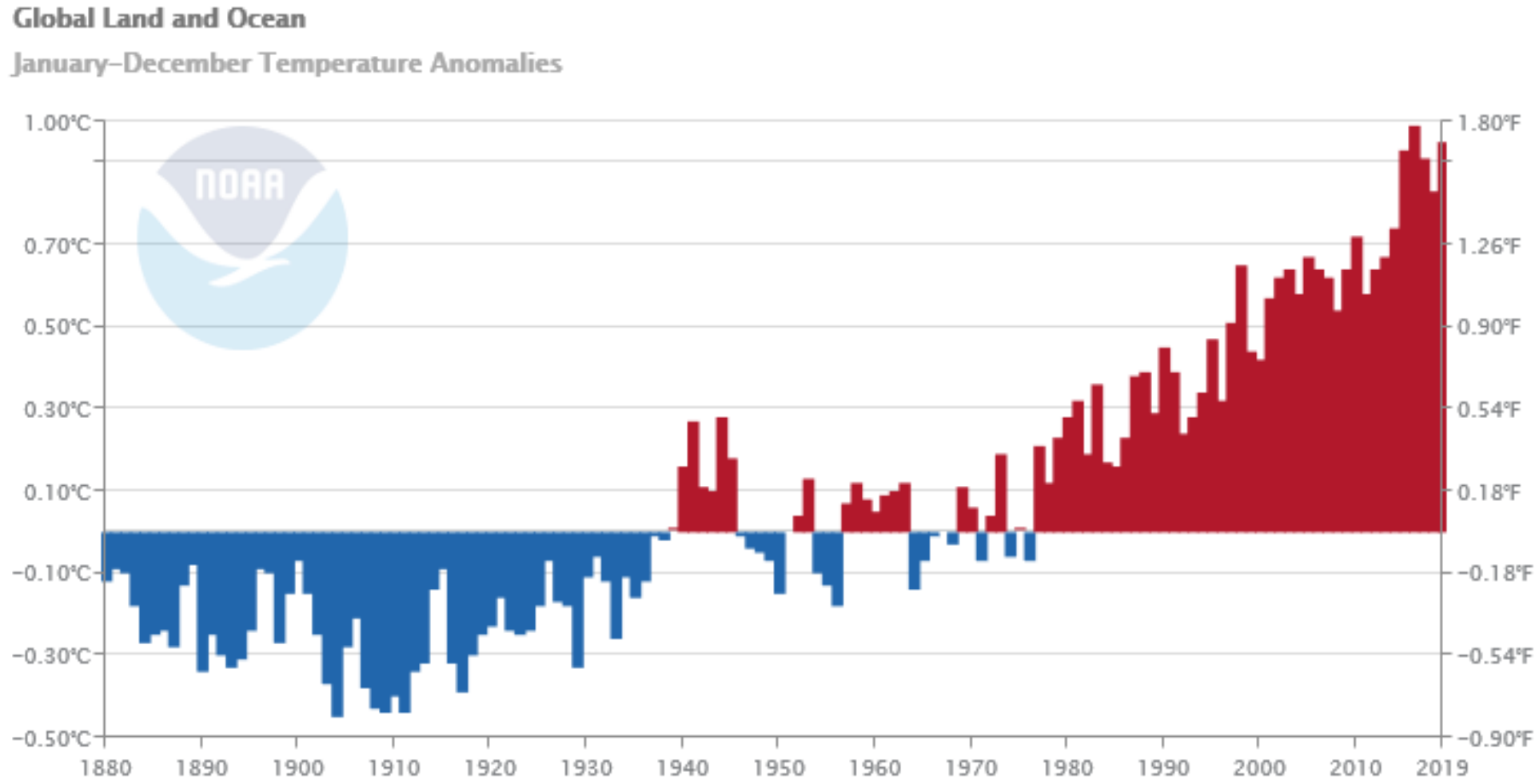
Kahtoola Bigfoot Snowshoe Festival 50K and Marathon
January 2010 Utah

How do you observe the climate?

Various Surface Temperature Measurement Platforms

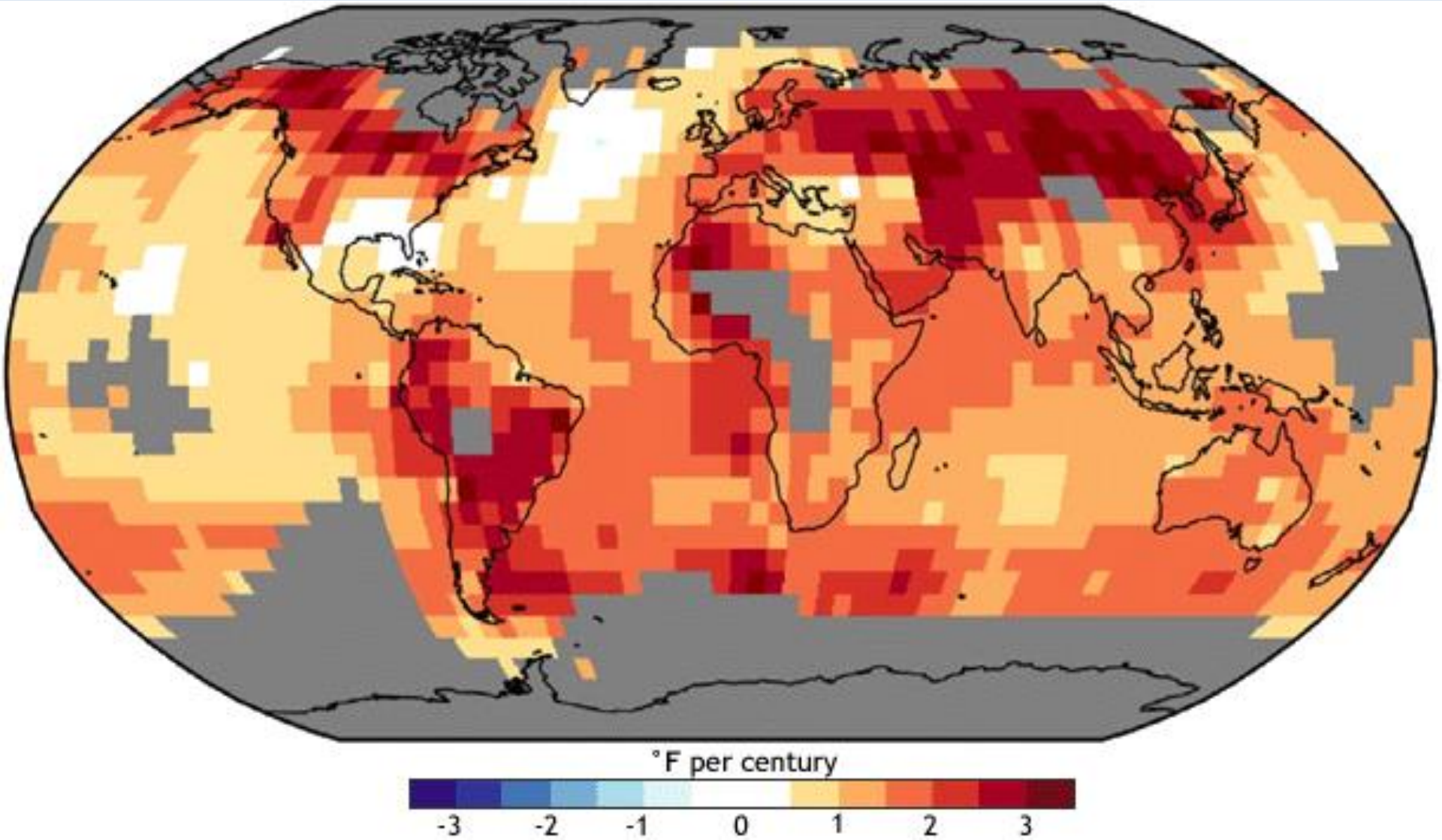


2019 Was 2nd Warmest Year on Record
Globe has Warmed about 1.9F since 1880



Where Has It Warmed?

Annual Temperature Trends 1901-2018

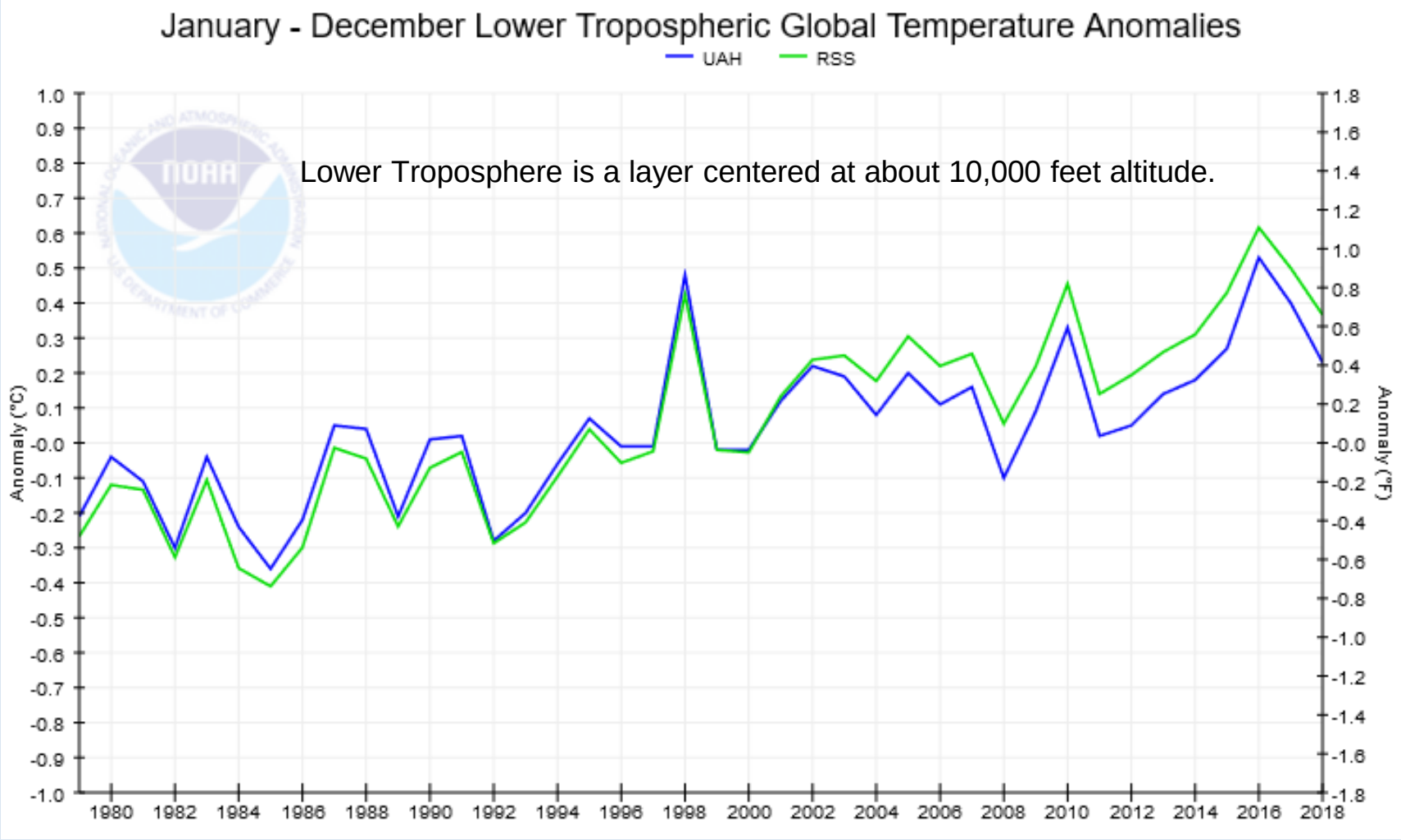


But what about other temperature measurements?

- Lower troposphere (layer centered about 10000 feet up) and surface are very different.

- Both surface air temperatures and satellite-based temperatures of lower troposphere show warming but there are differences between surface and troposphere temperature trends.

Satellite Temperatures: Warmed about 1.2ºF since 1979

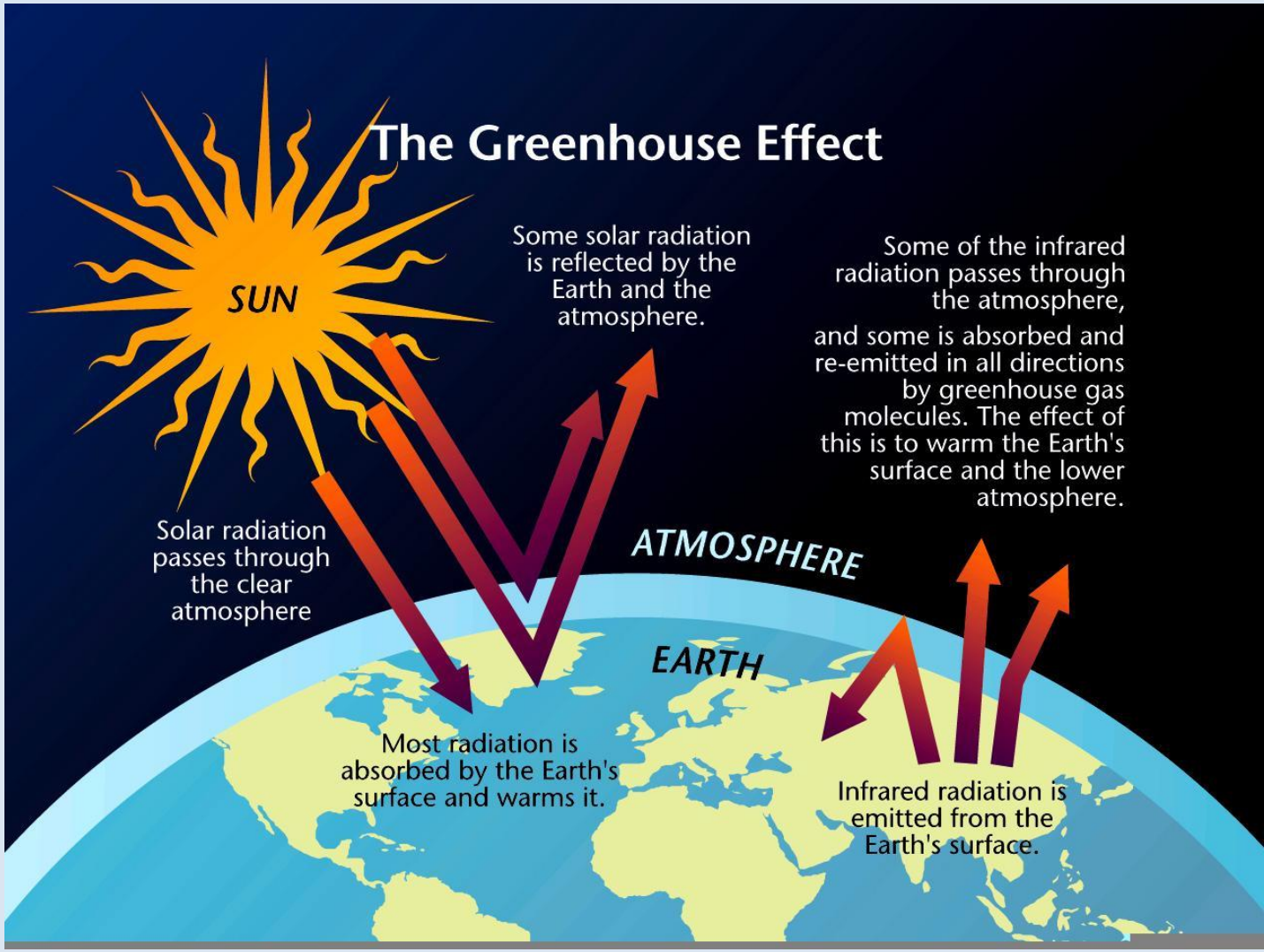


Why is it warming?

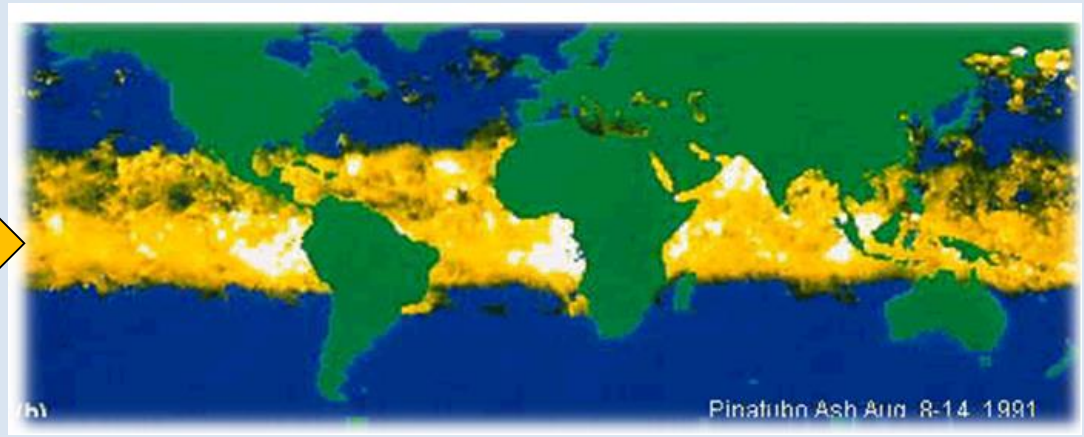
- Possible reasons
  - ➢The sun
  - ➢Stuff in the atmosphere

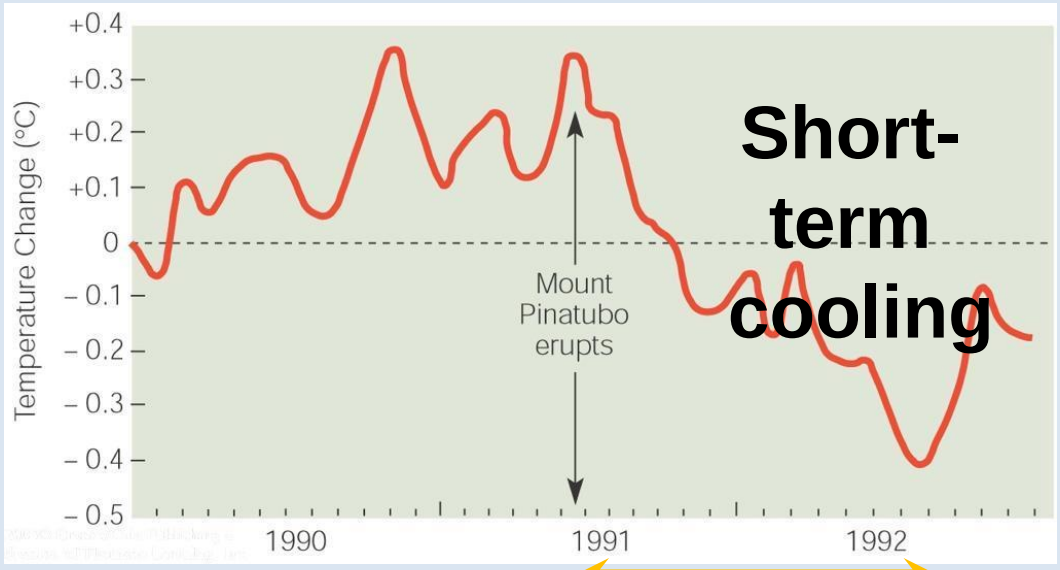
Earth's Atmosphere

Without a natural greenhouse effect Earth's average temperature would be close to 0°F rather than it's current 58°F average.

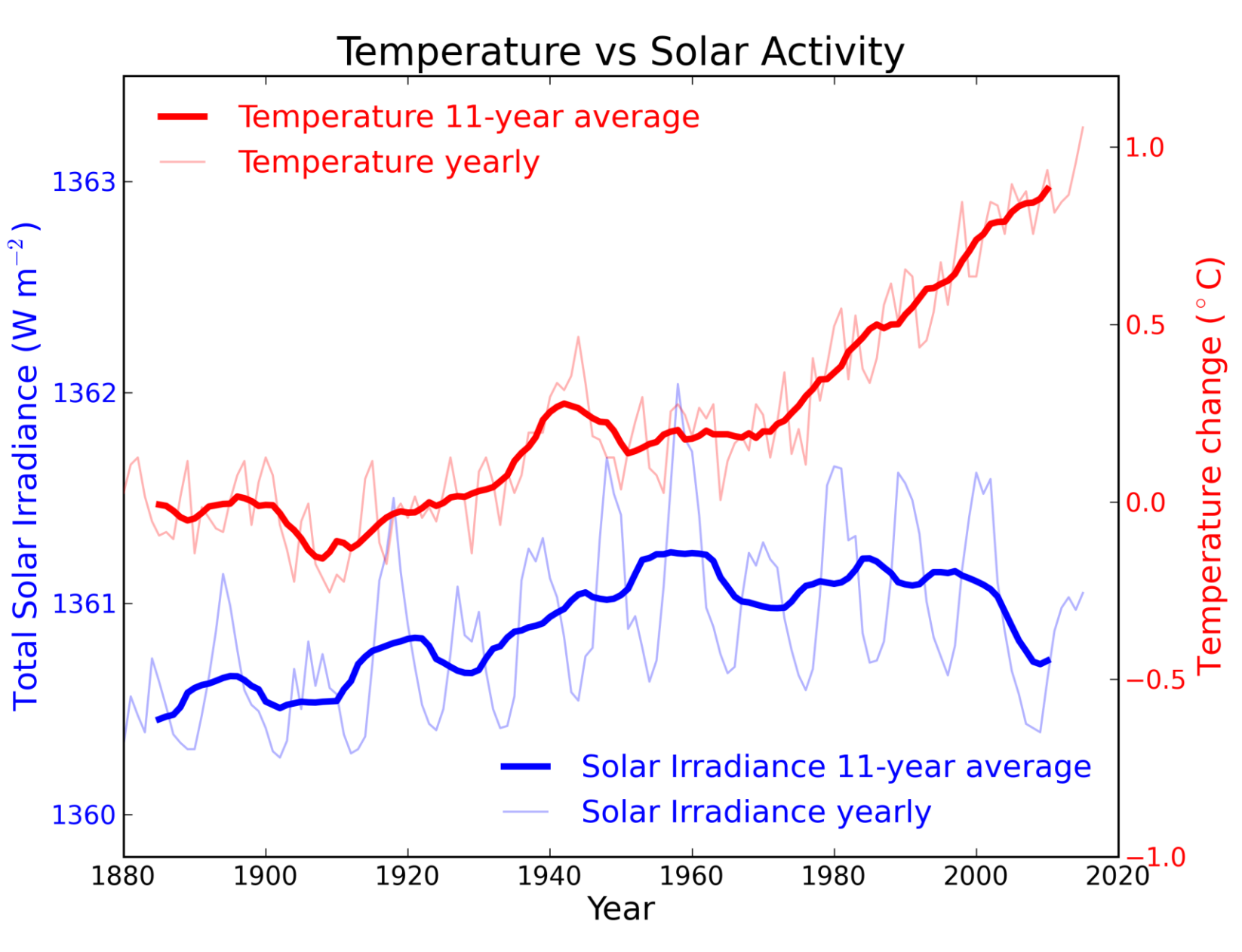


Aerosols and the Atmosphere

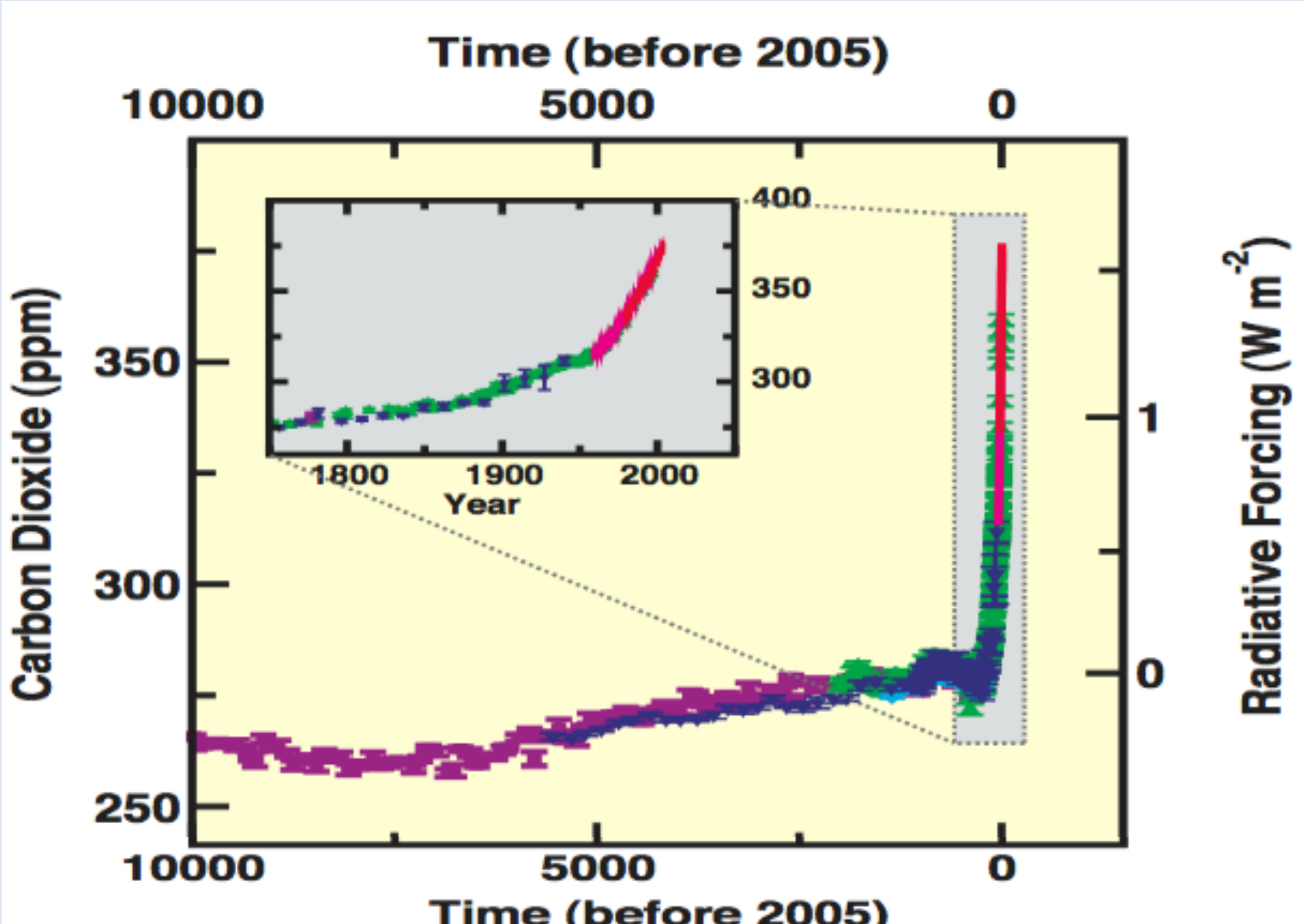




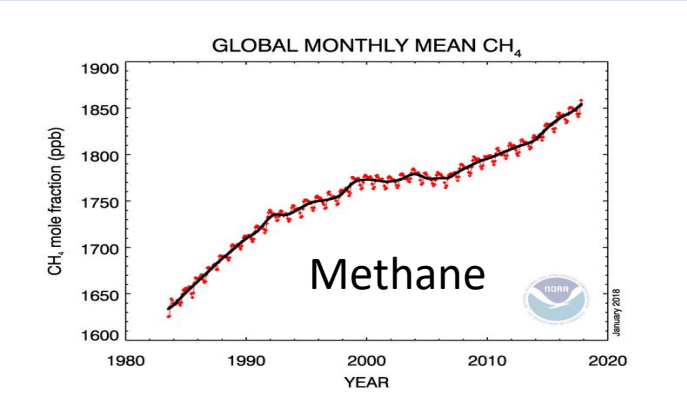
Temperature vs Sun's Energy Output

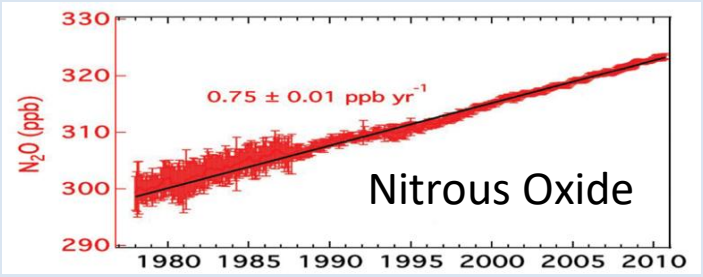


Climate Forcings:Anthropogenic (Human Induced)

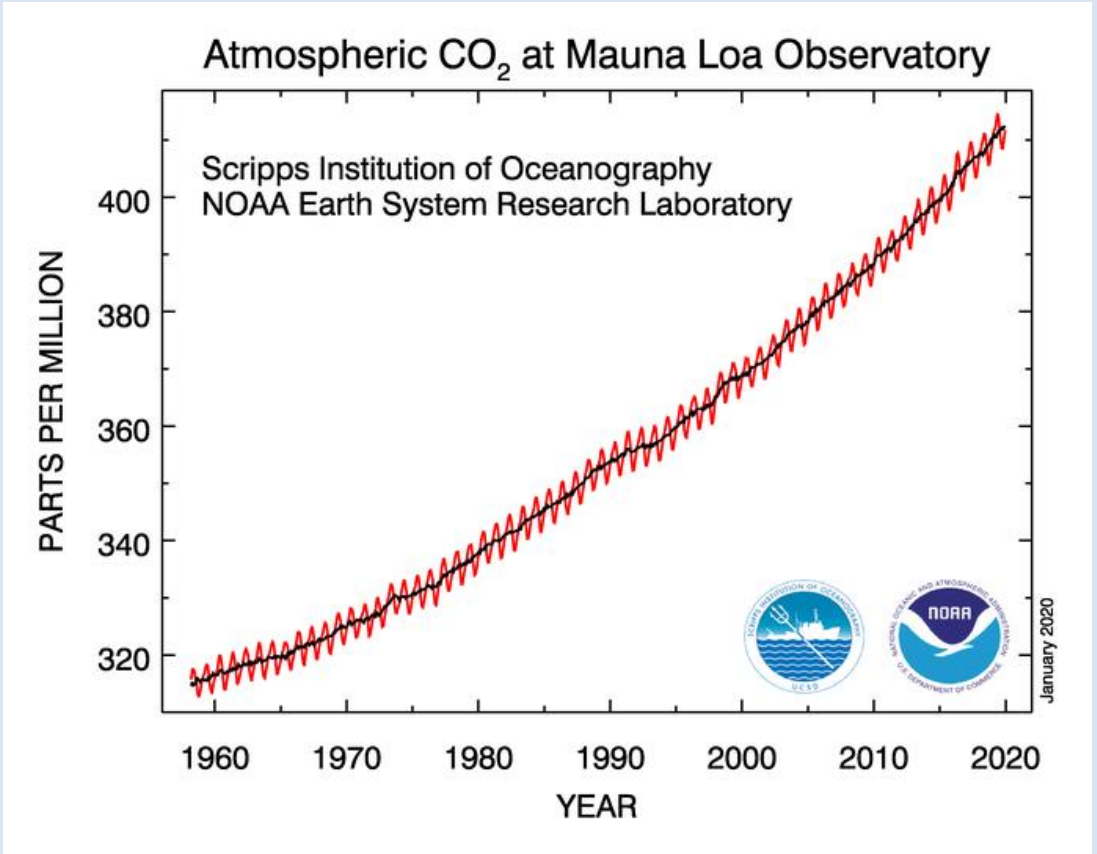


Recent Greenhouse Gas Trends





CO_2 is now over 411 PPM



Most major greenhouse gases are ↑

Carbon dioxide (CO_2)

Methane (CH_4)

Nitrous Oxide (N_2O)

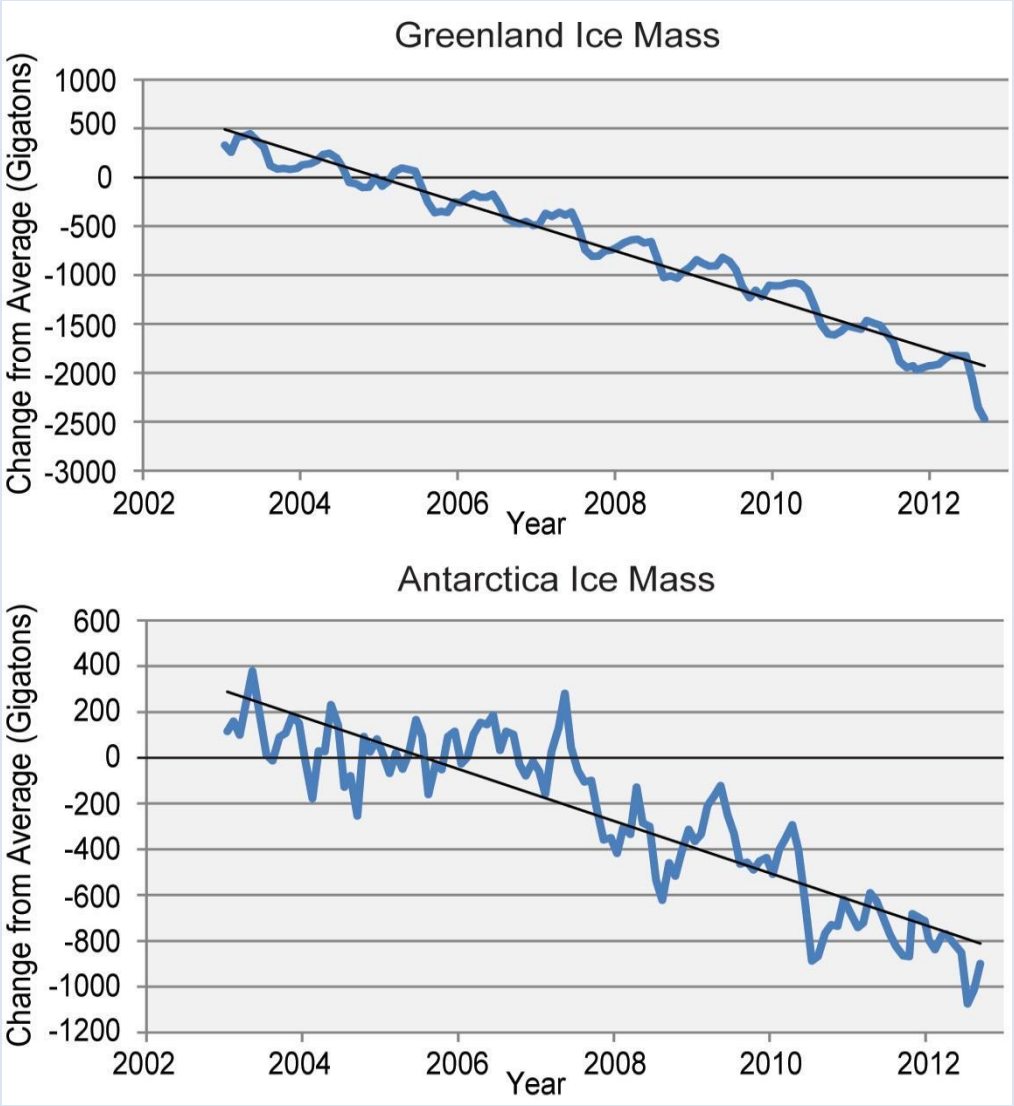
Other Indicators of Climate Change

Changes in Muir Glacier, Alaska:
From 1941 to 2004

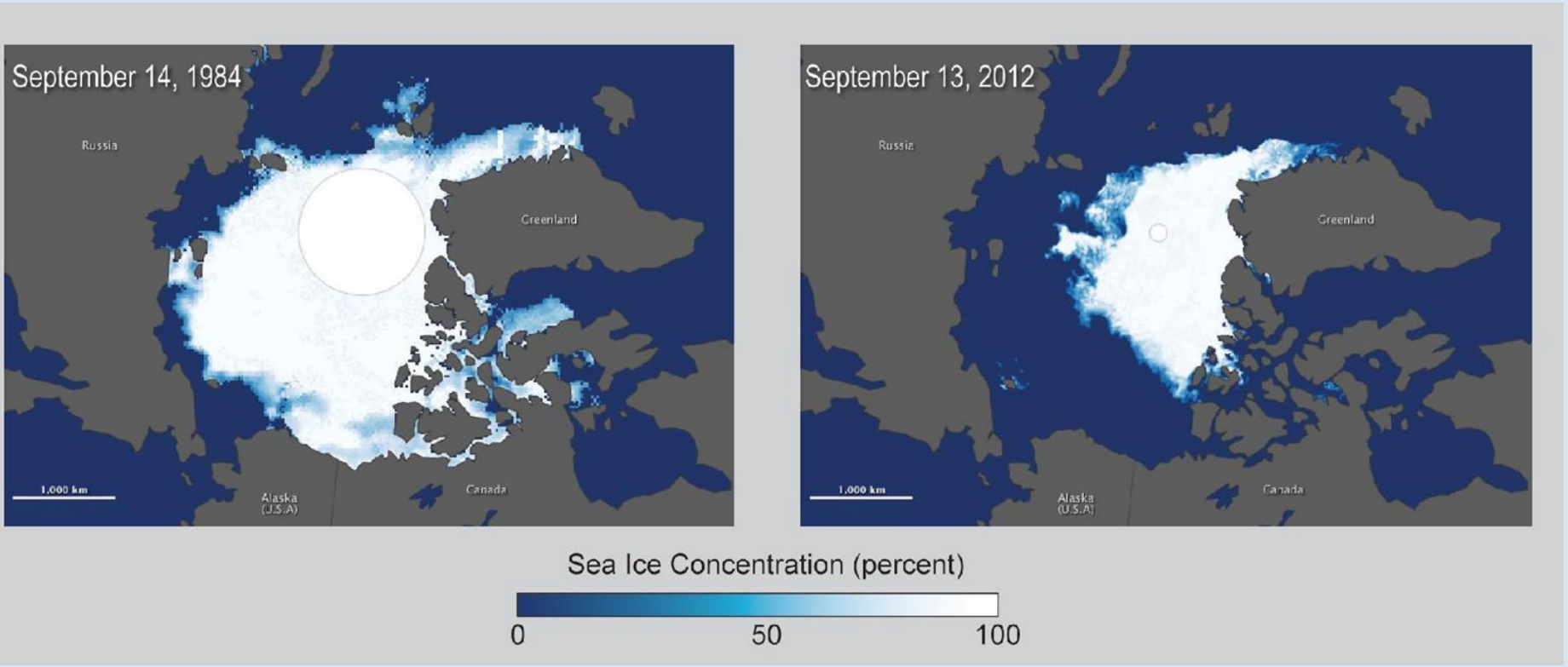
Image Credit: *National Snow and Ice Data Center*

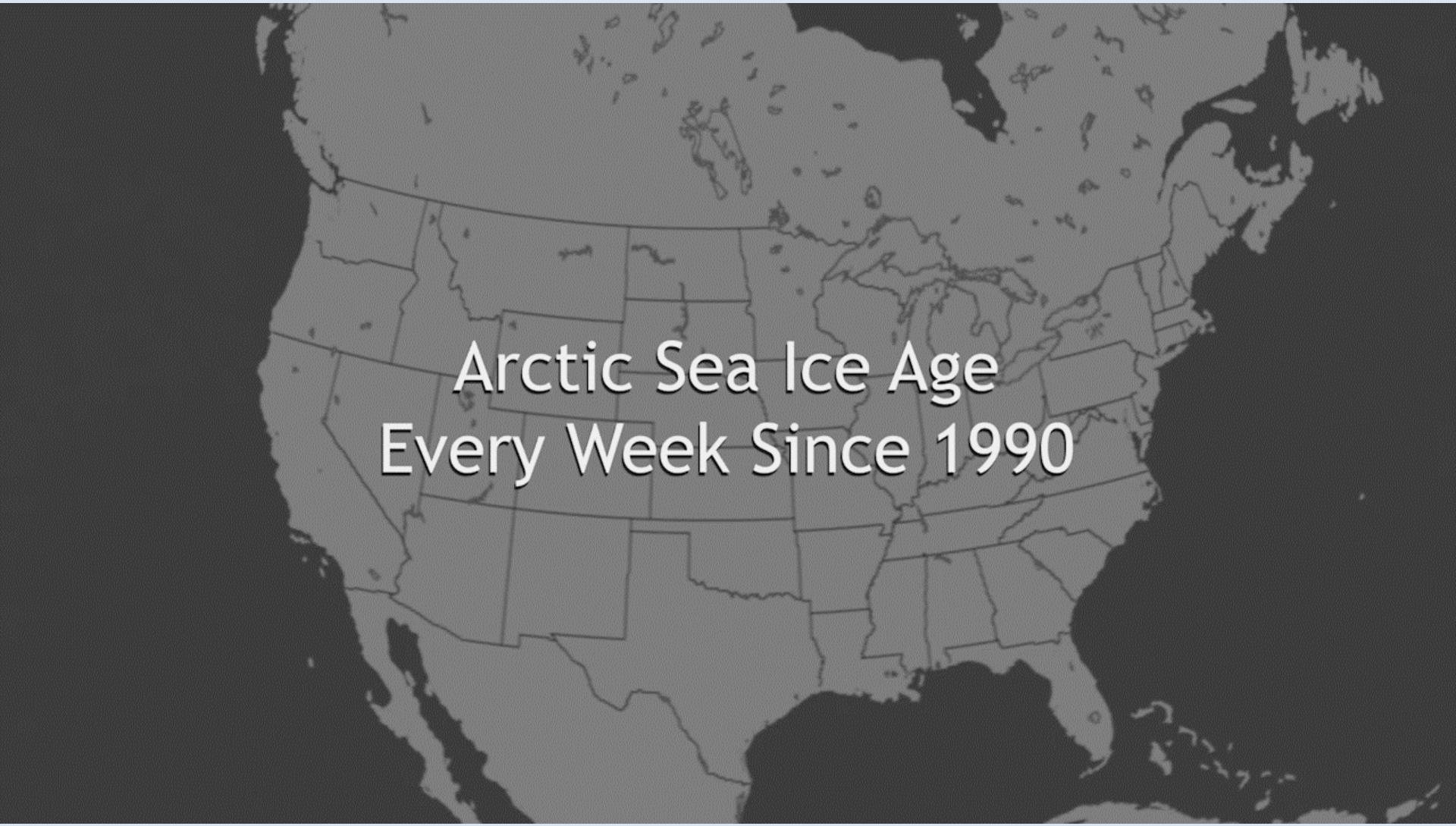
From 1941 to 2004, the glacier retreated more than seven miles and thinned by more than 875 yards and ocean water filled the valley.

Ice Loss from the Two Polar Ice Sheets

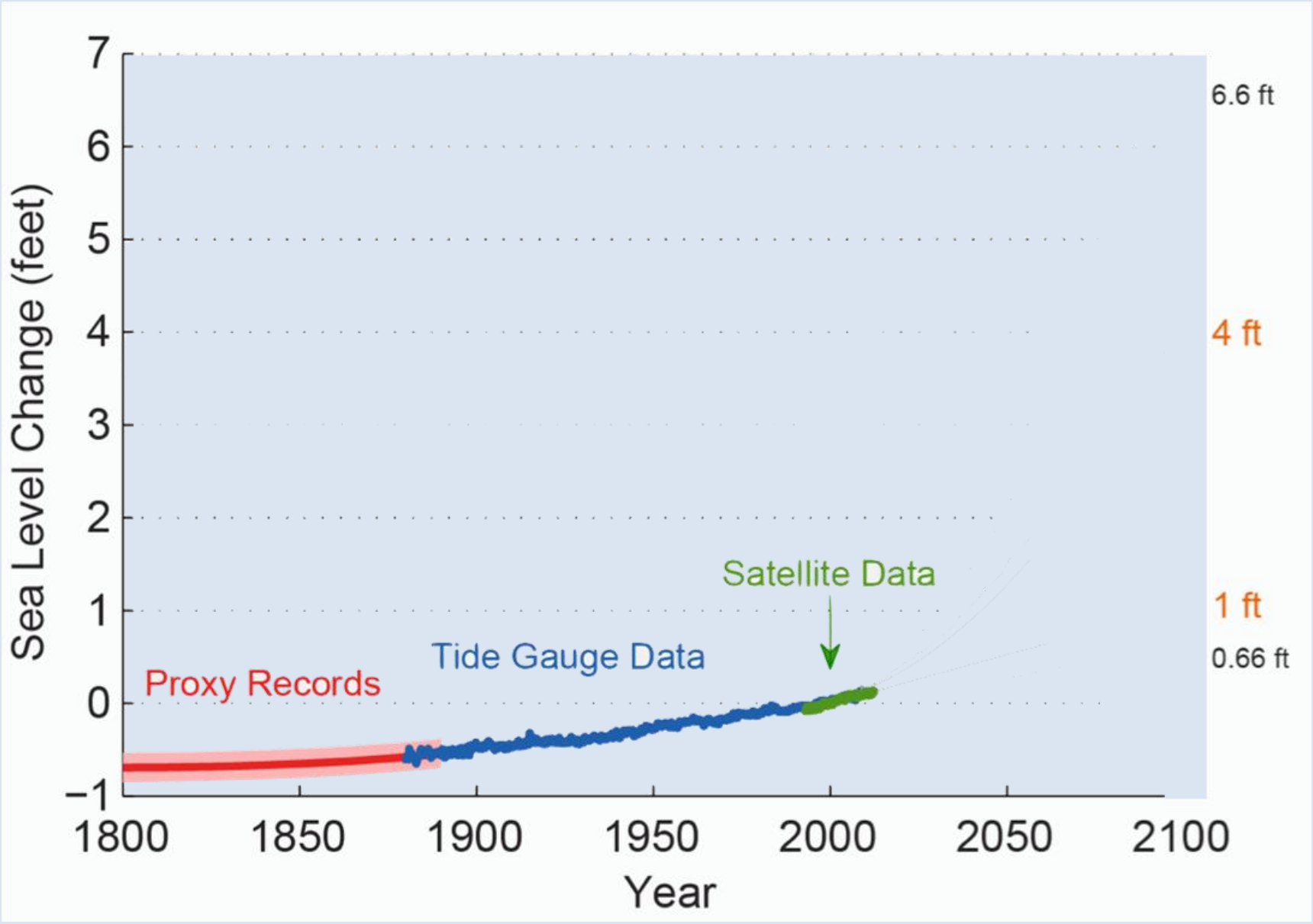


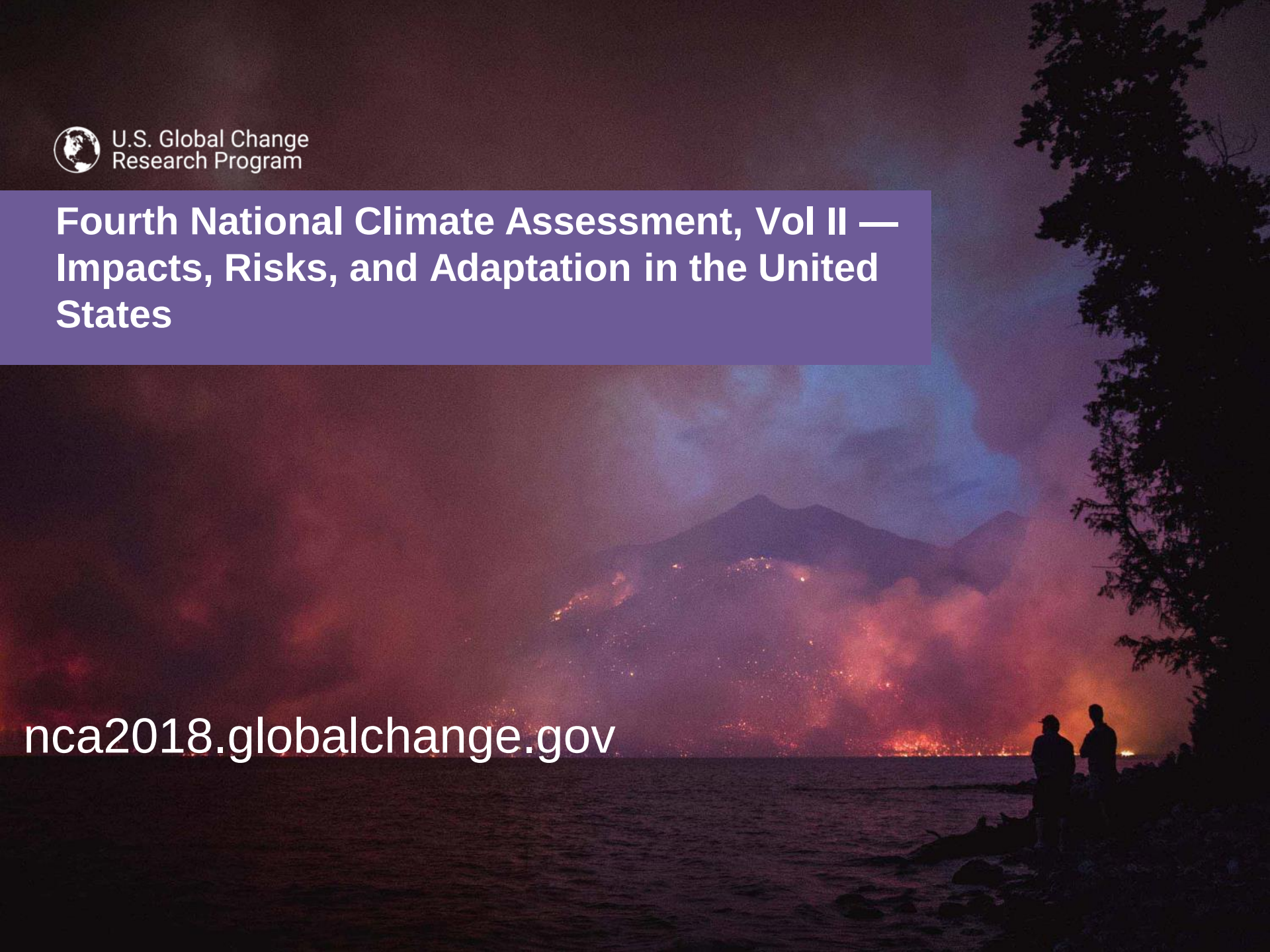
Arctic Sea Ice Decline




Arctic Sea Ice Age
Every Week Since 1990

Past Changes Global Sea Level




U.S. Global Change
Research Program
Fourth National Climate Assessment, Vol II —
Impacts, Risks, and Adaptation in the United
States
nca2018.globalchange.gov

CSSR About Chapters Report Downloads

Climate Science Special Report

Fourth National Climate Assessment (NCA4), Volume I

This report is an authoritative assessment of the science of climate change, with a focus on the United States. It represents the first of two volumes of the Fourth National Climate Assessment, mandated by the Global Change Research Act of 1990.

Recommended Citation

Executive Summary

Ch. 1: Our Globally Changing Climate

Ch. 2: Physical Drivers of Climate Change

Ch. 3: Detection and Attribution of Climate Change

Ch. 4: Climate Models, Scenarios, and Projections

Ch. 5: Large-Scale Circulation and Climate Variability

Ch. 6: Temperature Changes in the United States

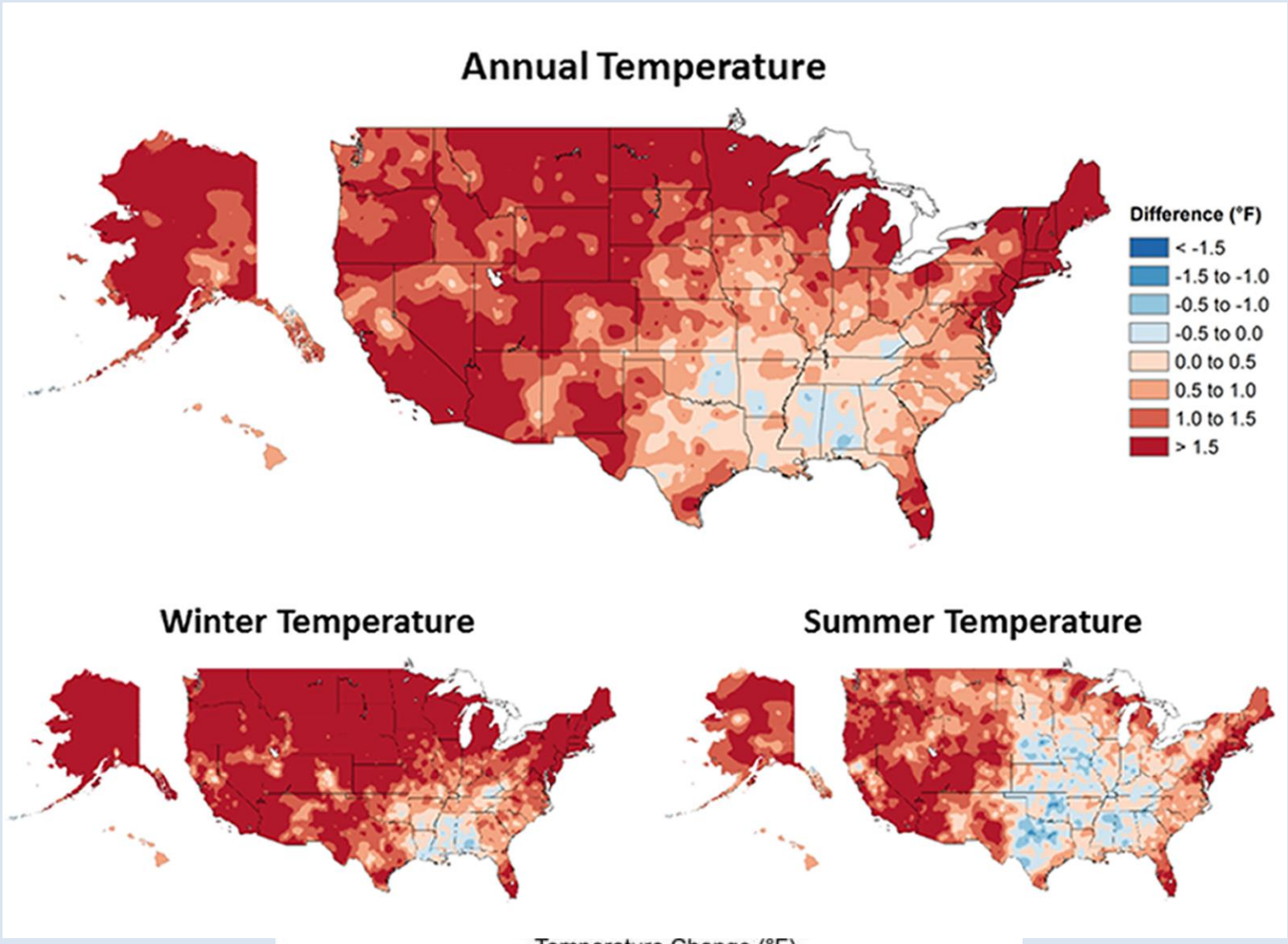
GlobalChange.gov
U.S. Global Change Research Program

Science2017.globalchange.gov

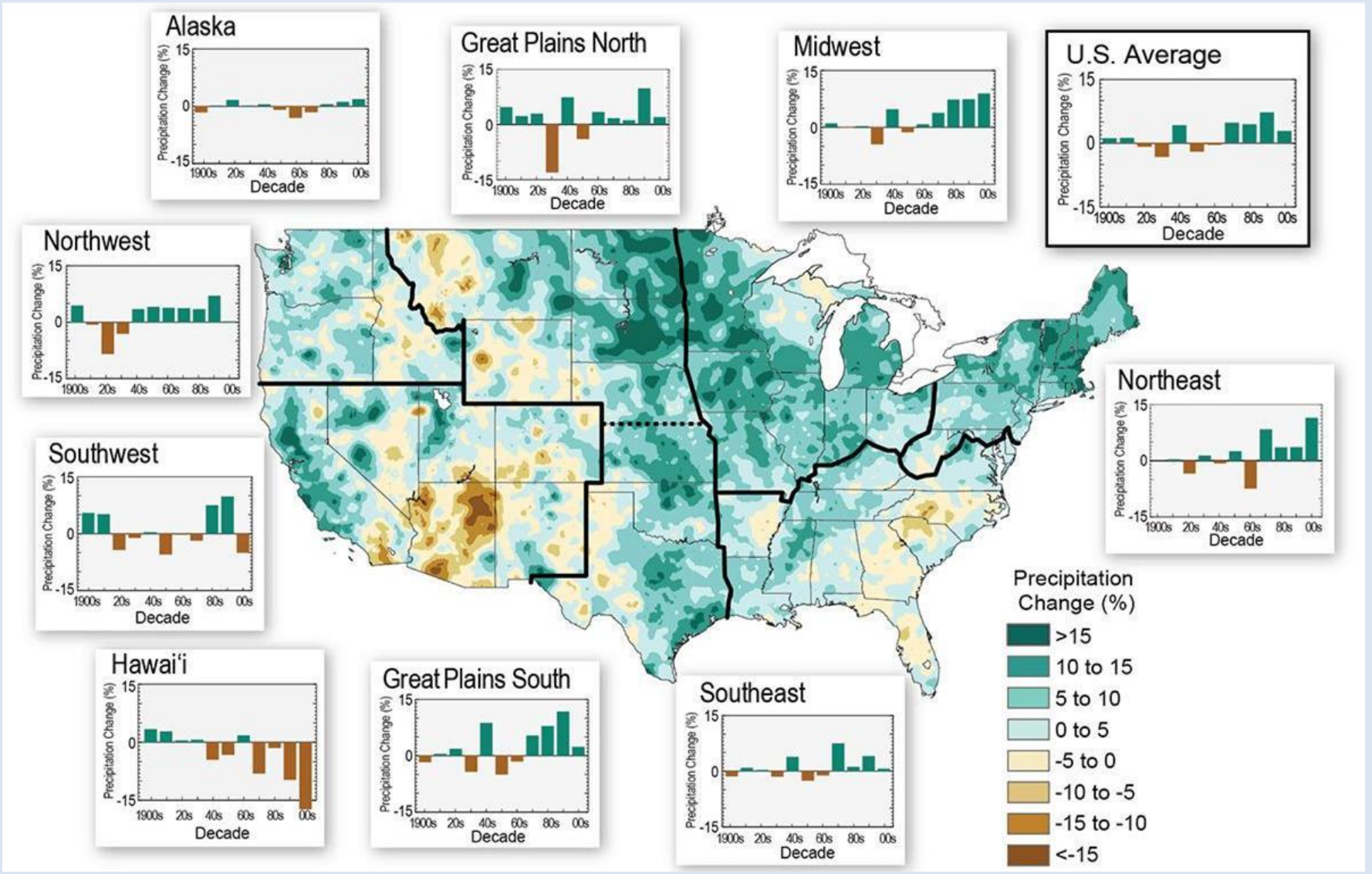
- Volume I is still the most comprehensive and up-to-date assessment of the state of climate science today. 12 federal agencies, 50 authors, almost 500 pages* It was subject to public review, two agency reviews, and a National Academy review, released in late 2017

- Volume II is the most comprehensive and up-to-date assessment of how climate change is affecting the U.S. and how we are responding. 12 federal agencies, 350 authors, over 1600 pages, also subject to public, multiple agency and National Academy reviews. Released in late 2018

Observed US Temperature Change, 1901-2017



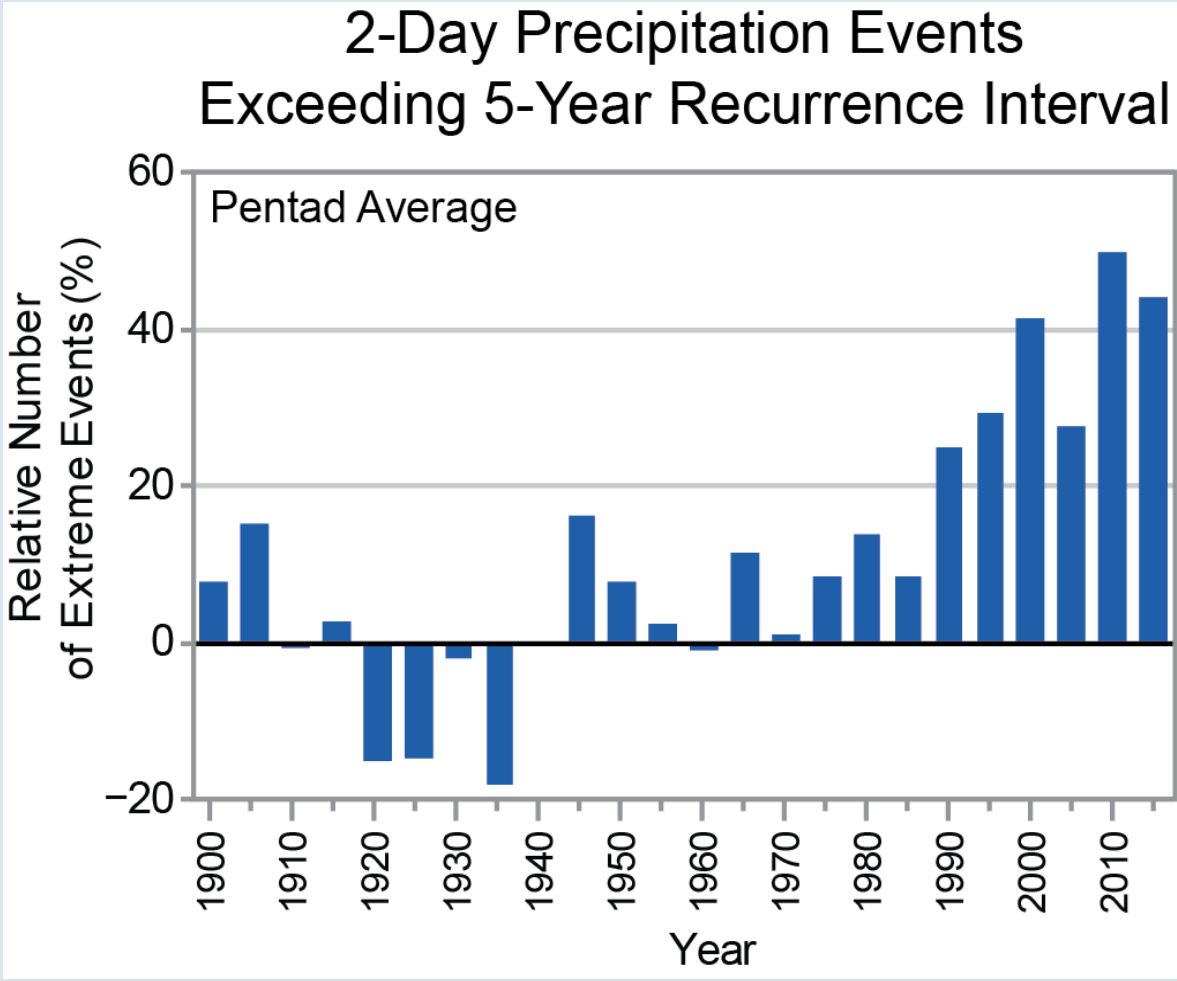
Observed US Precipitation Change



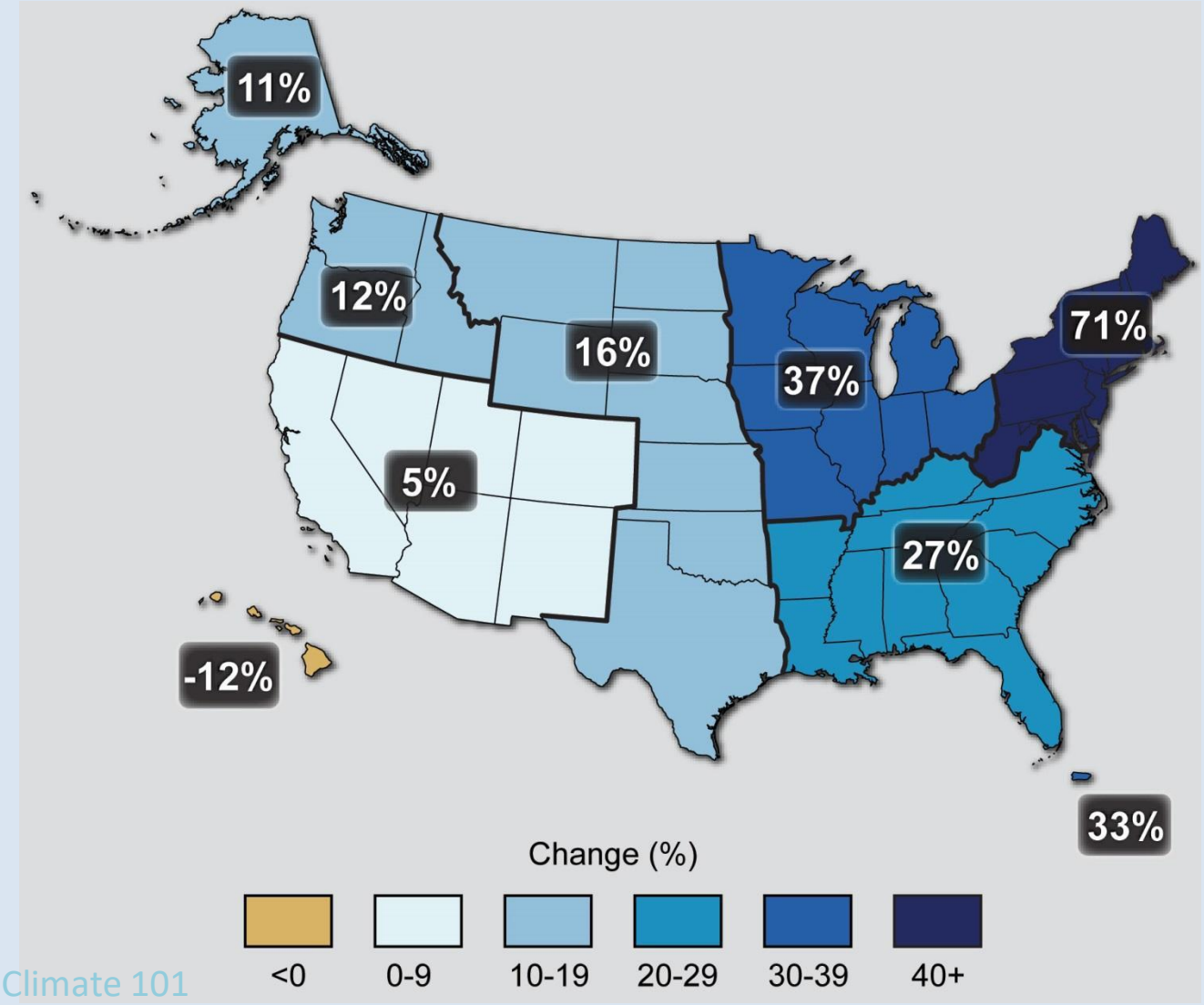
EXTREME WEATHER

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.

Observed Trends in Heavy Precipitation Events in the U.S.



Observed Change in Very Heavy Precipitation



Why do scientists think human activities are the main cause of recent climate change?

- Detection and Attribution
  - Detection is detection of a significant change
  - Attribution is determining the main cause
- Global Climate Models: attribution and projections for the future.

Global Climate Models:

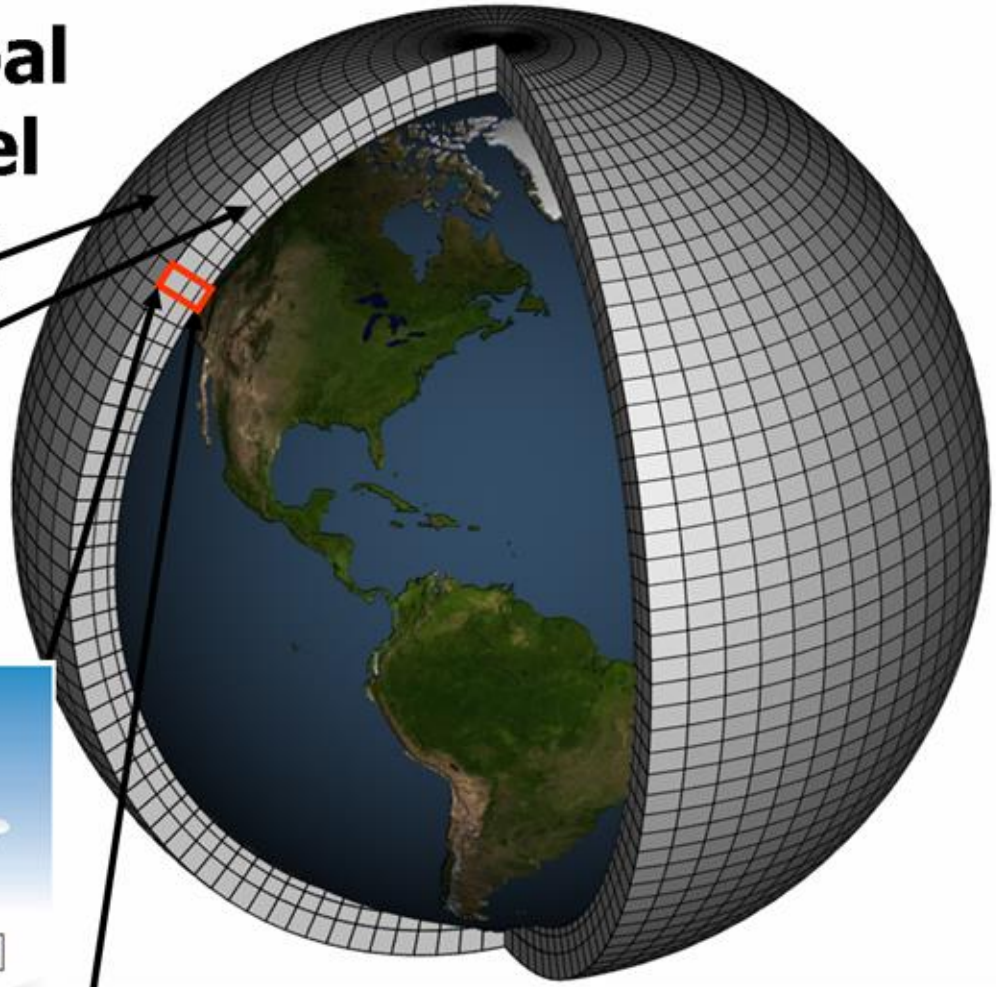
Complex computer programs (500,000+ lines of code) that solve various equations (e.g. differential equations of fluid dynamics, chemistry) at individual locations.

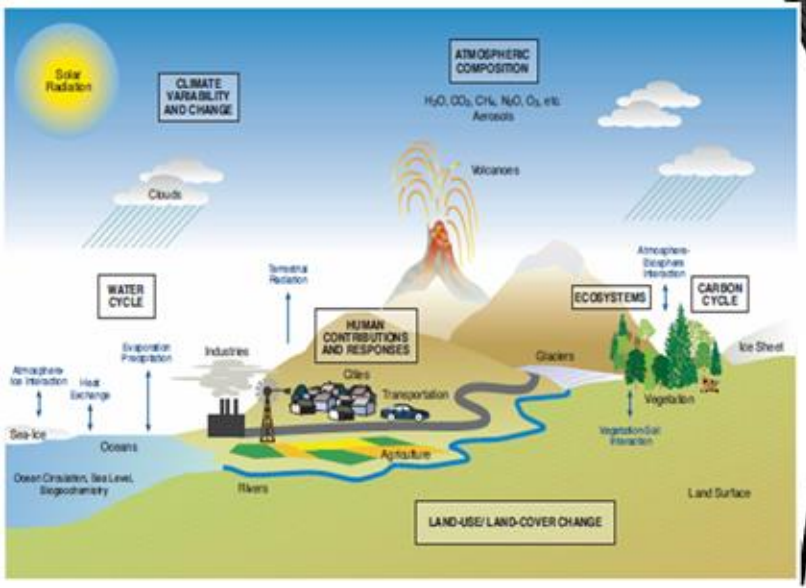
Simulates day to day weather that forms the climate.

Schematic for Global Atmospheric Model

Horizontal Grid (Latitude-Longitude)

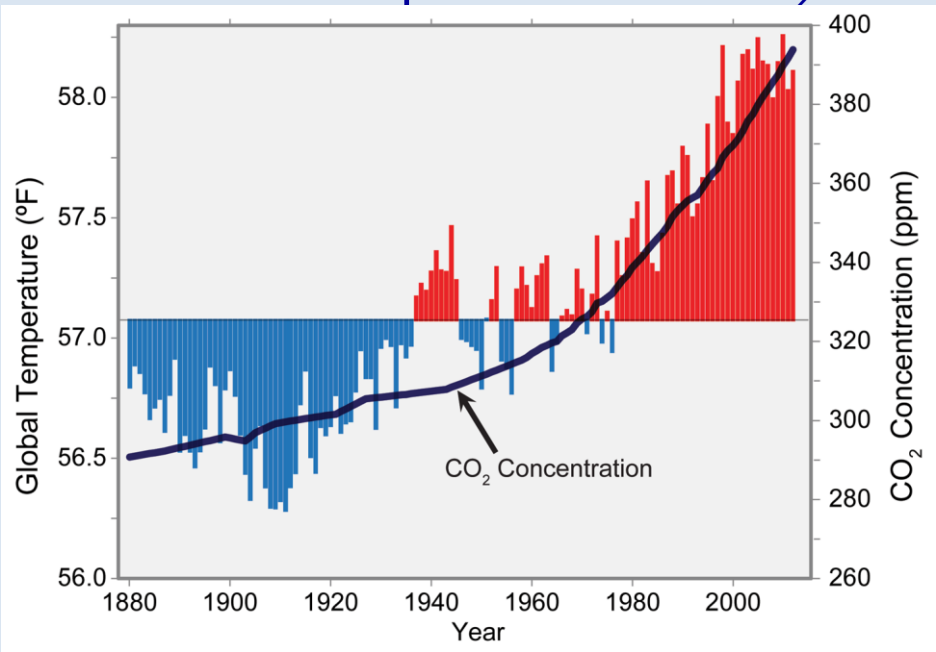
Vertical Grid (Height or Pressure)



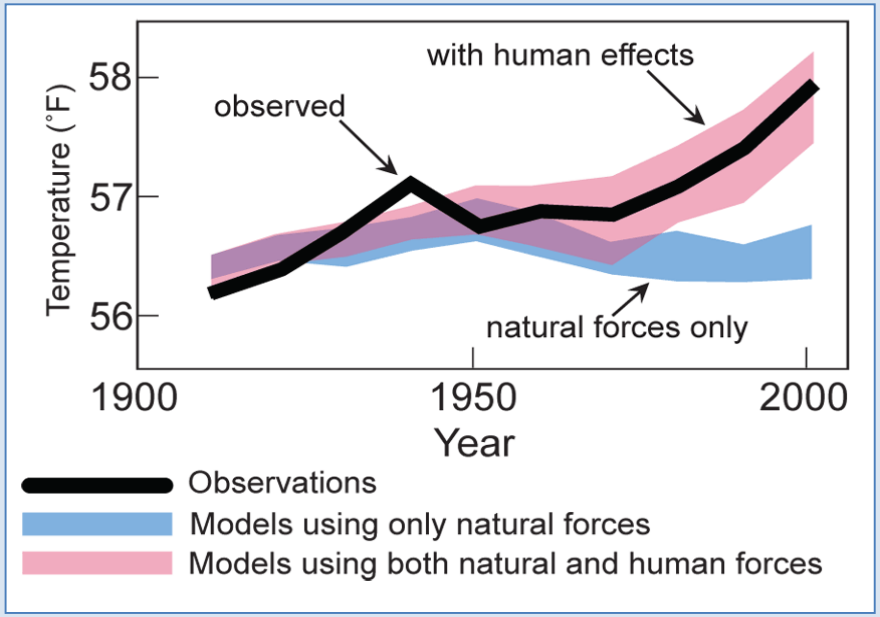


Detection and Attribution: Increasing Temperatures Correlate with Human Influences

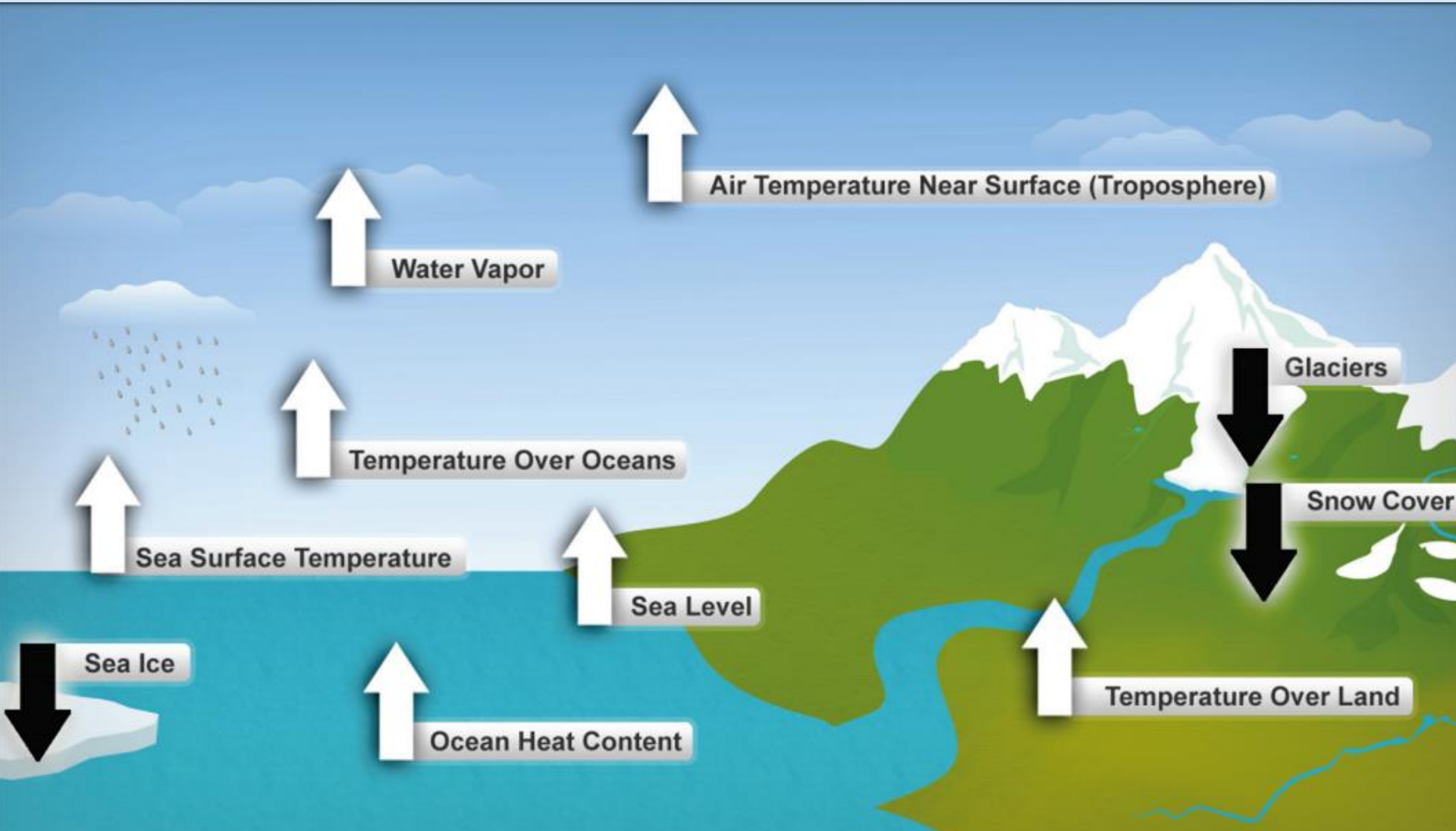
Global Temperature and CO_2



Separating Human and Natural Influences on Climate



All indicators expected to increase in a warming world are increasing and those expected to decrease are decreasing

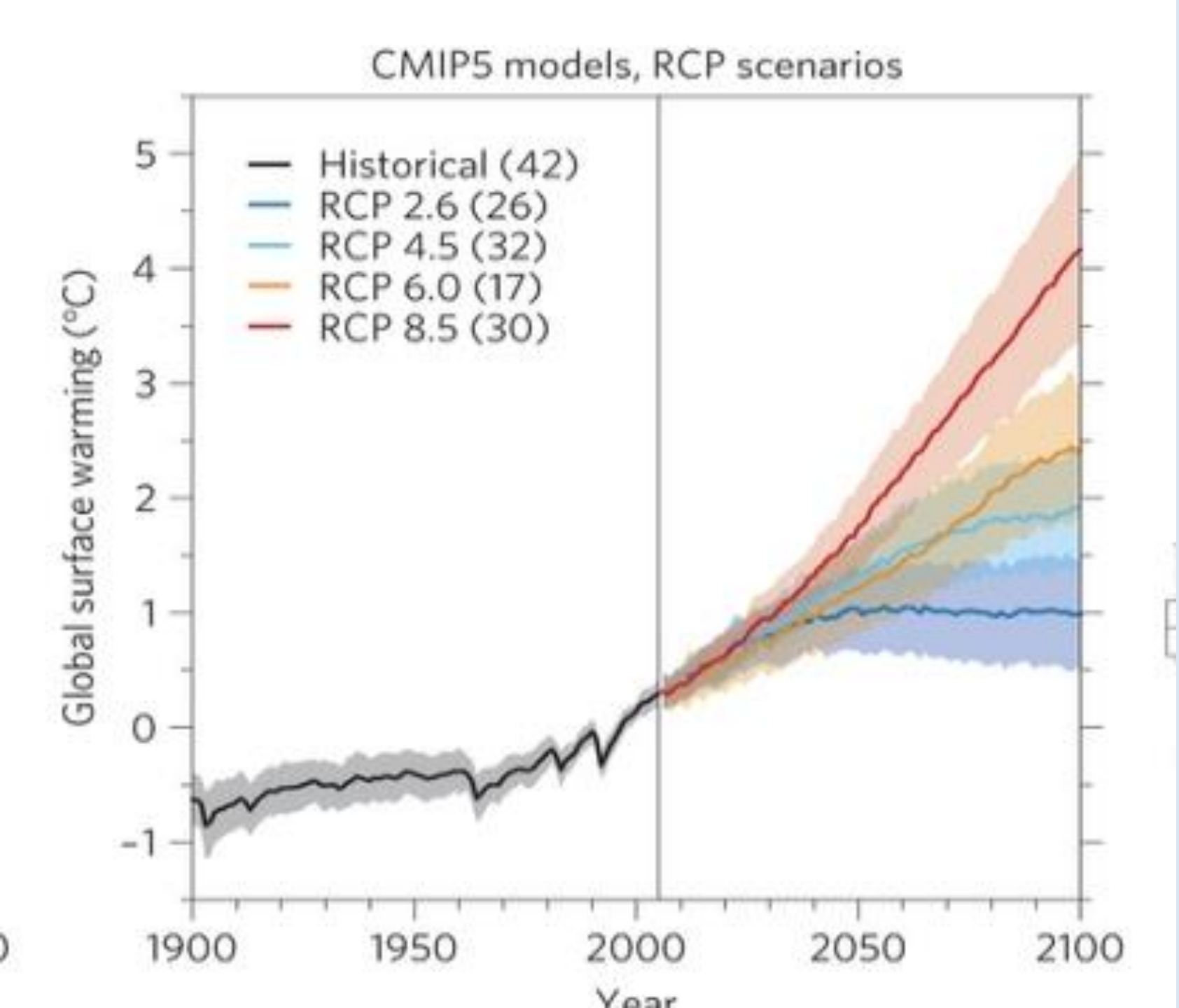


What about extreme events, can we say anything about an anthropogenic influence?

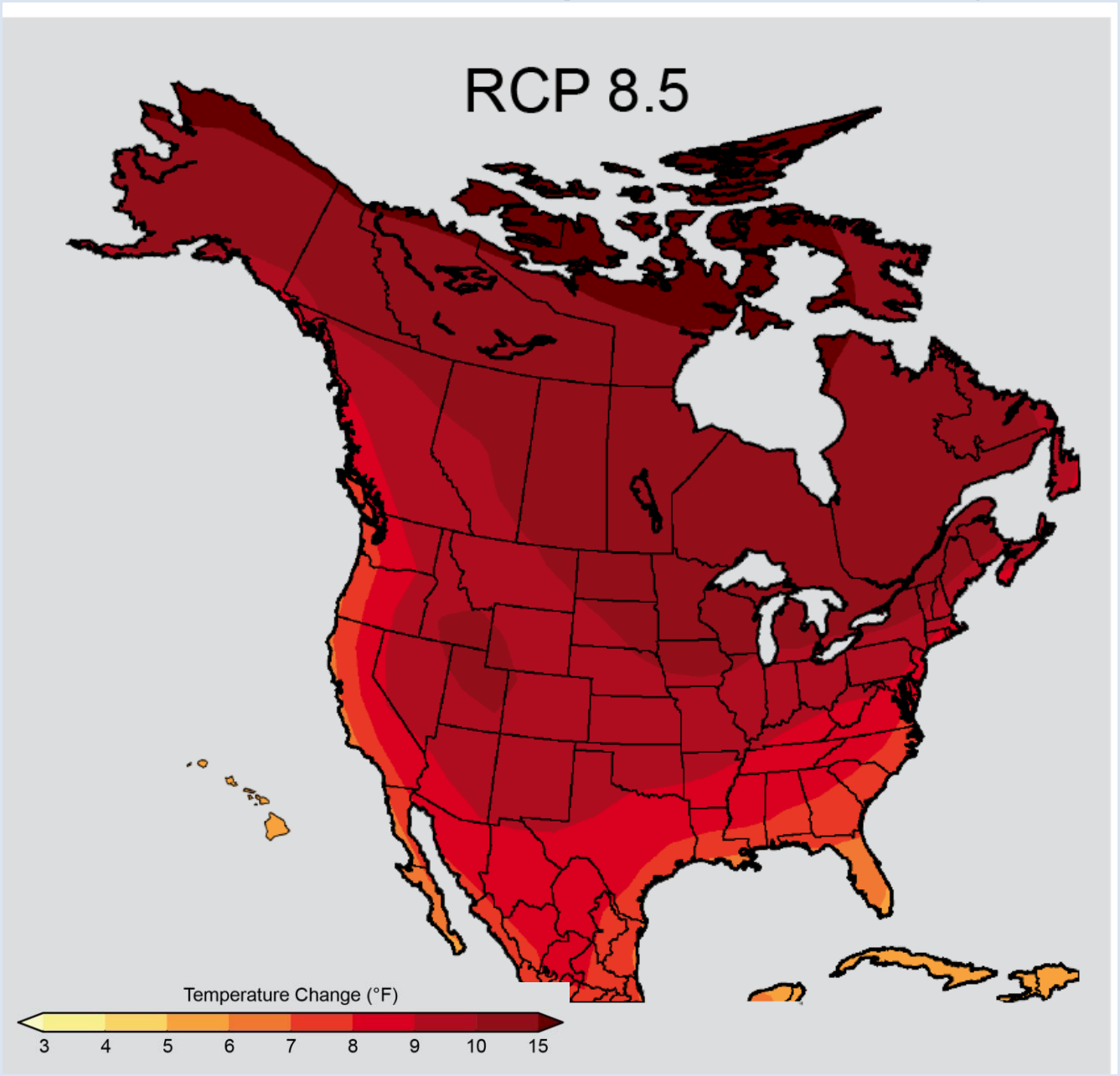
- The field of “event attribution” uses climate models to determine if climate change influenced either the occurrence or severity of an extreme event.
- Example: Hurricane Harvey
  - Dropped almost 50 inches of precipitation on the Houston, TX area over a 4 day period
  - Research shows that rainfall was 20% greater due to climate change.

FUTURE CLIMATE

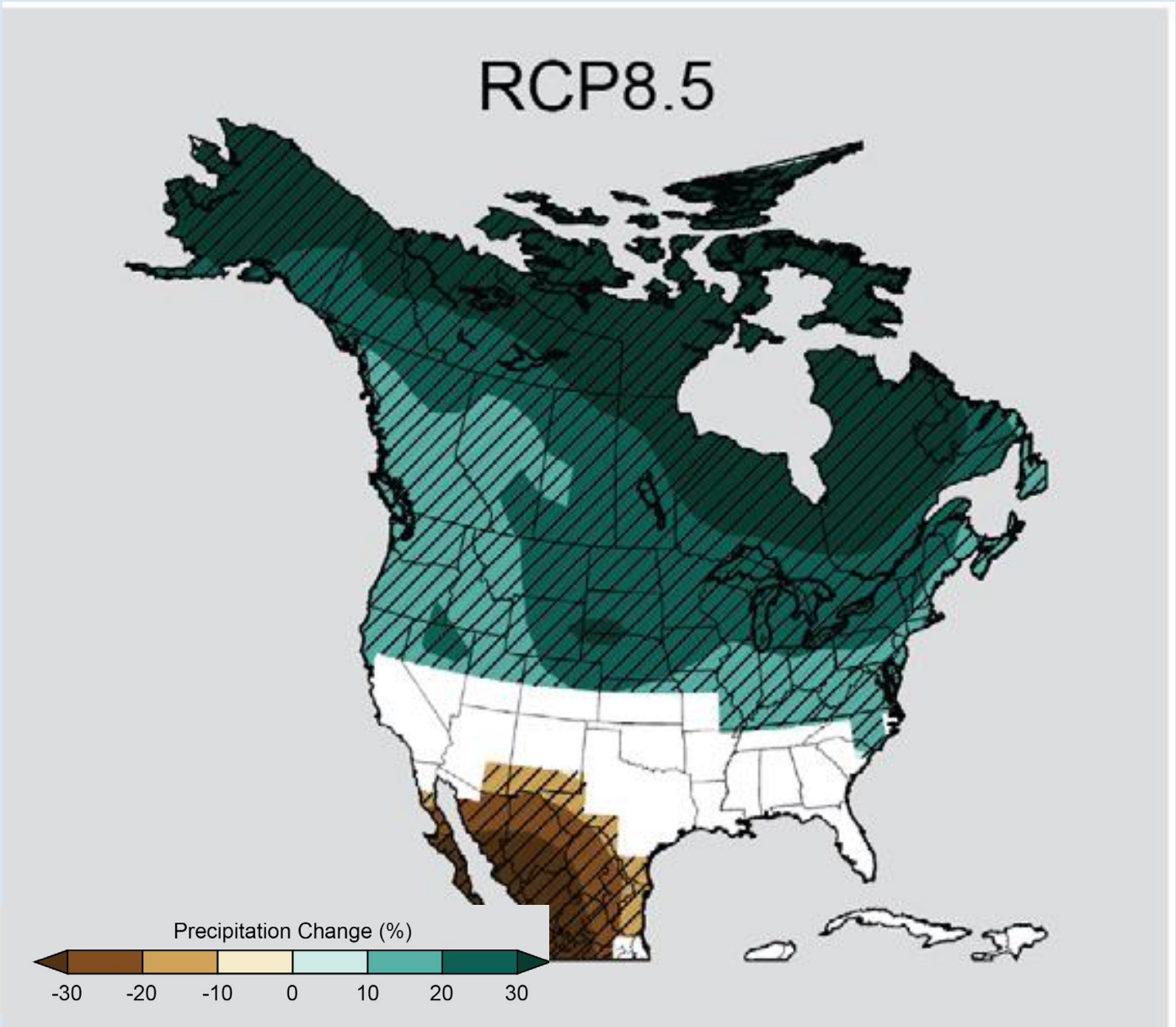
Human-induced climate change is projected to continue, and it will accelerate significantly if emissions of heat-trapping gases continue to increase.


CMIP5 models, RCP scenarios
Historical (42)
RCP 2.6 (26)
RCP 4.5 (32)
RCP 6.0 (17)
RCP 8.5 (30)
Global surface warming (°C)
5
4
3
2
1
0
-1
1900
1950
2000
2050
2100
Year

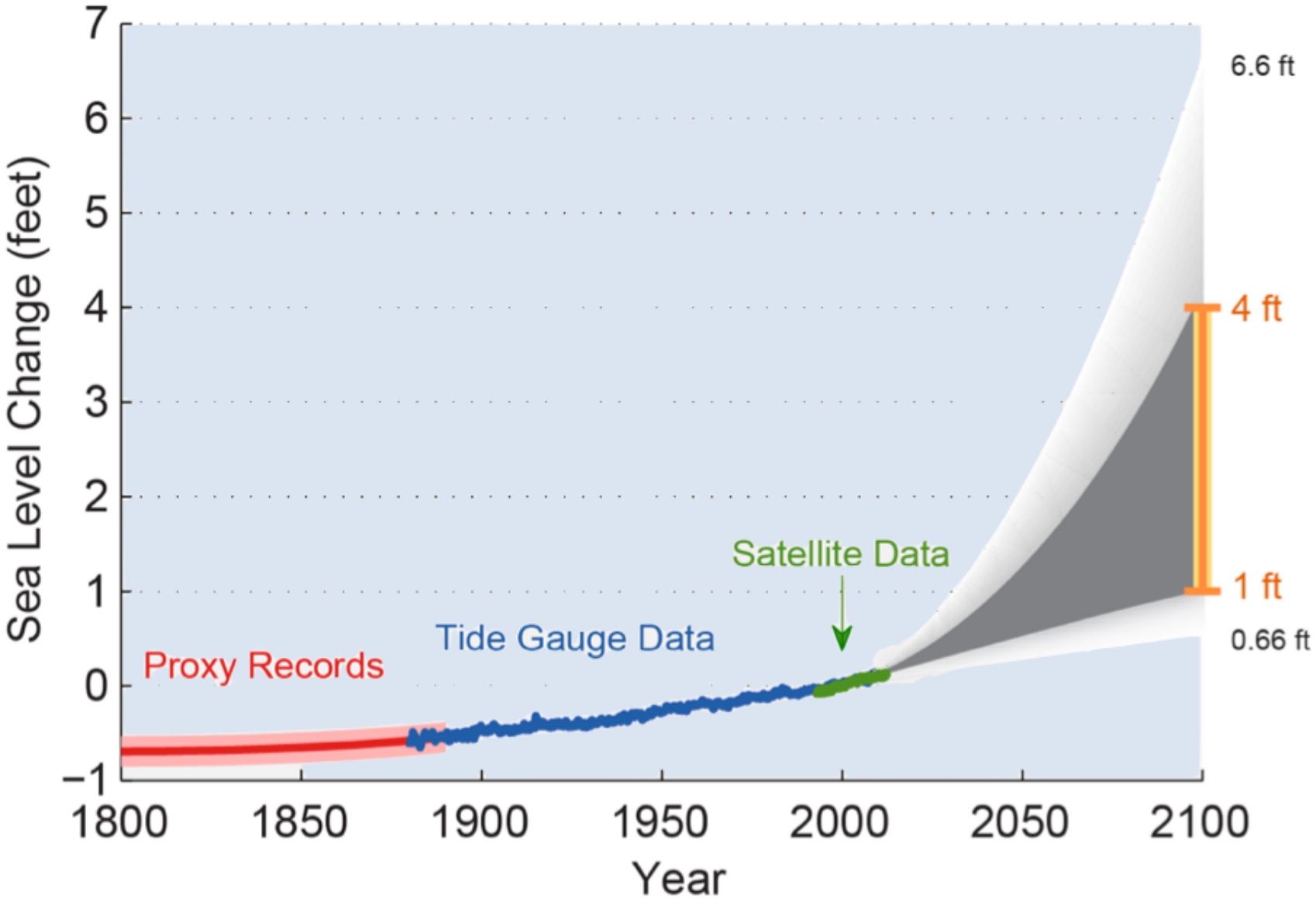
CMIP5: Annual Temperature Change 2070-2099



CMIP5: Winter Precipitation Change 2070-2099



Projected Changes Global Sea Level

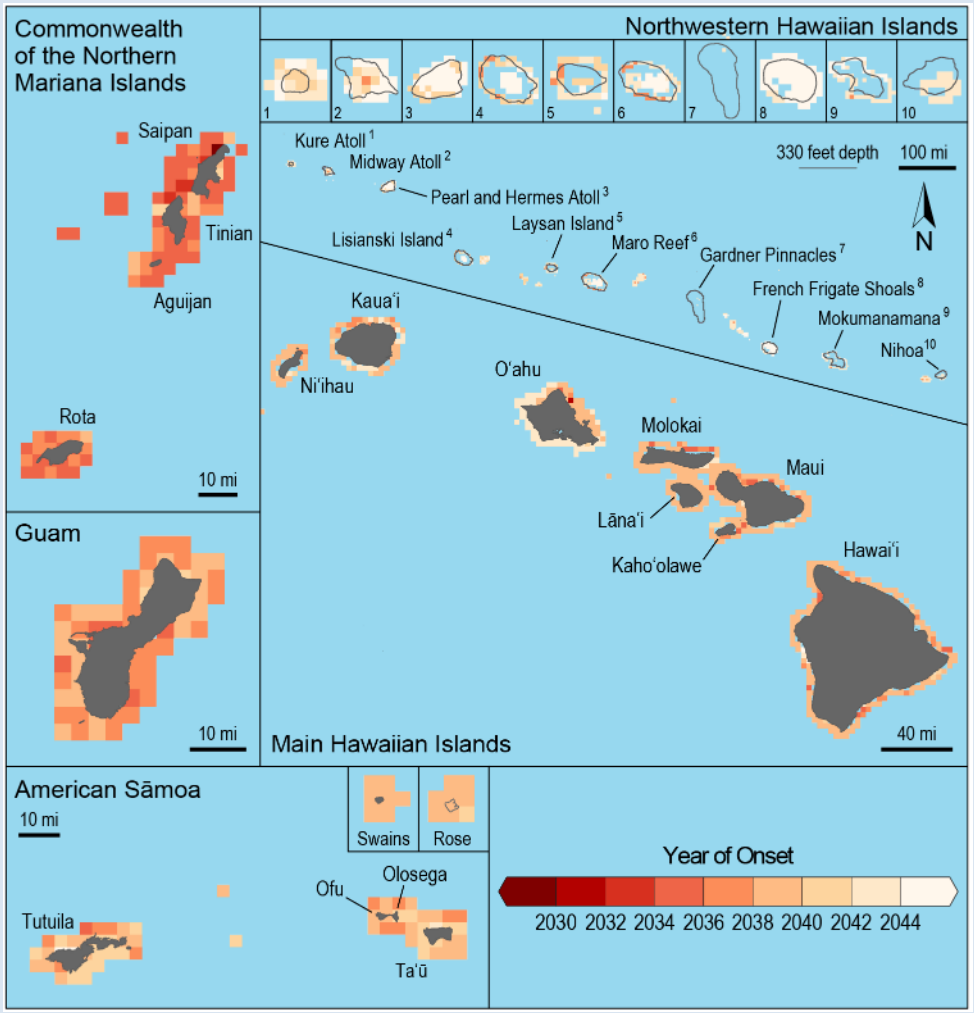


How will climate change impact our world and what can be done about it?

A couple of examples from the Fourth National Climate Assessment

Severe Coral Bleaching Projected for Hawai'i and the U.S.-Affiliated Pacific Islands

The figure shows the years when severe coral bleaching is projected to occur annually in the Hawai'i and U.S.-Affiliated Pacific Islands region under a higher scenario (RCP8.5). Darker colors indicate earlier projected onset of coral bleaching. Under projected warming of approximately 0.5°F per decade, all nearshore coral reefs in the region will experience annual bleaching before 2050.



Adaptation Measures in Kivalina, Alaska

A rock revetment was installed in the Alaska Native Village of Kivalina in 2010 to reduce increasing risks from erosion. A new rock revetment wall has a projected lifespan of 15 to 20 years.

Reduced winter sea ice allows more coastal erosion during winter storms

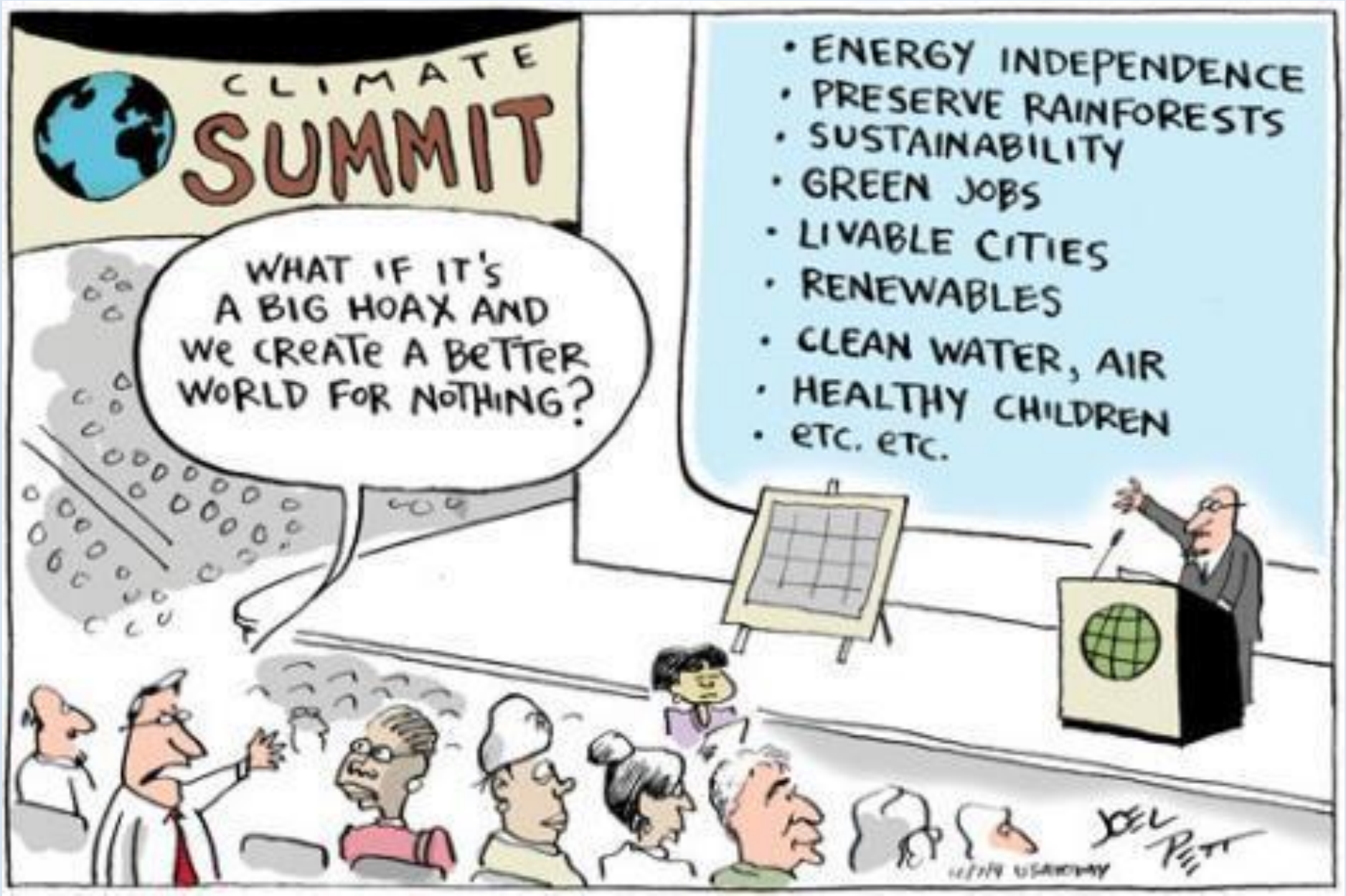
Shift in Plant Hardiness Zones

Average Annual Extreme Minimum Temperature by Climate-Related Planting Zone

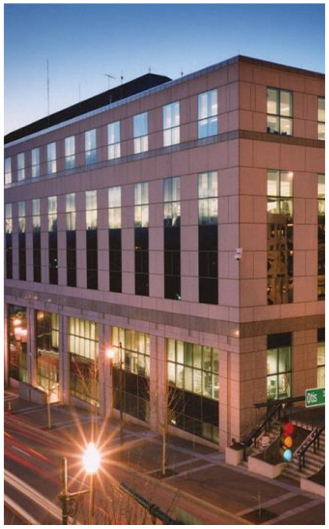
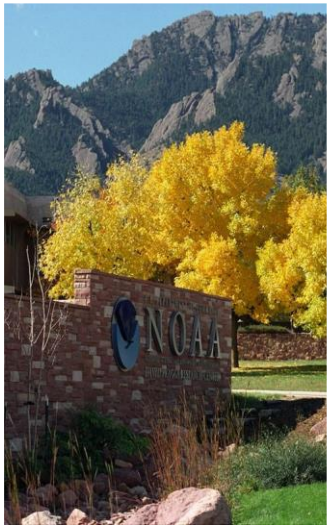
No Change in Zone	Zone 5 (-19 to -10 °F)	Zone 7 (1 to 10 °F)	Zone 9 (21 to 30 °F)
Zone 4 (-29 to -20 °F)	Zone 6 (-9 to 0 °F)	Zone 8 (11 to 20 °F)	Zone 10 (31 to 40 °F)

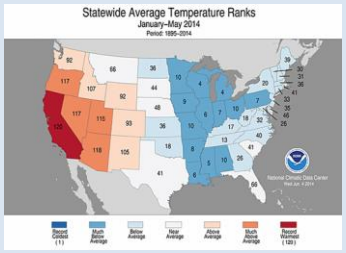
Concluding Thoughts

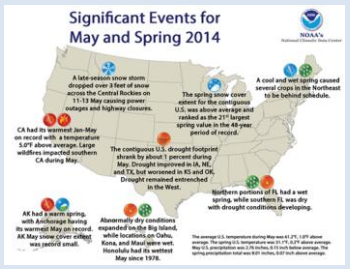
- There are both positive and negative impacts to global warming
- Overall, the net impacts are likely to be negative
- Ecosystems have evolved and human systems are adapted to the current climate

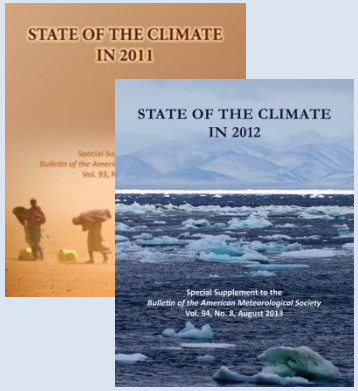

CLIMATE
SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• ETC. ETC.
JOEL PETT

Thank you for your time!





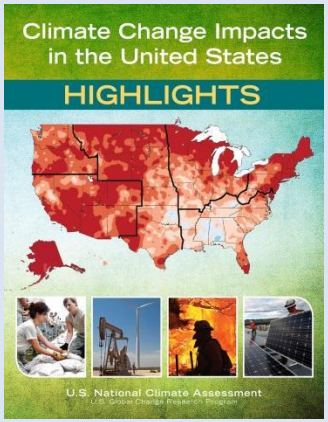
To visit the NCEI website

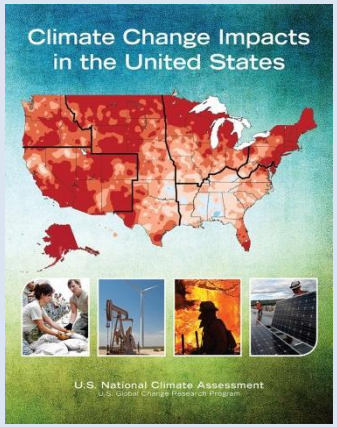
ncei.noaa.gov

To access the *Climate Change in the United States* report, please visit:

science2017.globalchange.gov

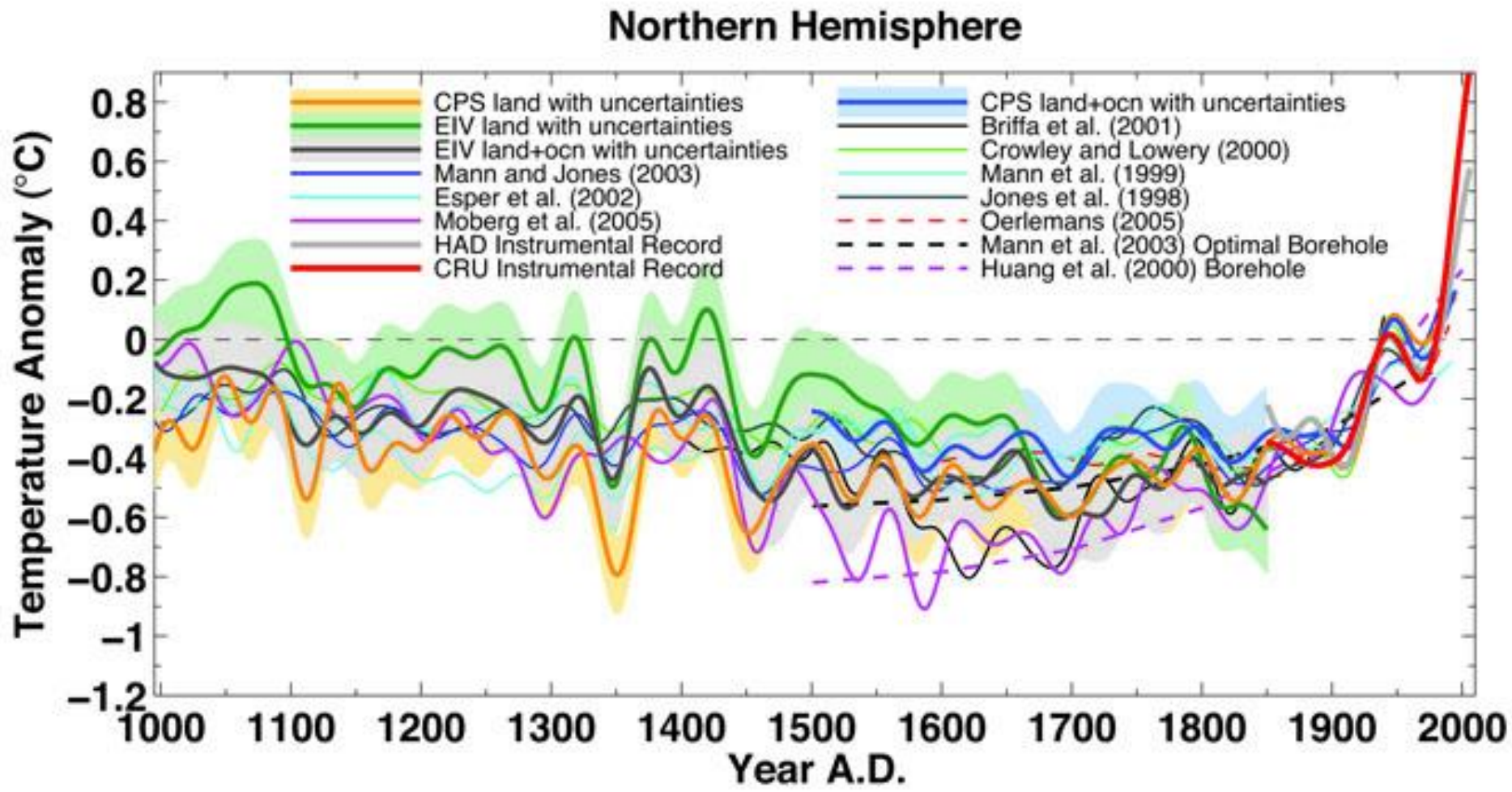
nca2018.globalchange.gov



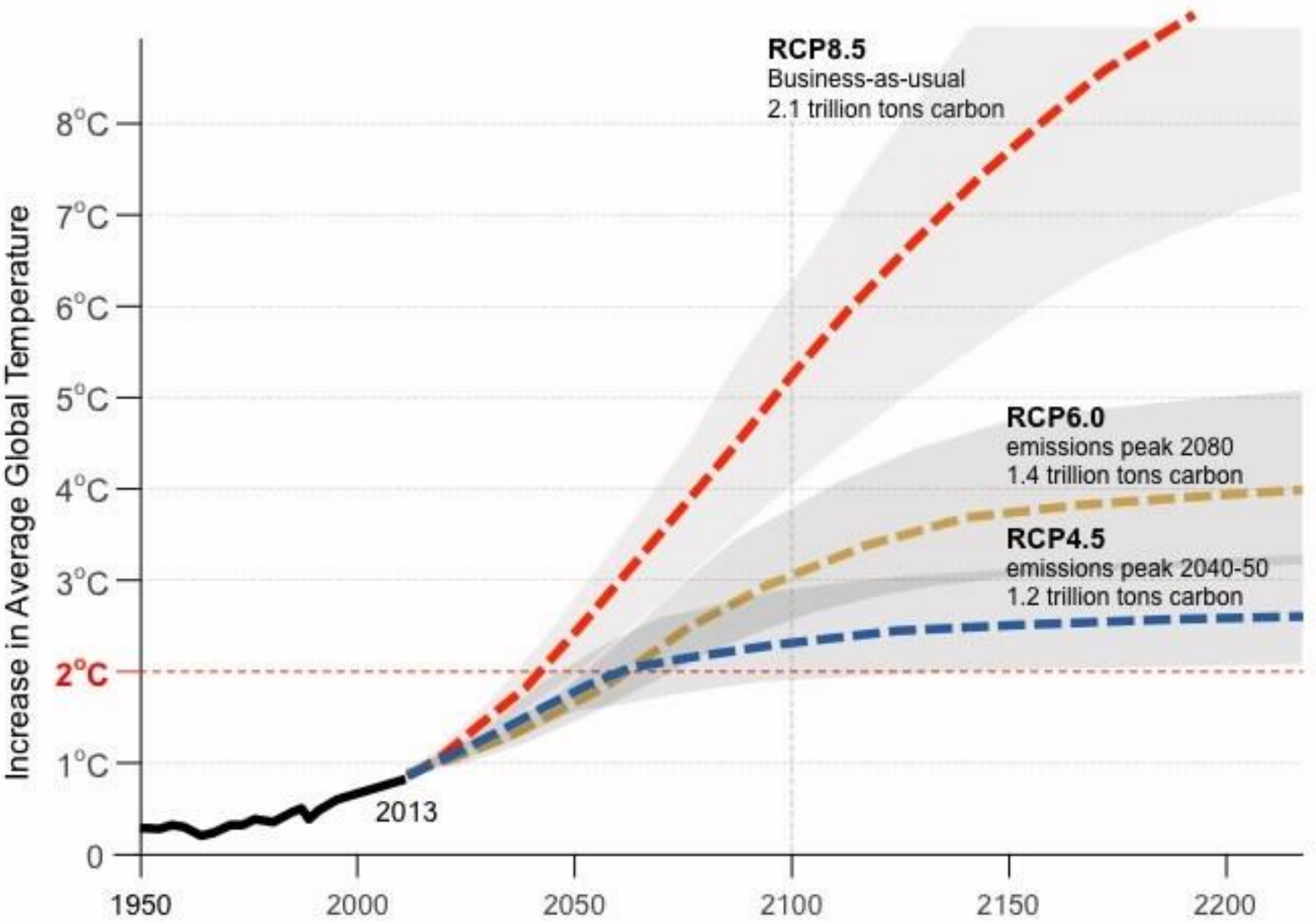


Backup Slides

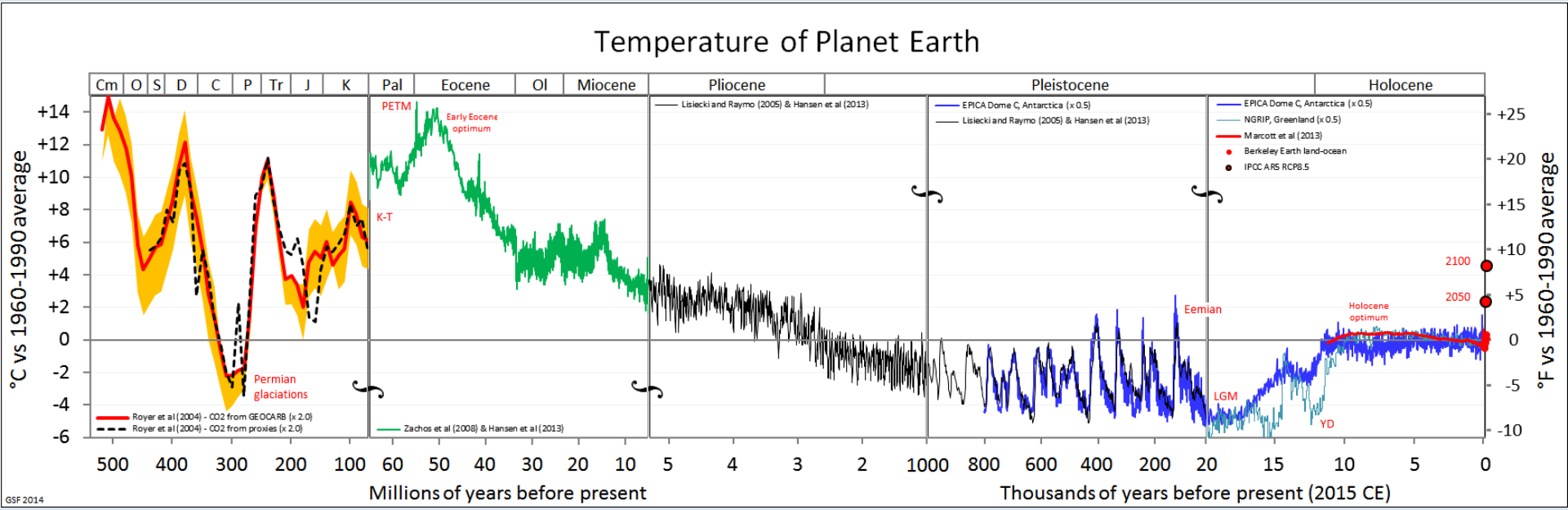
Was the Medieval Warm Period Warmer Than Today?

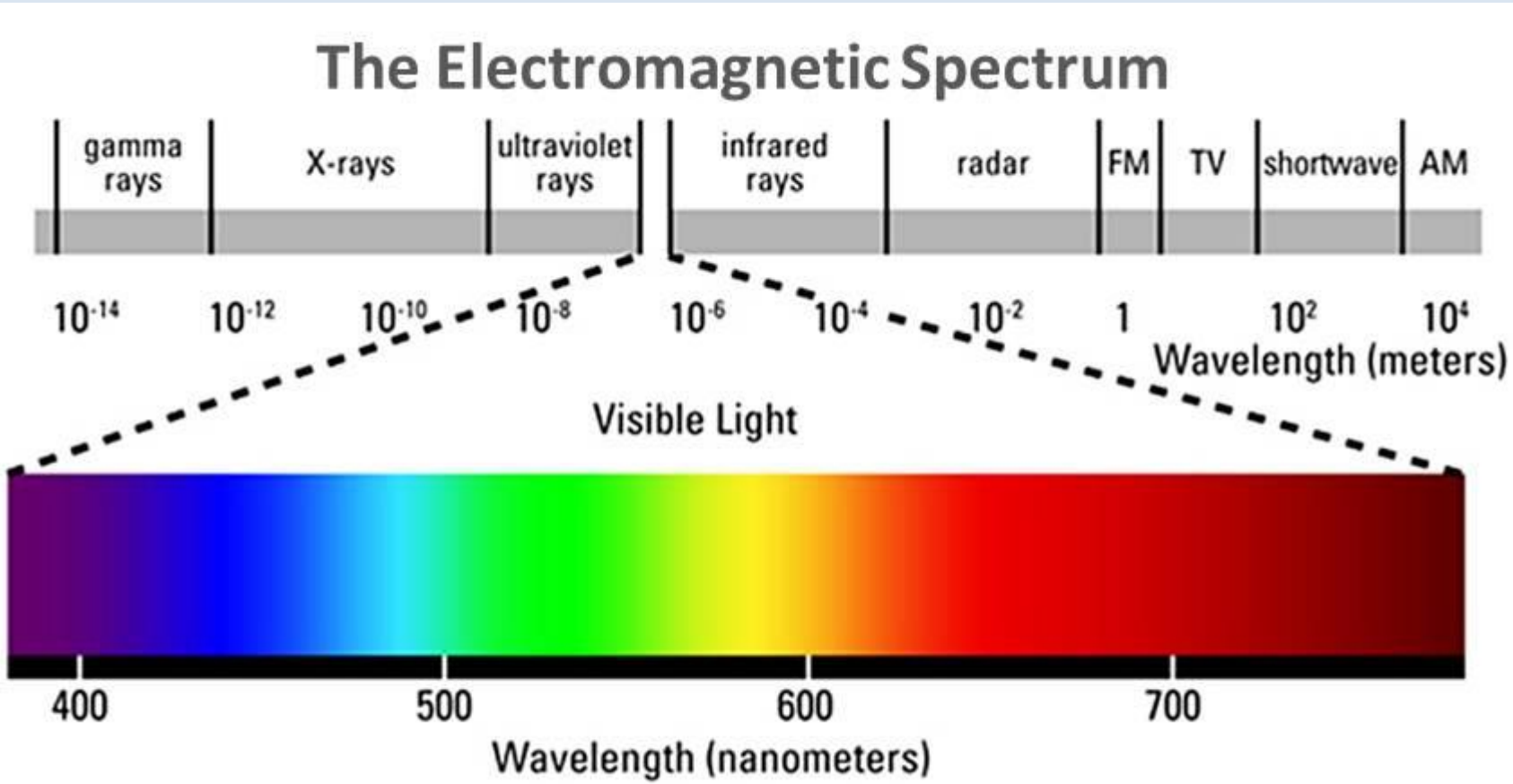


Global Temperature Projections To 2200 for Different Emissions Scenarios



Global Temperature Through Deep Time




The Electromagnetic Spectrum
gamma rays
X-rays
ultraviolet rays
infrared rays
radar
FM
TV
shortwave
AM
10-14
10-12
10-10
10-8
10-6
10-4
10-2
1
102
104
Wavelength (meters)
Visible Light
400
500
600
700
Wavelength (nanometers)