

# Committee on Energy Resources and the Environment



U.S. Global Change  
Research Program

# CLIMATE SCIENCE

## SPECIAL REPORT



Fourth National Climate Assessment □ Volume I

# U.S. National Climate Assessment Volume 1: Summary of Findings

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NARUC Mtg February 13, 2018<sub>2</sub>

# 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

[science2017.globalchange.gov](https://science2017.globalchange.gov)

**NCA Volume II on impacts expected to be published in Dec. 2018**

# USGCRP Climate Science Special Report

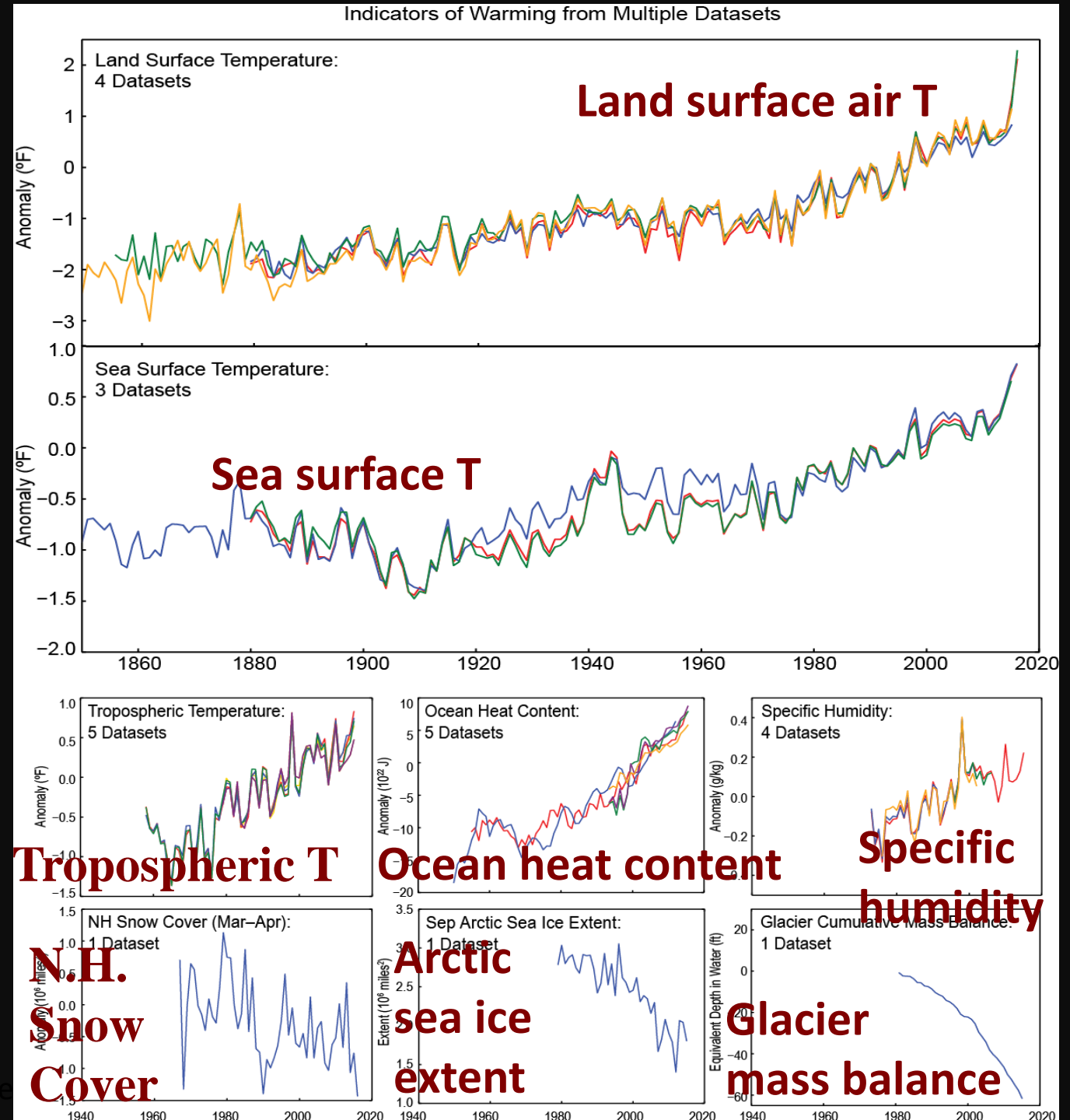
## Volume 1 of the 4<sup>th</sup> National Climate Assessment

- CSSR is an authoritative assessment of the science of climate change, with a focus on the United States
  - 477 pages
  - 32 Lead Authors and 19 Contributing Authors (federal, national lab, academic, and industry scientists)
- Overseen by a federal Science Steering Committee
- Extensively reviewed (including public, National Academy of Sciences, and U.S. agencies)
  - 3 Review editors that were not authors

# The Science: The Bottom Line

- Our climate is changing,
  - It is happening now;
  - It is happening extremely rapidly;
- Severe weather is becoming more intense;
- Sea levels are rising;
- It is largely happening because of human activities and associated pollution;
- The climate will continue to change over the coming decades.

# There are Many Observed Indicators of a Changing Climate



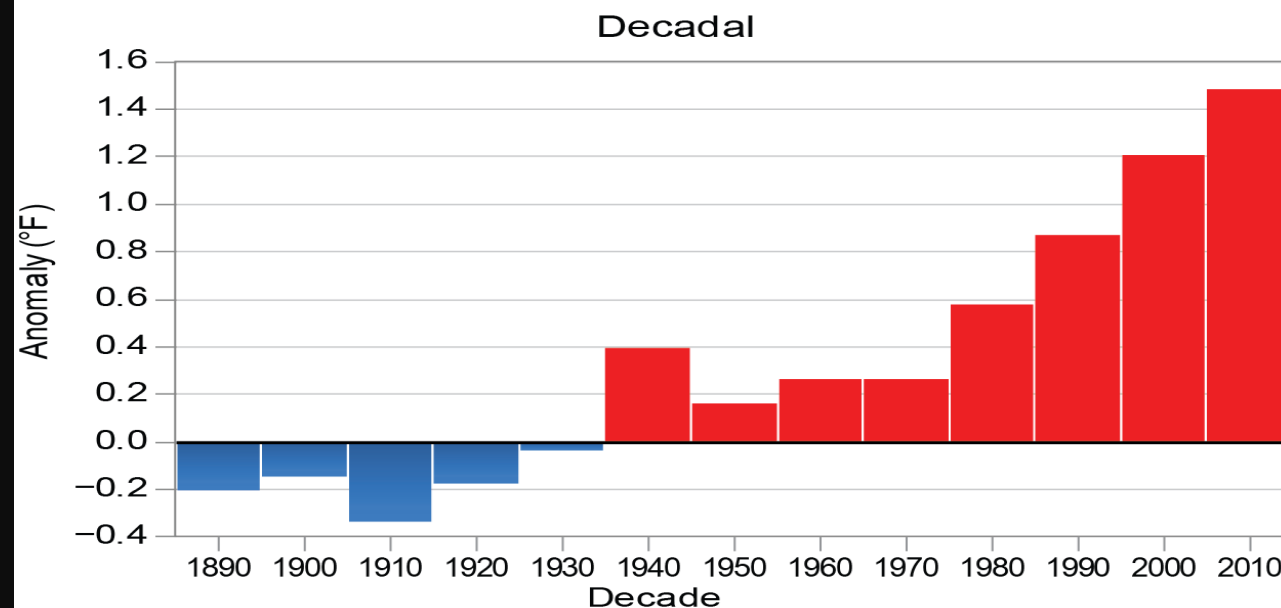
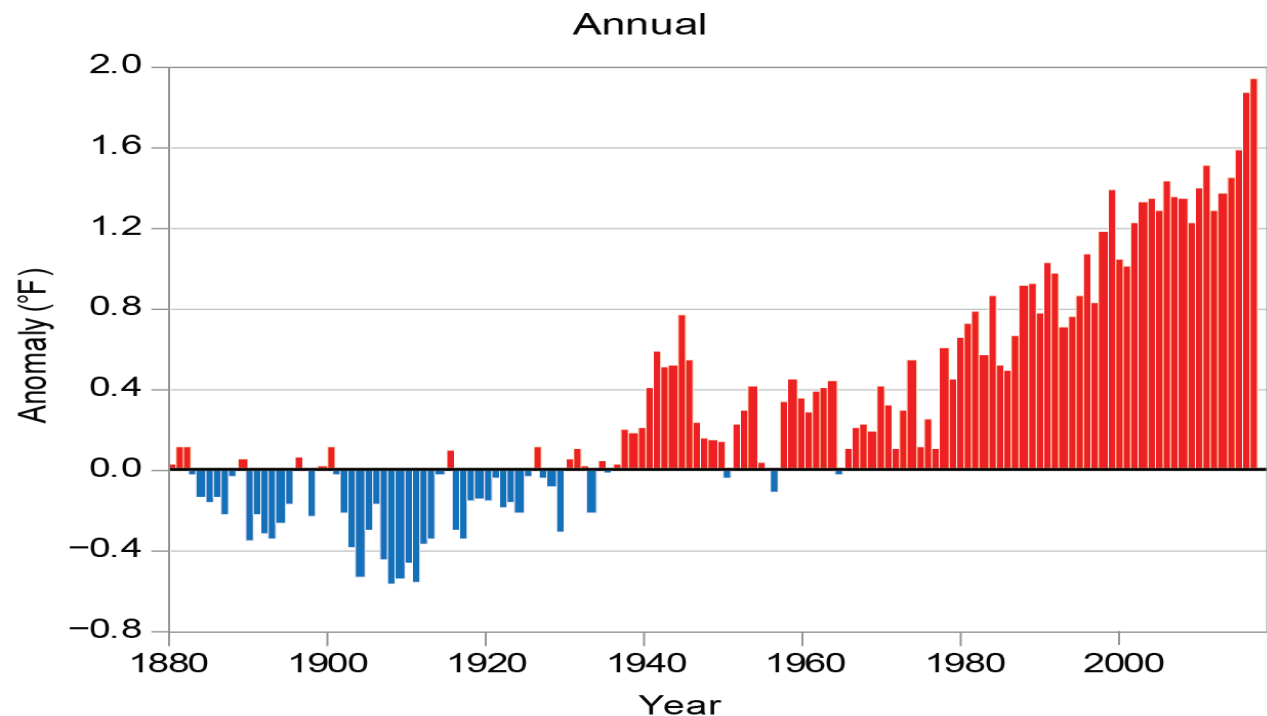
# Global Annually-Averaged Temperature Record (NOAA, through 2016)

Globally, annually-averaged temperature has increased by 1.8 °F from 1901-2016

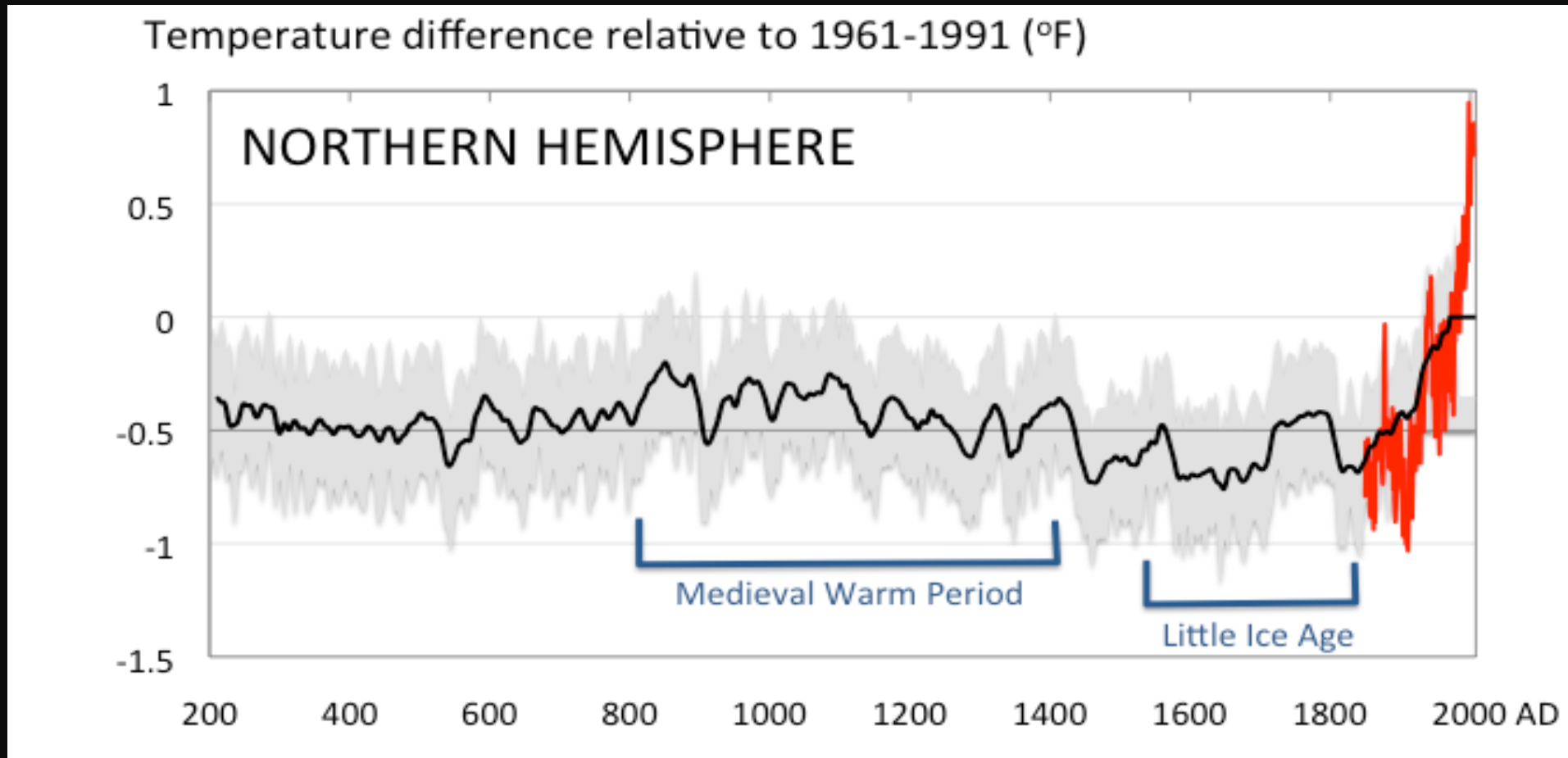
Date

Graphs are relative to 1901-1960

## Global Land and Ocean Temperature Anomalies



# Conditions today appear to be unusual in the context of the last 2,000 years ...

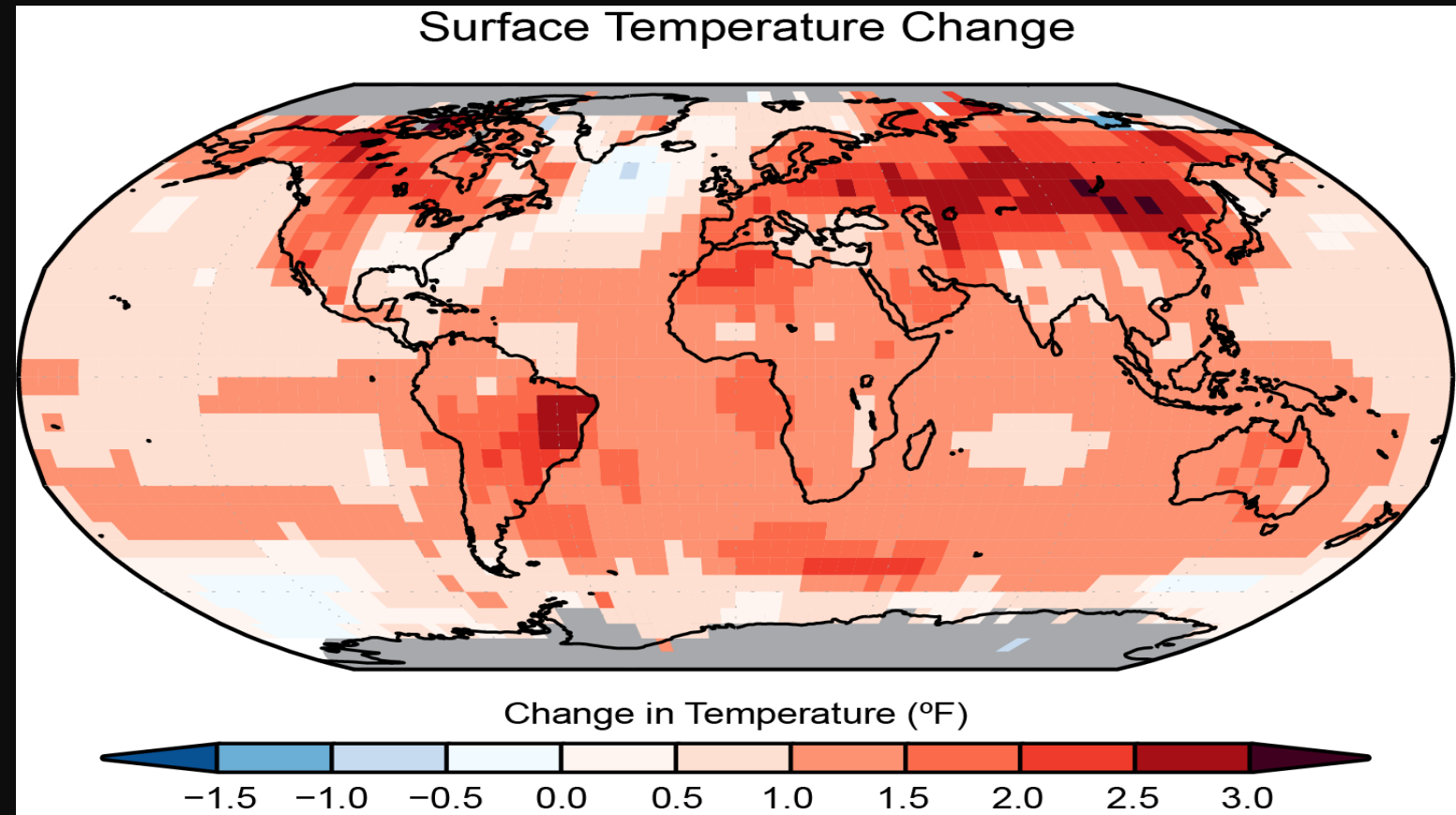


# Our Climate Continues to Change Rapidly

The global long-term warming trend is continuing.

2016 was the warmest year on record, 2015 is 2<sup>nd</sup> and far surpassed 2014, which is 3<sup>rd</sup>.

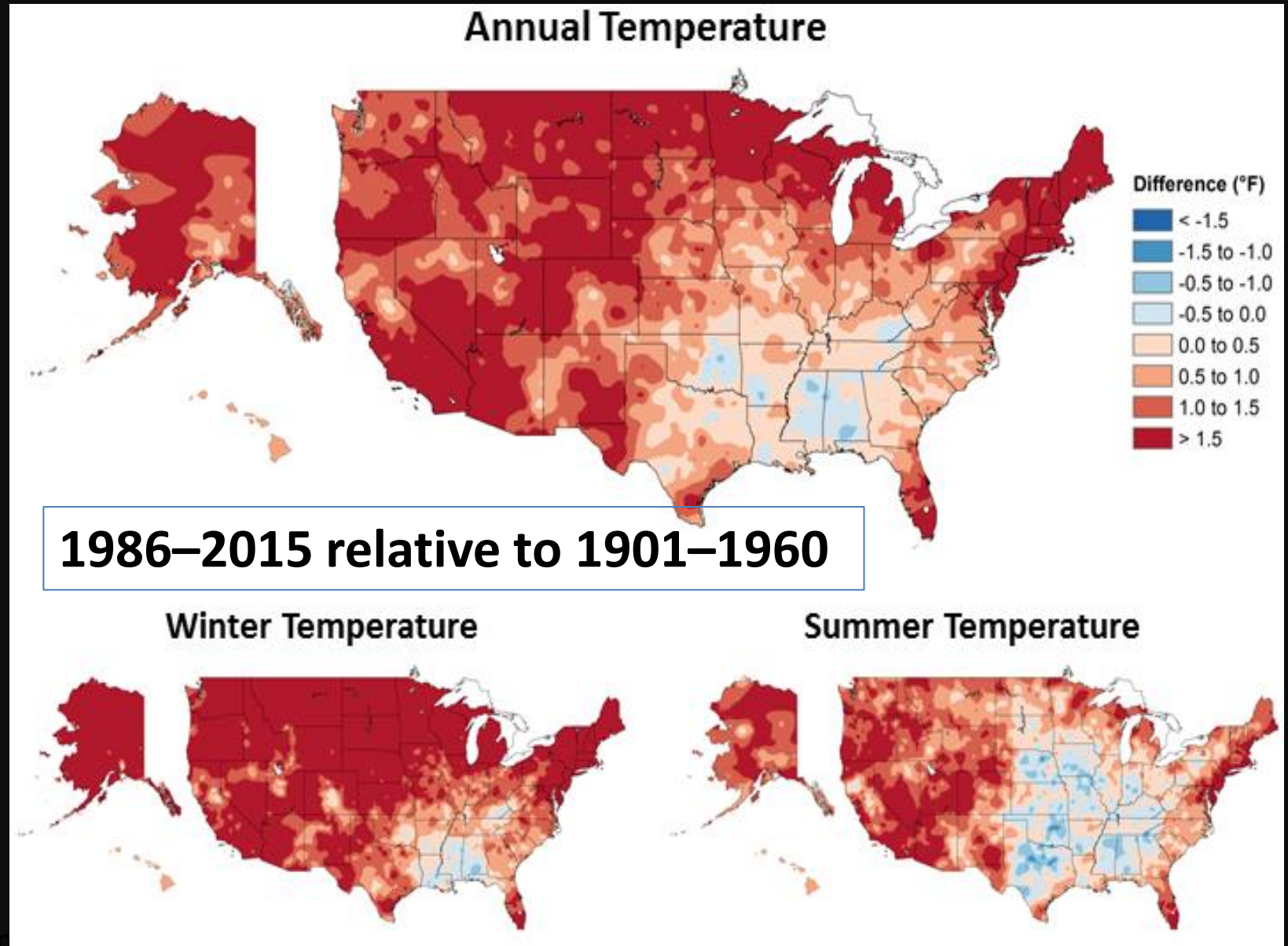
Sixteen of the last 17 years are the warmest years on record for the globe.



**Temperature trends (change in ° F) for the period 1986-2015 relative to 1901-1960**

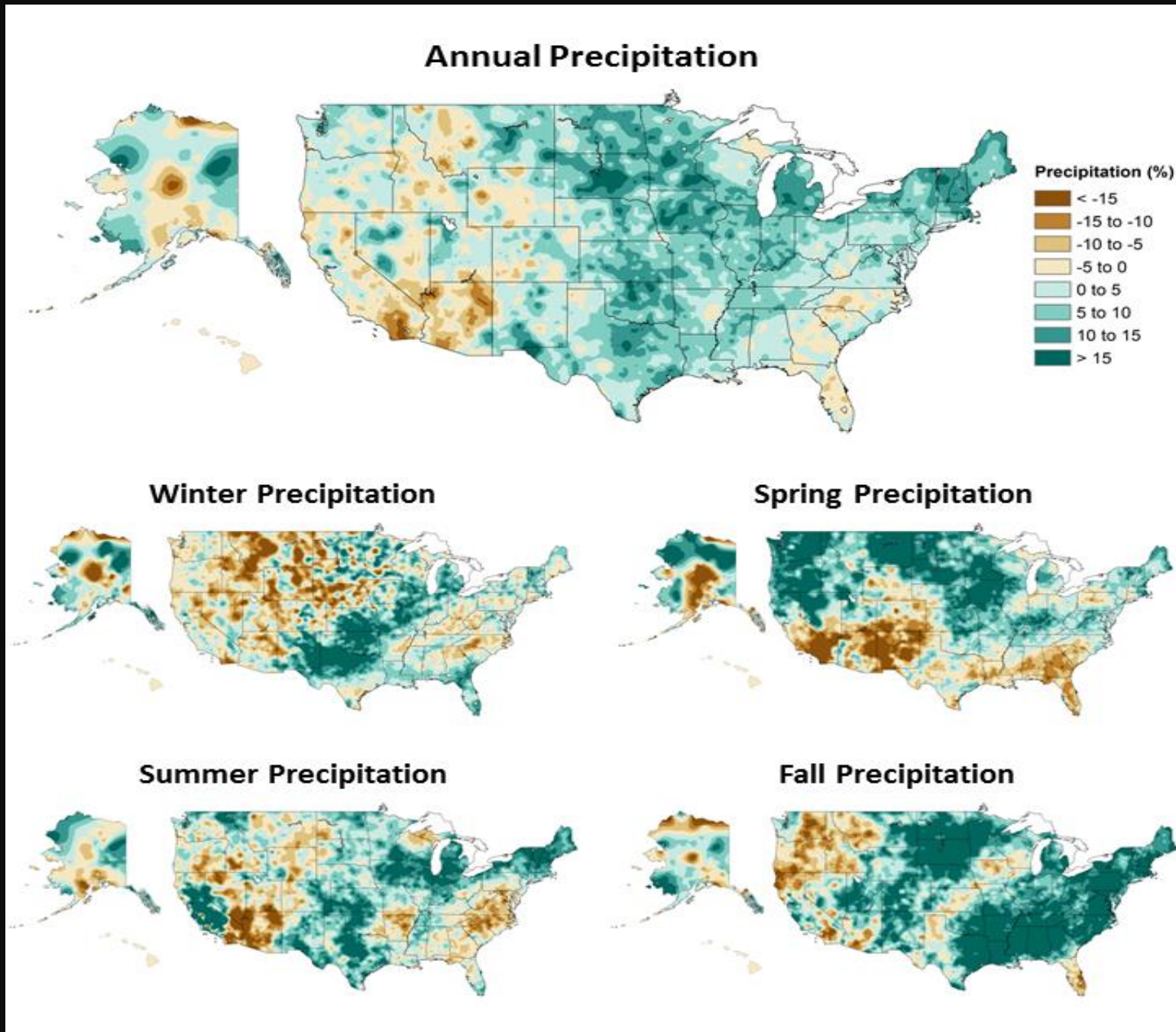
# Observed U.S. Temperature Change

Over contiguous United States, annually-averaged temperature has increased by 1.8 °F from 1895-2016

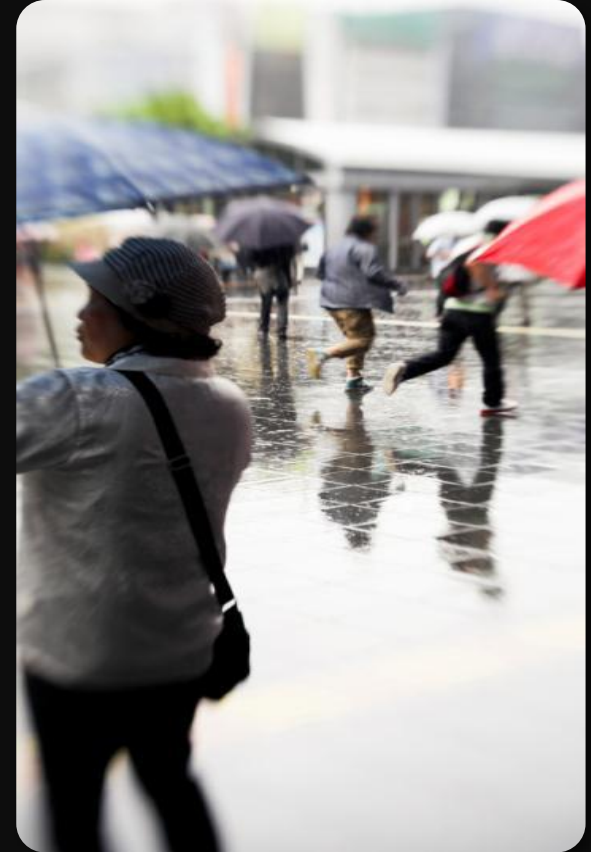


# Observed U.S. Precipitation Change

Annual precipitation has increased in most of the Northern and Southern Plains, Midwest, and Northeast and has decreased in much of the West, Southwest, and Southeast.



# We are seeing changing trends in extreme weather and climate events

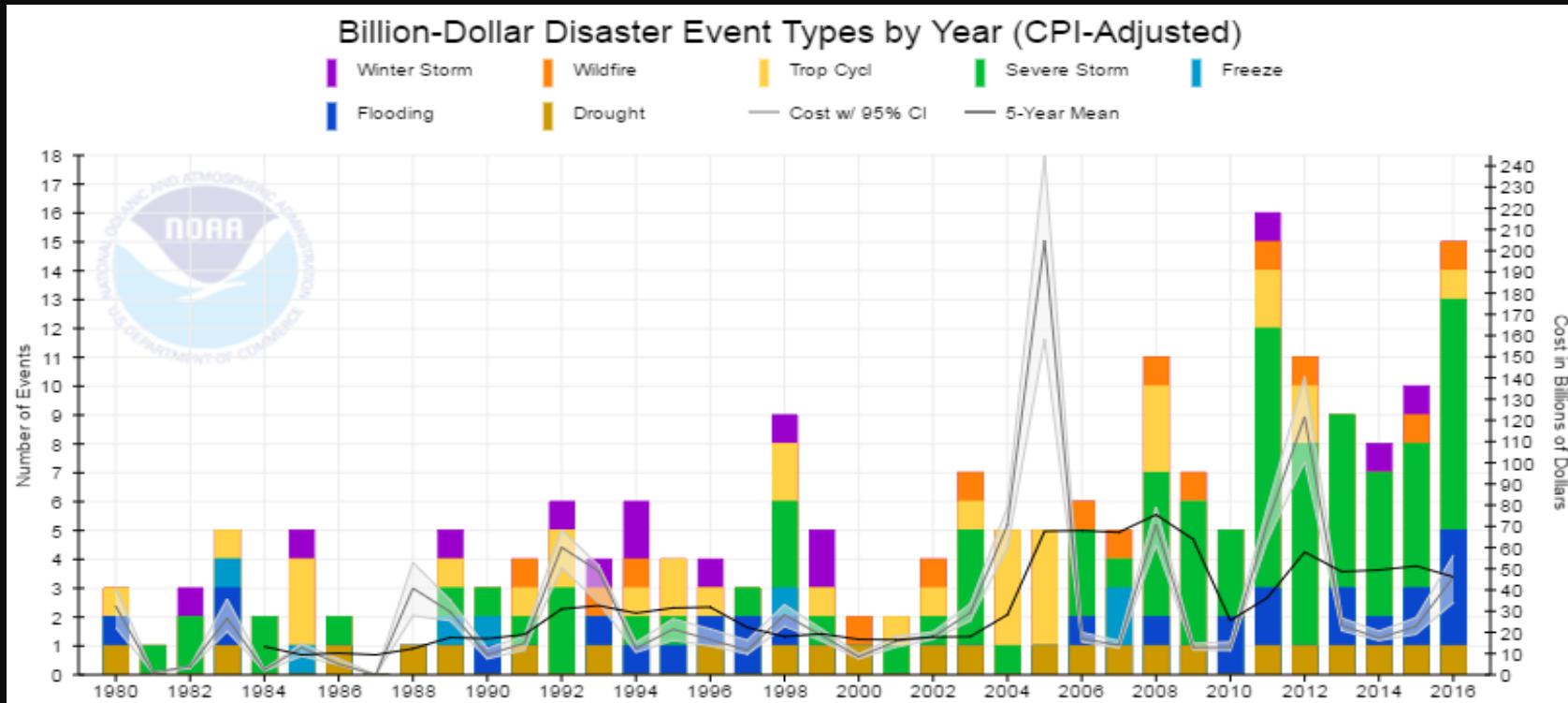


# NOAA Analyses

## Increasing Effects of Severe Weather on U.S. Economy: Total of \$1.1 trillion since 1980

Every U.S. region has been affected by this growing trend.

Billion-dollar weather and climate disasters frequency: 1980-2016 (accounts for inflation)



Similar trend globally

203 weather and climate disasters reached or exceeded \$1 billion during this period (CPI-adjusted)

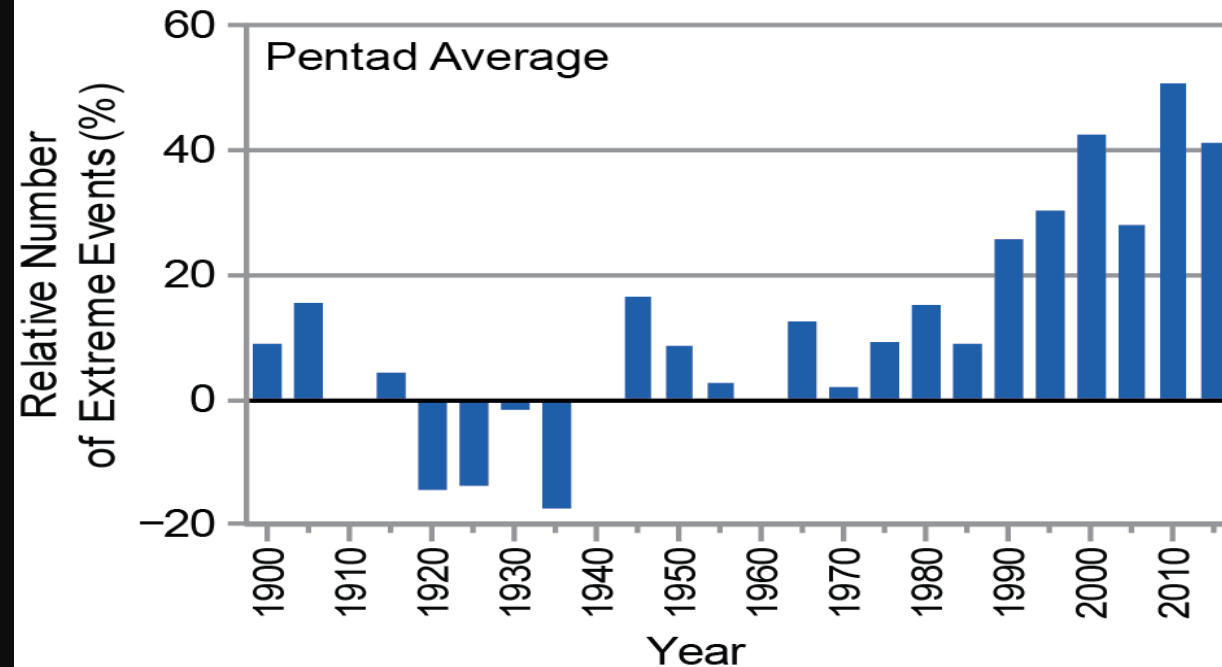
# Certain Types of Extreme Events Show Important Trends Globally and in United States

- Heat waves are generally increasing in number and intensity; Cold waves are decreasing.
- More precipitation coming as larger events.
- Increasing risk of floods in some regions (NE, MW).
- Increasing intensity of droughts in some regions (SW, SE).
- Incidence of large wildfires has increased (West, Alaska)
- Increasing intensity of Atlantic hurricanes.
- Tornado activity more variable – increase in outbreaks.
- Hail may be coming more intense also but more uncertain.

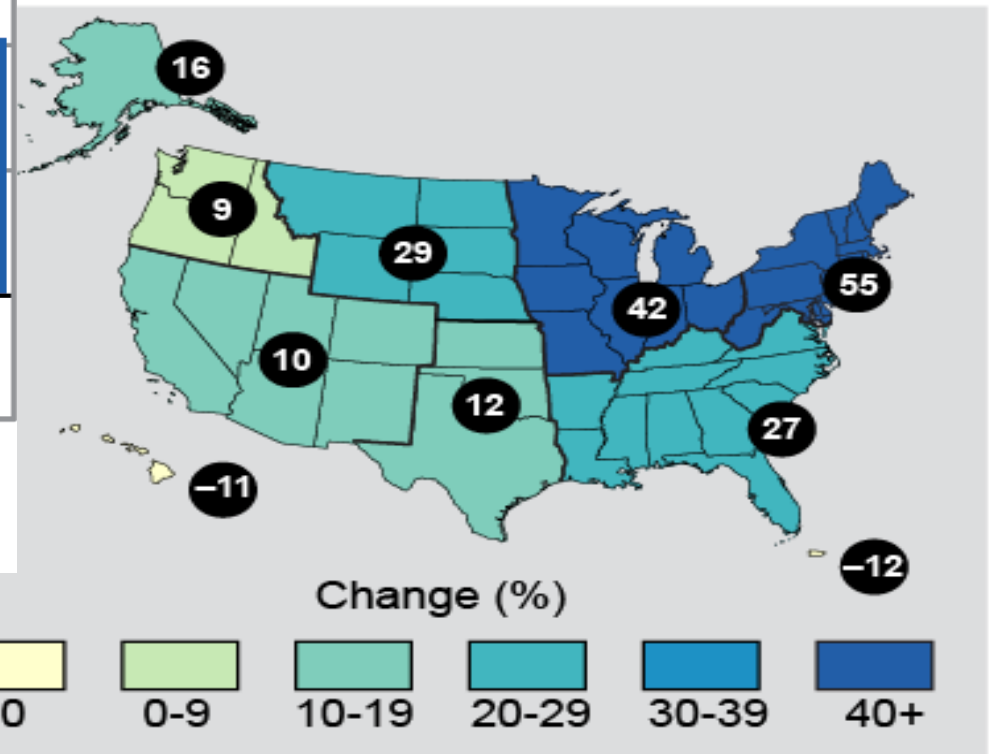
**These trends are expected to continue.**

# Extreme Precipitation Events are Increasing in Frequency and Intensity

2-Day Precipitation Events  
Exceeding 5-Year Recurrence Interval



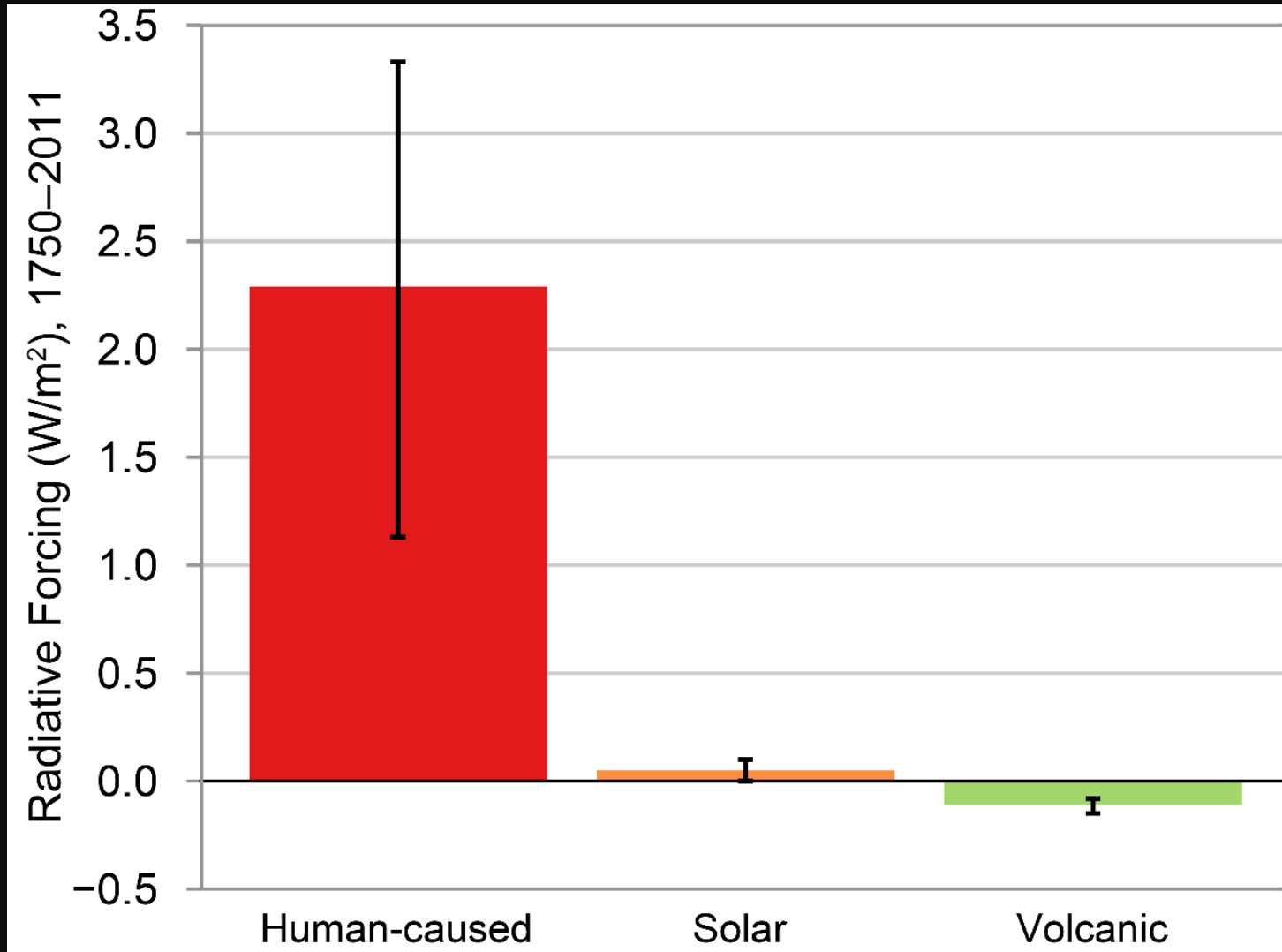
99th Percentile Precipitation  
(1958–2016)



# What is Causing Observed Changes in Climate

- Many lines of evidence demonstrate that human activities, especially emissions of greenhouse gases, are primarily responsible for the observed climate changes.
- For the period extending over the last century, there are no credible alternative explanations supported by the extent of the observational evidence.
  - Solar output changes and natural variability can only contribute marginally to the observed changes in climate over this time period.
  - No natural cycles are found in the observational record that can explain the observed changes in climate.

# Human Activities Driving Climate Change

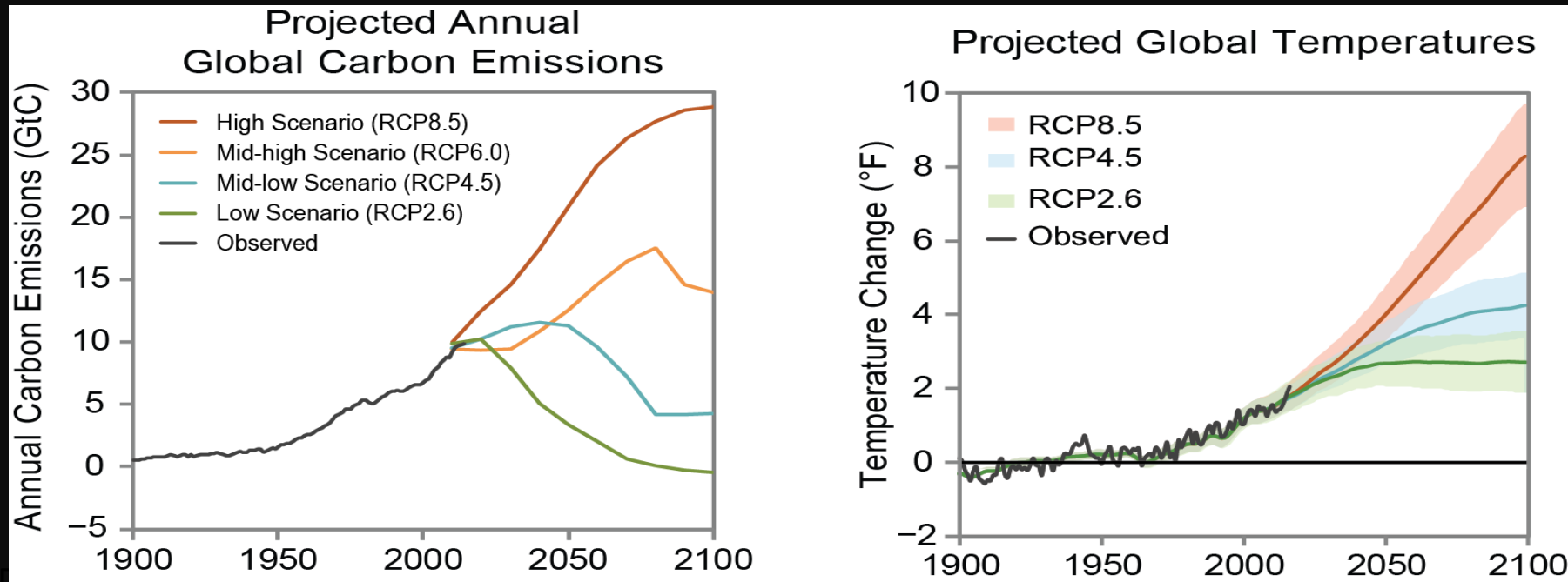


It is extremely likely that human activities, especially emissions of greenhouse gases, are the dominant cause of the observed warming since the mid-20th century.

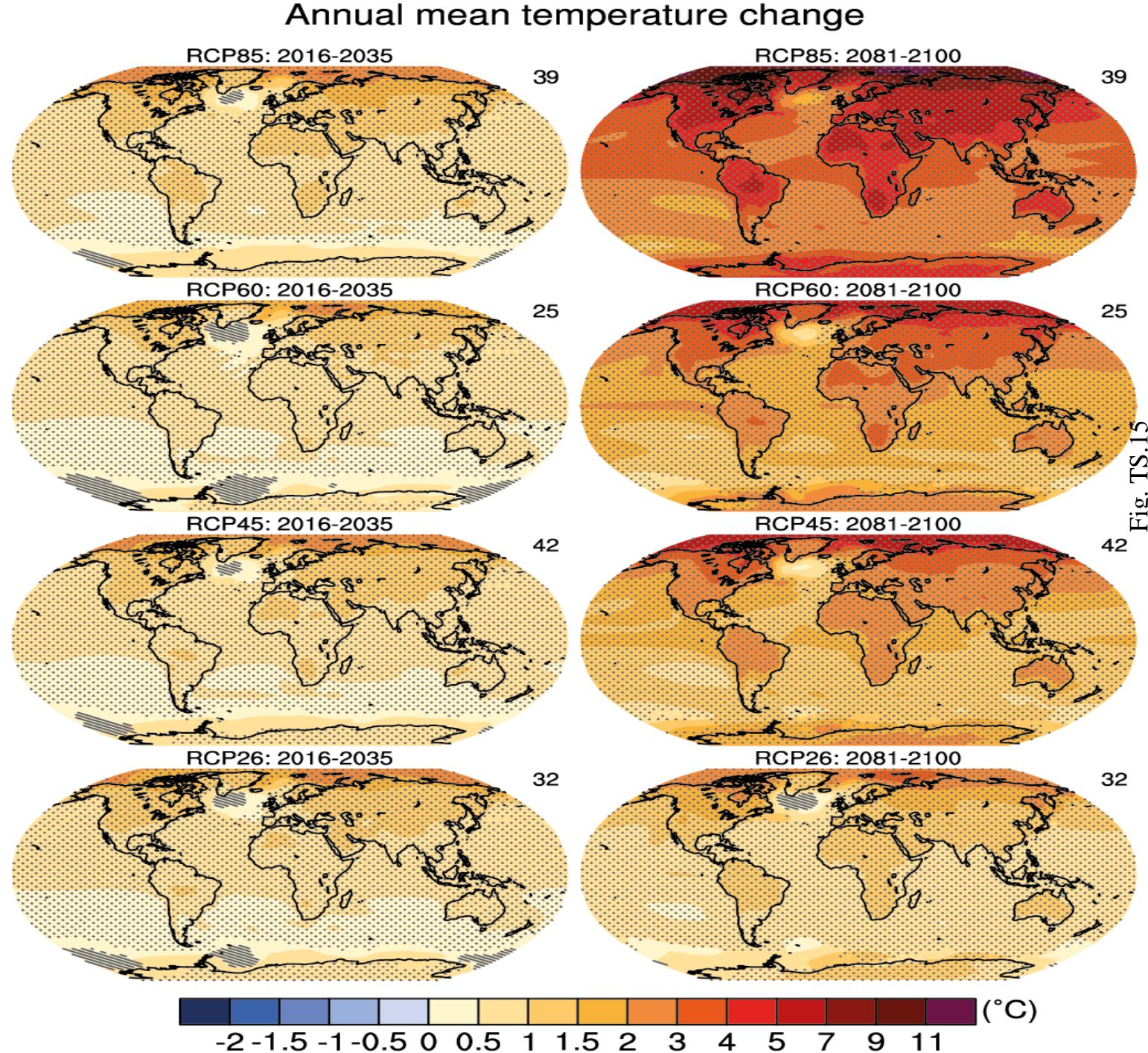
Contributions to radiative forcing on climate since 1750

# Climate will Continue to Change

- Globally climate is expected to continue to change over this century and beyond.
- The magnitude of climate change depends primarily on the additional amount of greenhouse gases emitted globally, and on the sensitivity of Earth's climate to those emissions.



# Global Temperature and Other Changes in Climate Depend on Future Emissions



# Projected U.S. Temperature Change

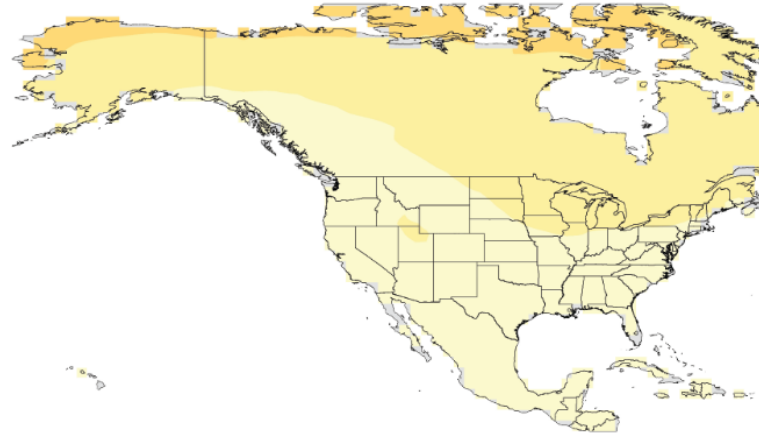
Projected changes  
in average annual  
temperatures (°F)

Relative to 1976–2005

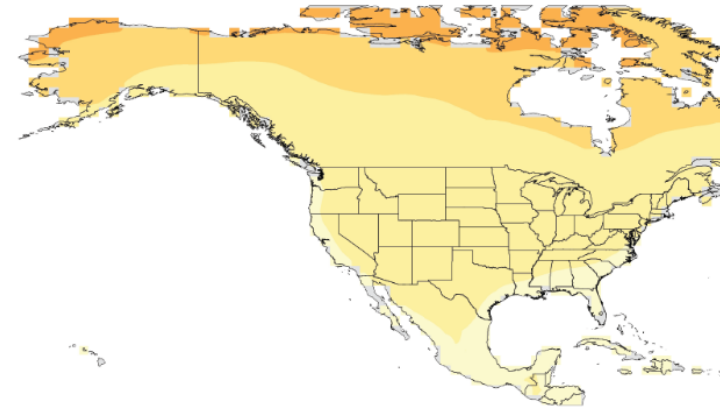
## Projected Changes in Average Annual Temperature

Mid 21st Century

Lower Scenario (RCP4.5)

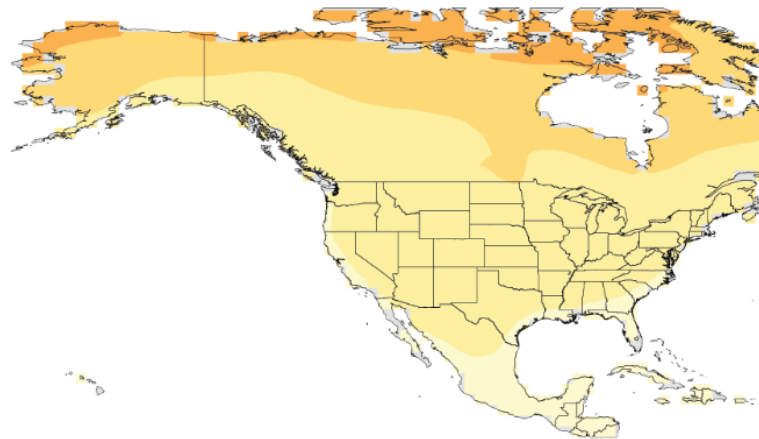


Higher Scenario (RCP8.5)

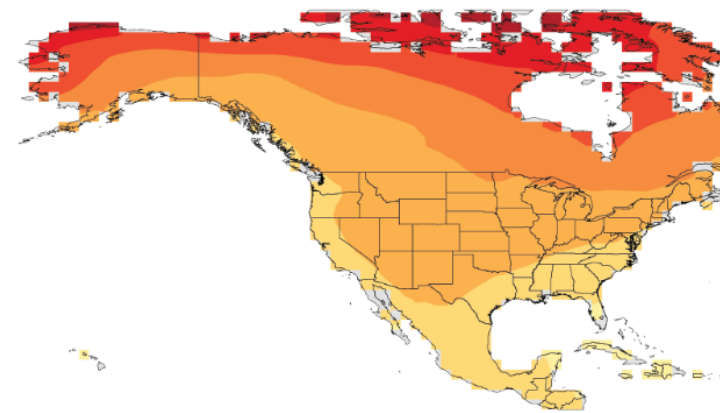


Late 21st Century

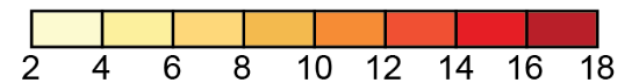
Lower Scenario (RCP4.5)



Higher Scenario (RCP8.5)

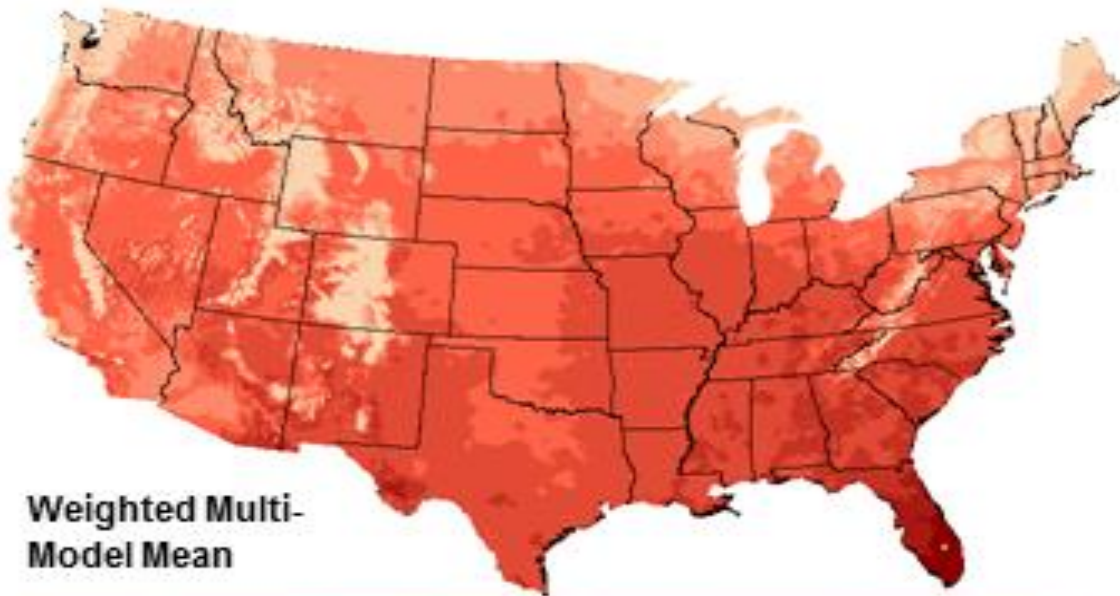


Change in Temperature (°F)

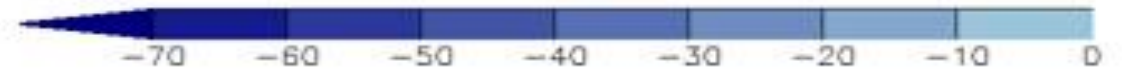
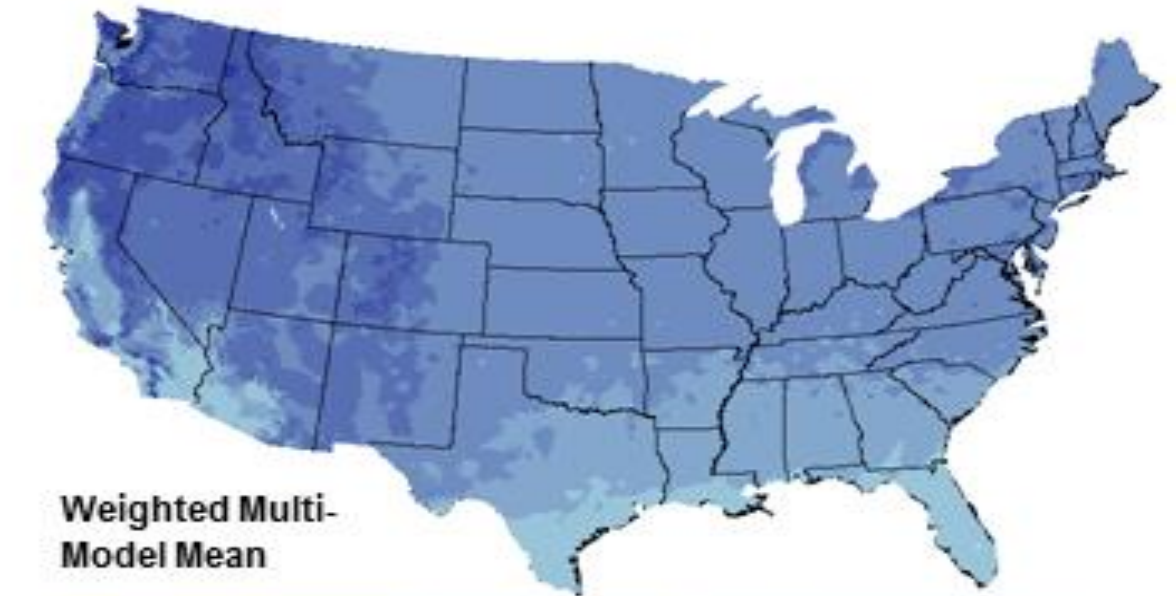


# Projected Changes: Number of Days with $T > 90^{\circ}\text{F}$ and $T < 32^{\circ}\text{F}$ for 2036-2065 (relative to 1976-2005) for a High Emissions Scenario

Projected Change in Number of Days Above  $90^{\circ}\text{F}$   
Mid-21<sup>st</sup> Century, Higher Emissions

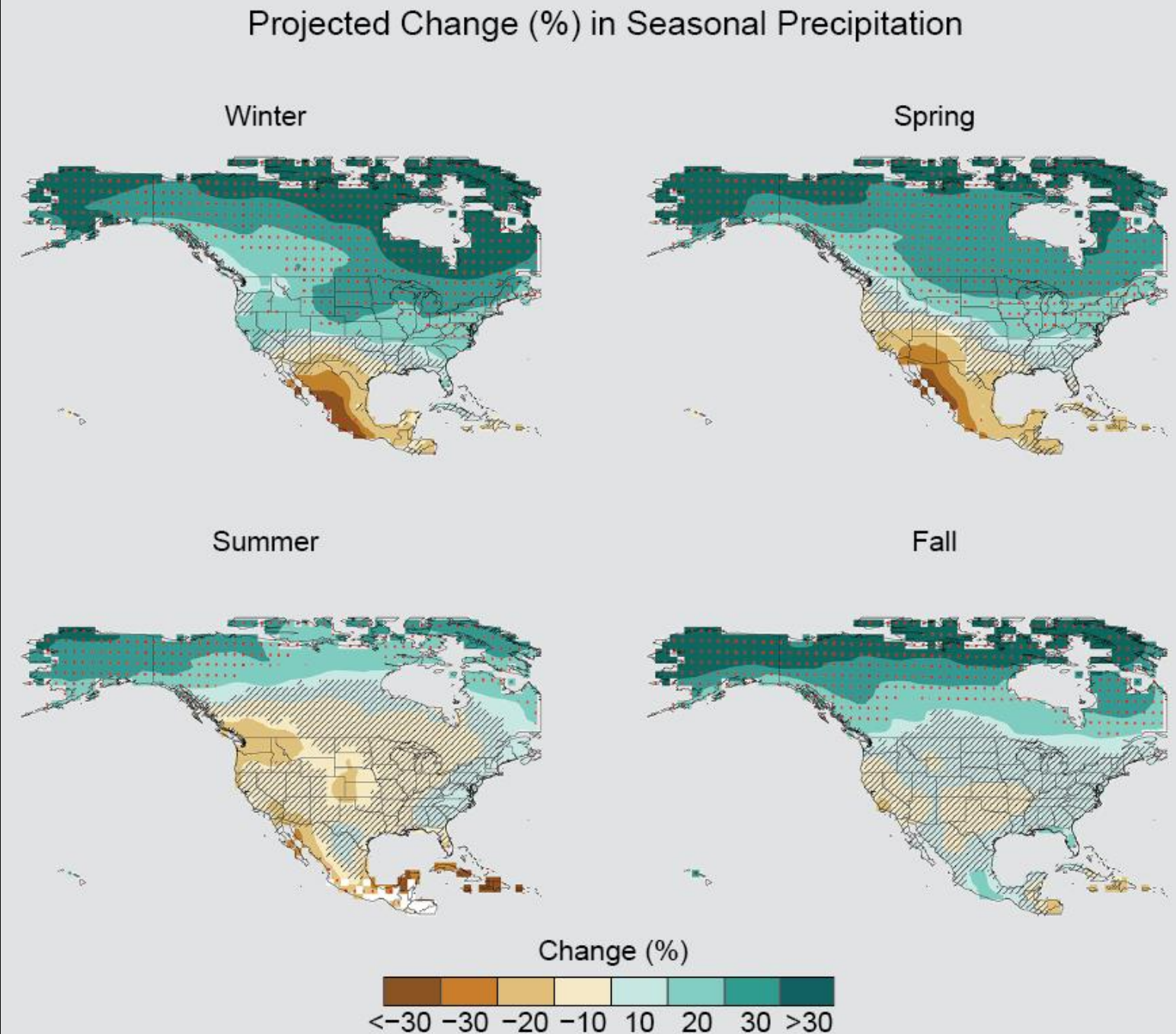


Project Change in Number of Days Below  $32^{\circ}\text{F}$   
Mid-21<sup>st</sup> Century, Higher Emissions

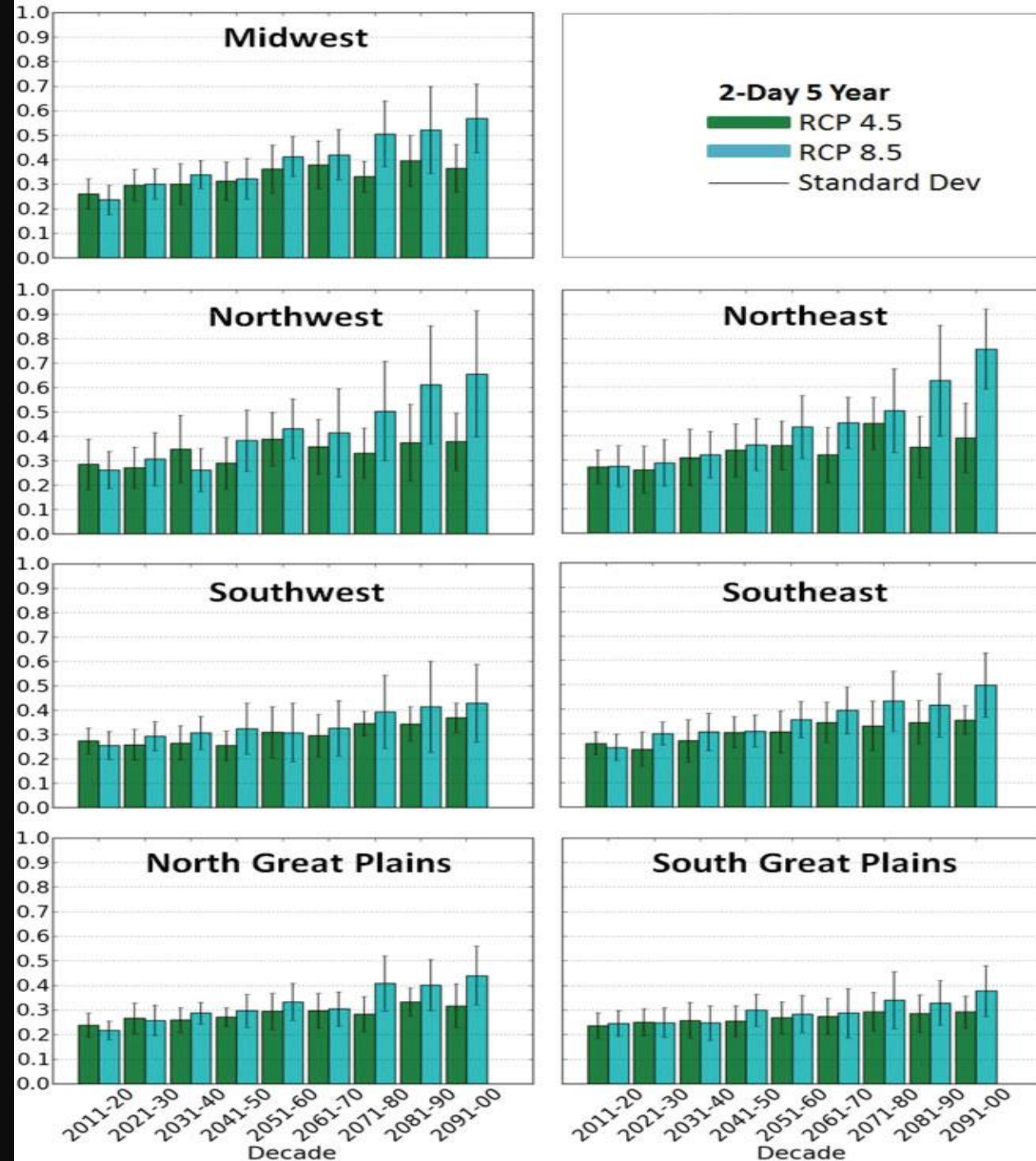


# Projected U.S. Precipitation Change

2070-2099 relative to 1975-2005  
For RCP8.5 (High scenario)



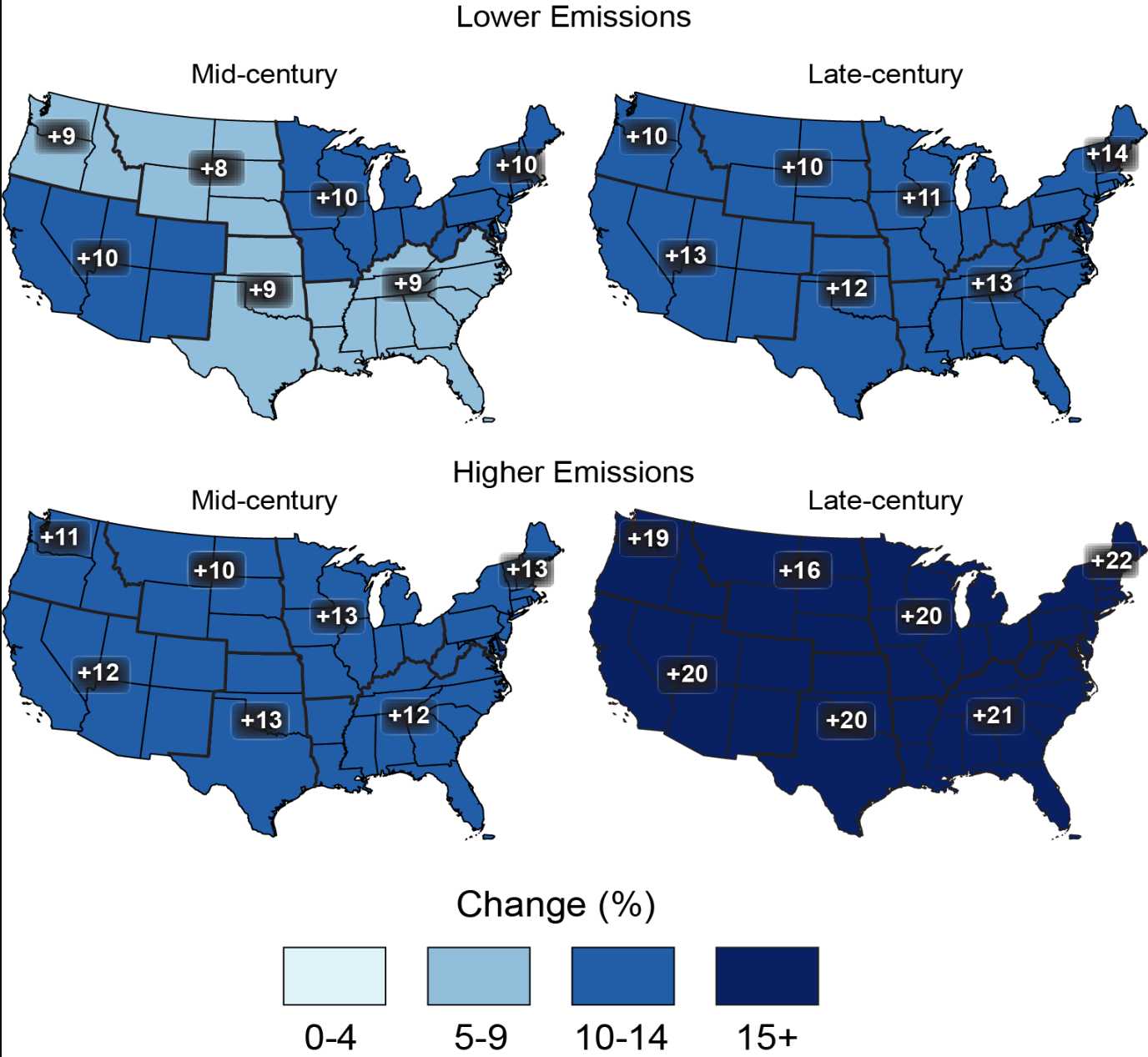
# Extreme Precipitation Event Frequency for events of 2-day duration and 5- year return (for high and intermediate scenarios)



# Projected Change in 20 year Return Period Extreme Precipitation Events

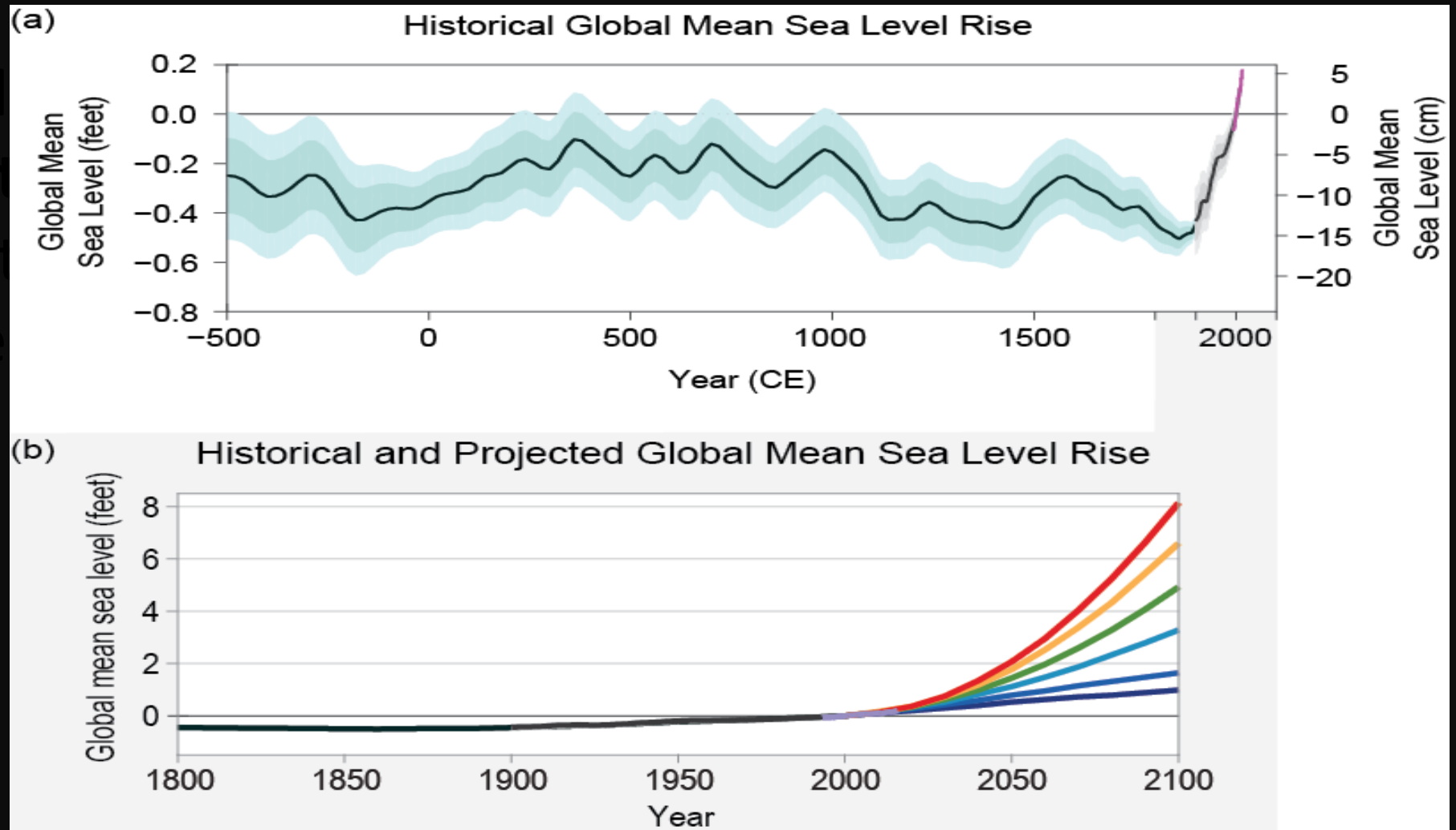
High and  
intermediate  
scenarios

Projected Change  
in Daily, 20-year Extreme Precipitation

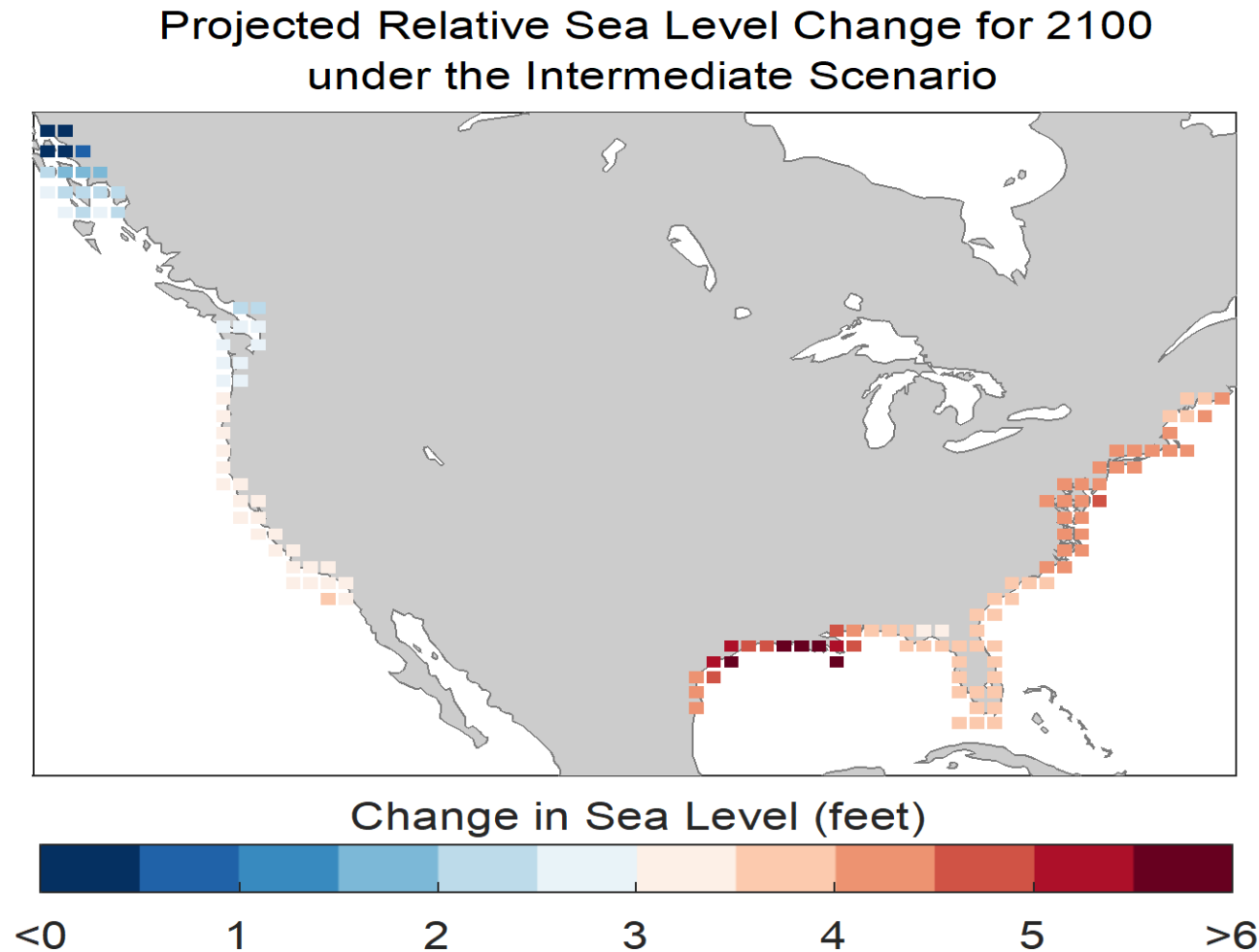


# Past and Projected Changes in Global Sea Level

Best estimate of SLR is another 1-4 feet by 2100



# Regional SLR in 2100 projected for the Intermediate Scenario (3.3 feet] GMSL

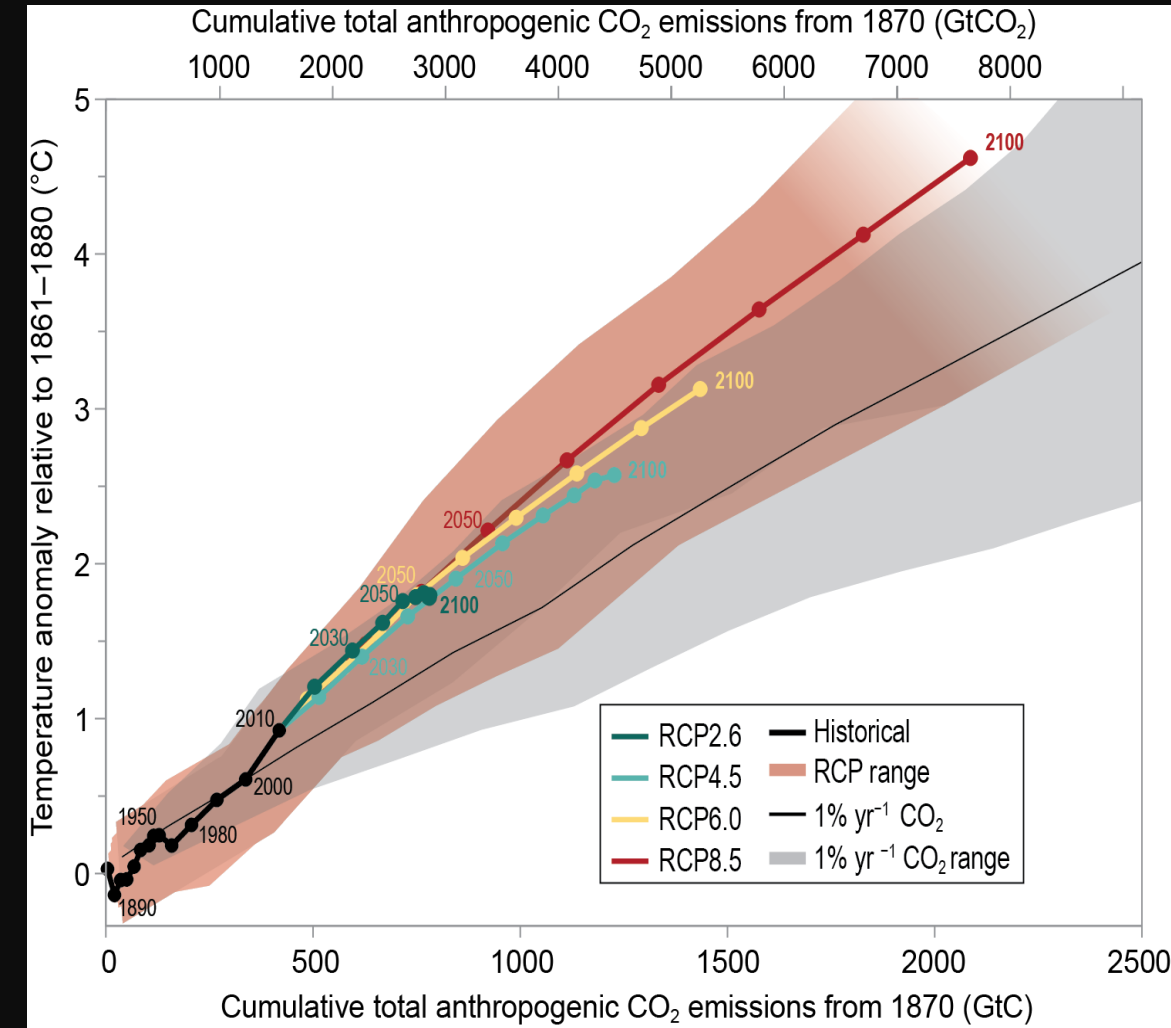


Stabilizing global mean temperature to less than **3.6°F (2°C)** requires **substantial reductions in net CO<sub>2</sub> emissions prior to 2040** and likely requires net emissions to become **zero or negative later in the century..**

Cumulative global CO<sub>2</sub> emissions must stay below **~800 GtC** for a 66% chance of preventing 2°C.

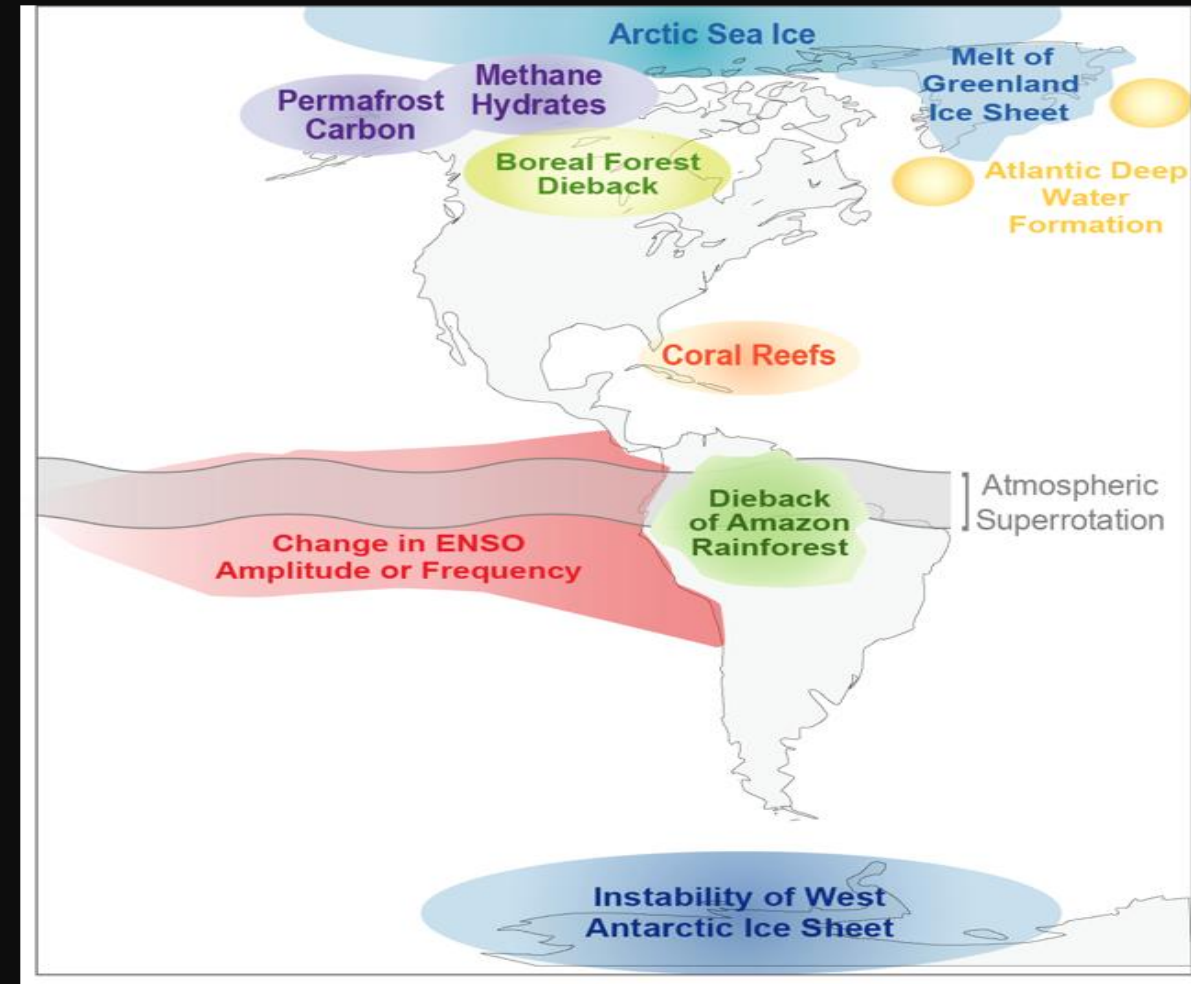
Assuming global emissions are at or above the RCP4.5 scenarios, emissions could continue for about 20 years before this threshold is reached.

# Perspective on Climate and Future Emissions



# Potential Surprises: There is a Significant Possibility for Unanticipated Changes

Both large-scale state shifts in the climate system (sometimes called tipping points) and compound extremes have the potential to generate unanticipated surprises. The further the earth system departs from historical climate forcings, and the more the climate changes, the greater the potential for these surprises. Unanticipated changes in climate change and climate impacts are possible throughout the next century.



Potential tipping points

# *Thank You*



# Committee on Energy Resources and the Environment