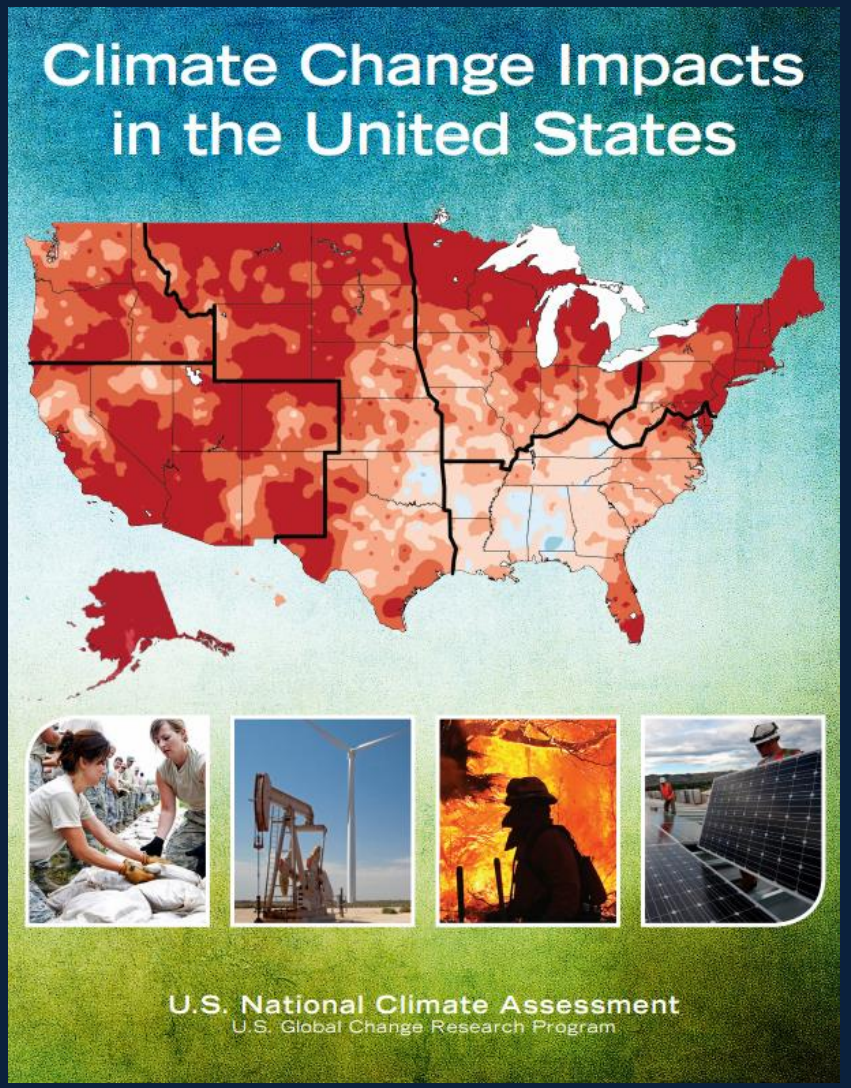
Climate Change Impacts:

Third National Climate Assessment
- and -
Related Resources

ROBERT TAYLOR

LAURA STEVENS

NOAA'S COOPERATIVE INSTITUTE FOR CLIMATE & SATELLITES



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Why does the NCA exist?

- The Global Change Research Act established the US Global Change Research Program to coordinate global change research across the federal government

United States Global Change Research Program

Global Change Research Act (1990) Mandate:

"To provide for development and coordination of a comprehensive and integrated United States research program which will assist the Nation and the world to **understand, assess, predict, and respond** to human-induced and natural processes of global change."

13 Federal Departments & Agencies + Executive Office of the President

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Why does the NCA exist?

- The National Climate Assessment is one of the requirements of the Global Change Research Act

GCRA (1990), Section 106:

… not less frequently than every 4 years, the Council… shall prepare… an assessment which –

- integrates, evaluates, and interprets the findings of the Program (USGCRP) and discusses the scientific uncertainties associated with such findings;
- analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and
- analyzes current trends in global change, both human- induced and natural, and projects major trends for the subsequent 25 to 100 years.

The NCA 2014

- Inclusive
  - 300 authors (academic, private, federal)
  - 60 member Federal Advisory Committee
  - 13 USGCRP agencies, plus a Technical Support Unit
- Public engagement
  - Listening sessions around the country
  - Request for information, input reports
- Future focus on sustained assessment
  - Intermediate products planned as well as quadrennial reports

The NCA 2014, continued

New topics covered

- Oceans, Coasts, Urban, Rural, Land use
- Cross-sector links like Energy/Water/Land

New format (http://nca2014.globalchange.gov)

- Digital products and interactive website
- Highlights, GCIS, traceable accounts

Extensive Review

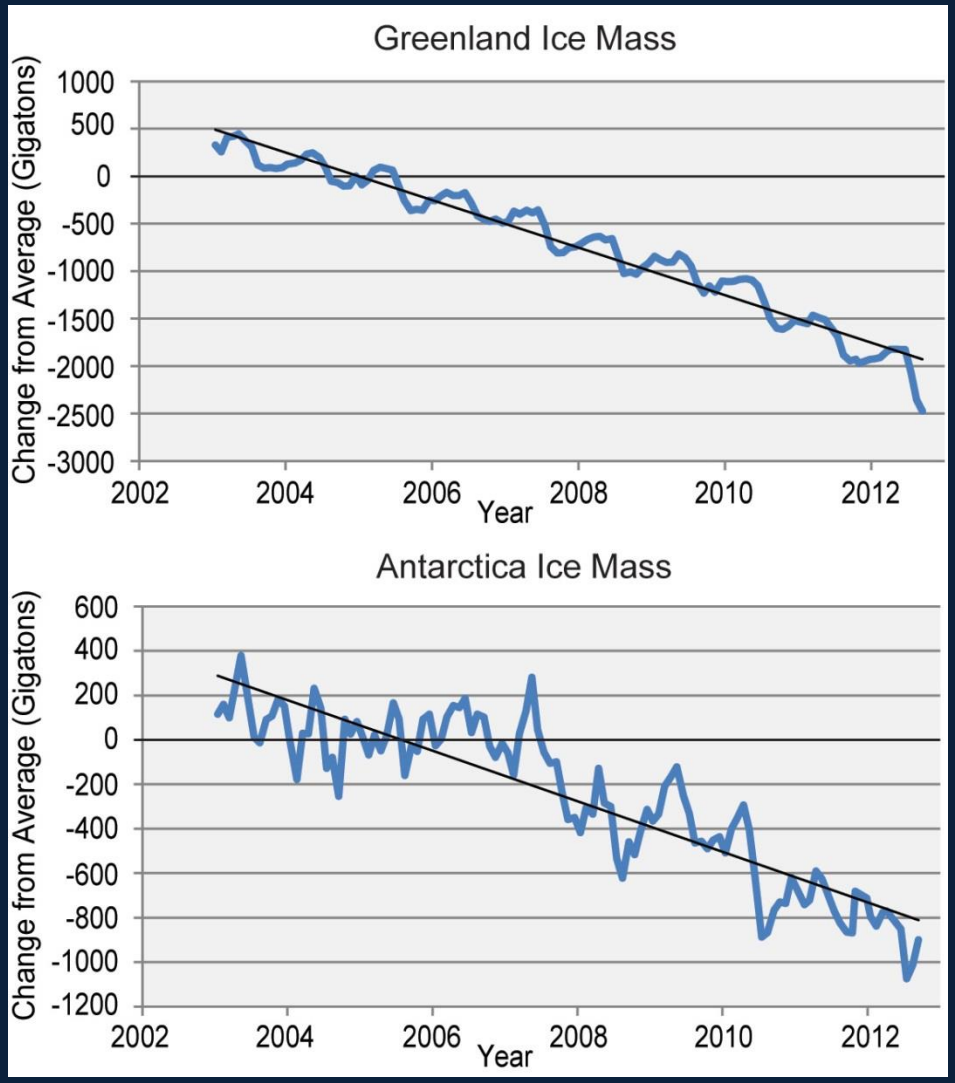
- National Academy of Sciences, agencies, public review, responses to all comments

Ice Loss from the Two Polar Ice Sheets

The 2000 Assessment

unknown

The 2014 Assessment



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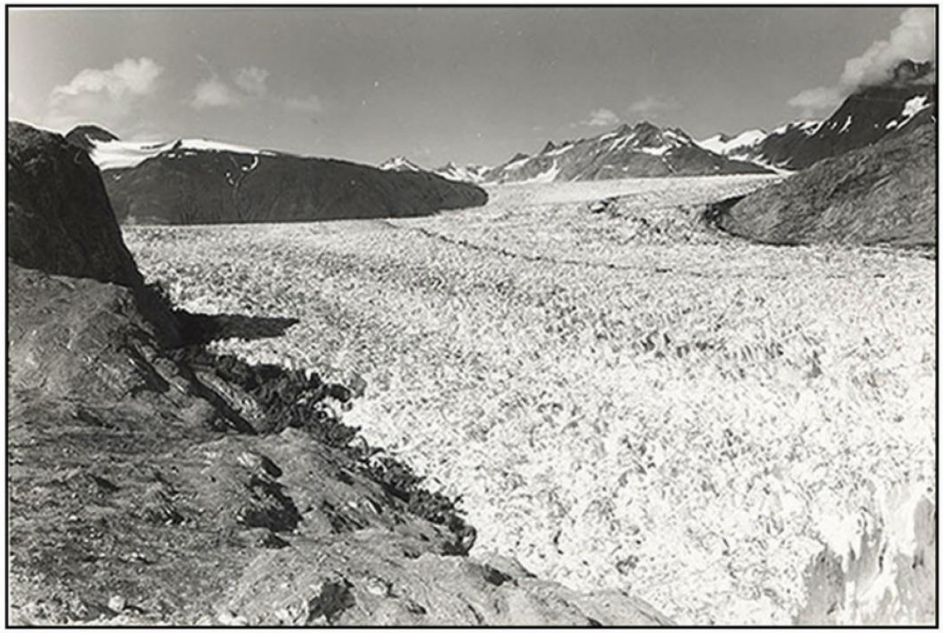
Muir Glacier Decline



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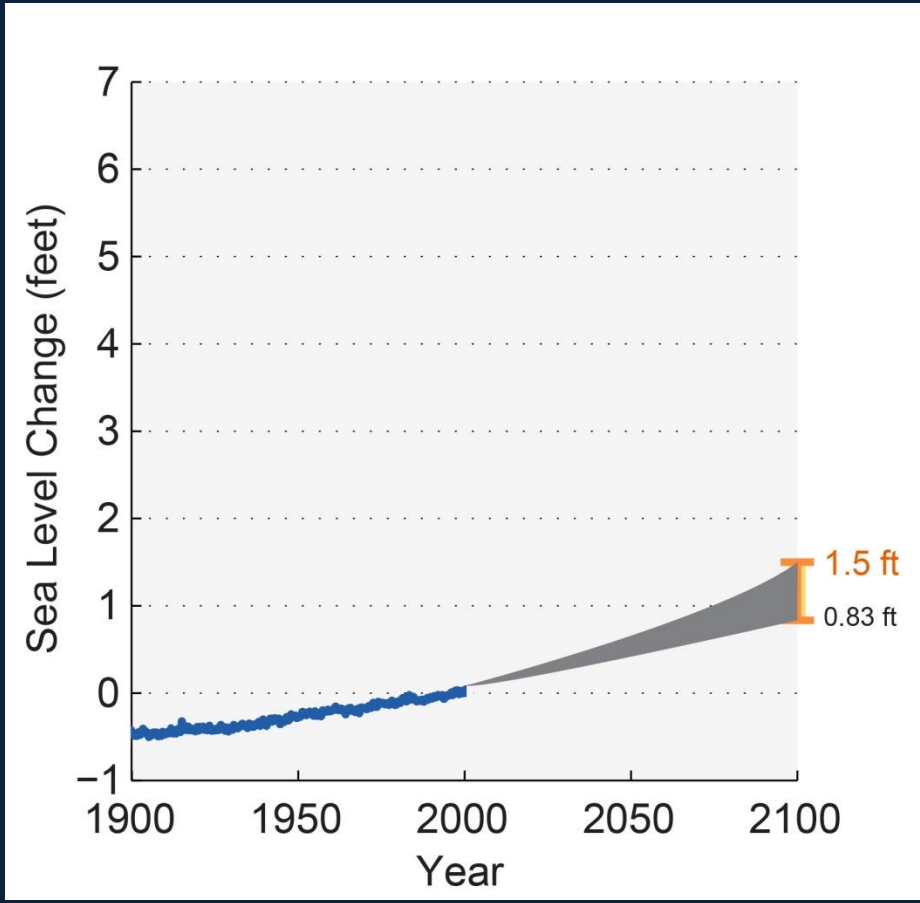
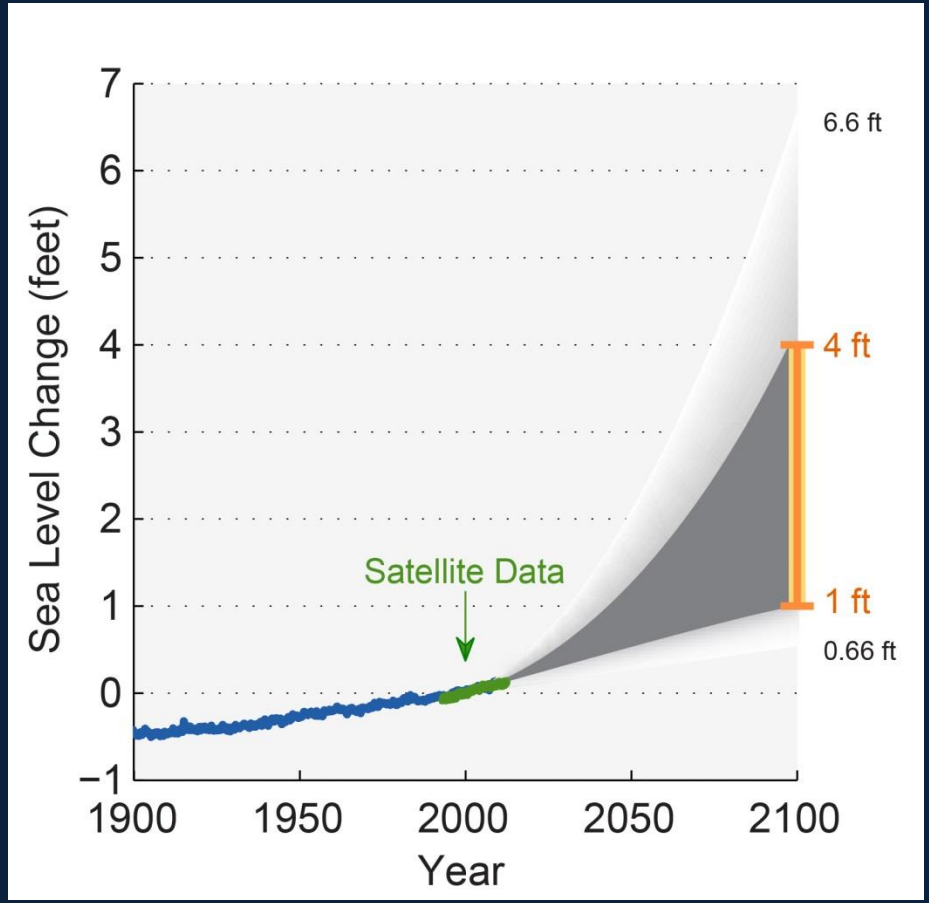
Observed and Projected

Global Sea Level Rise

The 2000 Assessment



The 2014 Assessment



Goals of the NCA

- A **sustained process** for informing an **integrated research program**
- A scientific foundation for decision support, including **scenarios and other tools at multiple scales**
- **Evaluation** of the implications of alternative **adaptation and mitigation options**
- **Community building** within regions and sectors that can lead to enhanced resilience

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Outcomes of the NCA

- **Ongoing, relevant, highly credible analysis** of scientific understanding of climate change impacts, risk, and vulnerability
- Enhanced timely **access to Assessment-related data** from multiple sources useful for decision making
- **National indicators** of change and the capacity to respond
- **Risk framing**

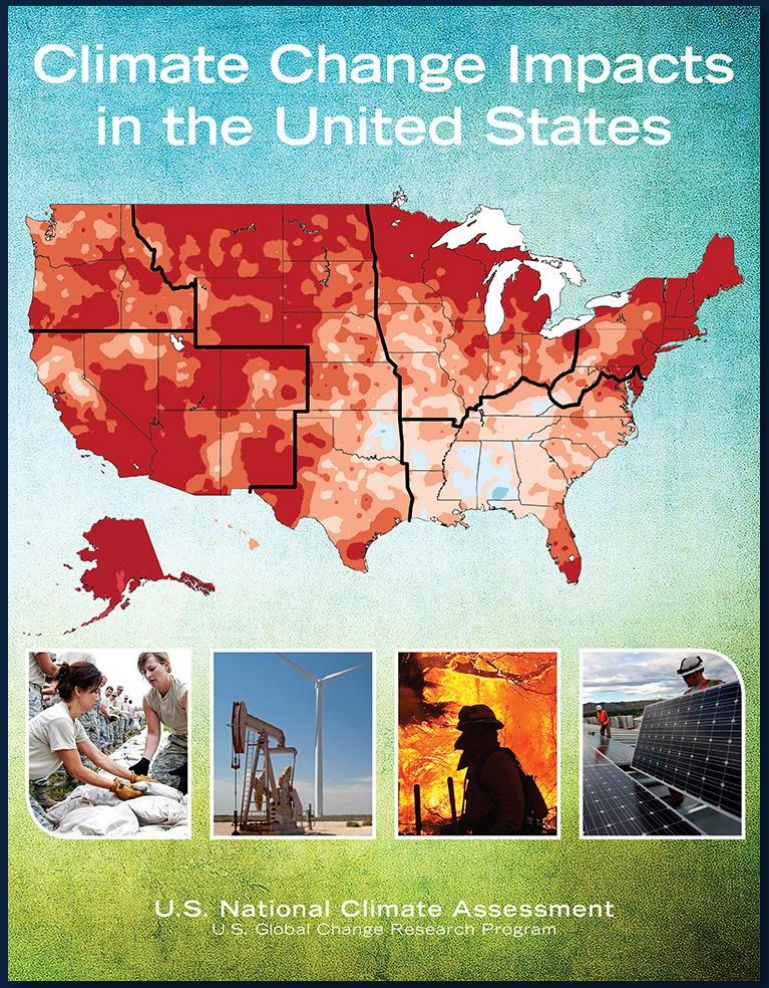
Where does the data come from?

- **Observations**: a description of historical climate trends
  - Temperature and precipitation
  - Examples include: Cooperative Observer Network (COOP), Global Historical Climatology Network (GHCN)

- **Climate projections**: simulated future climate conditions based on different emissions scenarios
  - Metrics such as number of hot days, number of warm nights, number of heavy precipitation days
  - Examples include: Coupled Model Intercomparison Project (CMIP3/CMIP5)

Outline for Third NCA Report

- Climate Change and the American People
- Overview and Report Findings
- Our Changing Climate
- Sectors & Sectoral Cross-
- cuts
- Regions & Biogeographical Cross-cuts
- Responses
- Appendices



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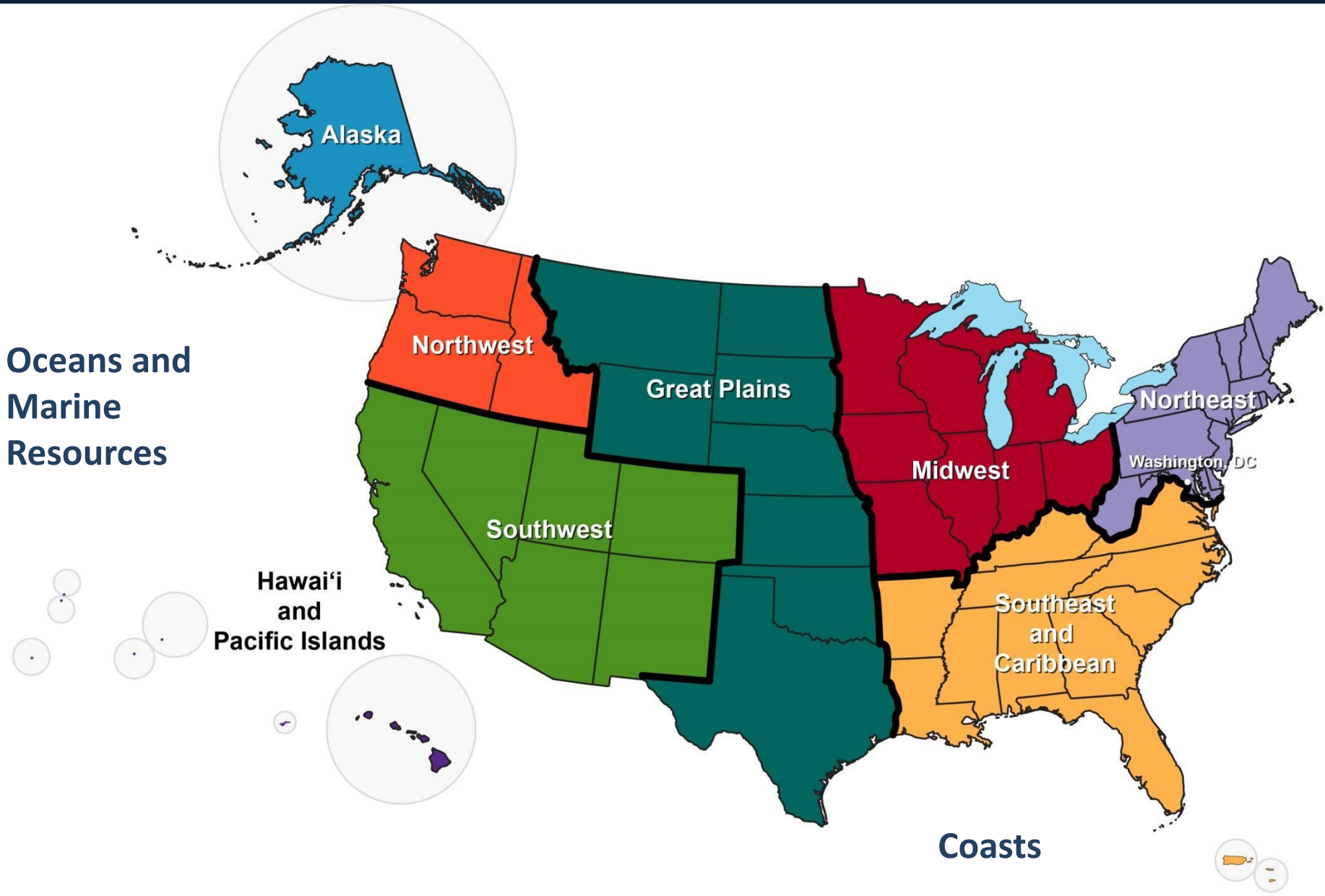
Sectors

- Water Resources
- Energy Supply and Use
- Transportation
- Agriculture
- Forests
- Ecosystems and Biodiversity
- Human Health

Sectoral Cross-Cuts

- Water, Energy, and Land Use
- Urban Systems, Infrastructure, and Vulnerability
- Impacts of Climate Change on Tribal, Indigenous, and Native Lands and Resources
- Land Use and Land Cover Change
- Rural Communities, Agriculture, and Development
- Biogeochemical Cycles

Regions & Biogeographical Cross-Cuts



Responses

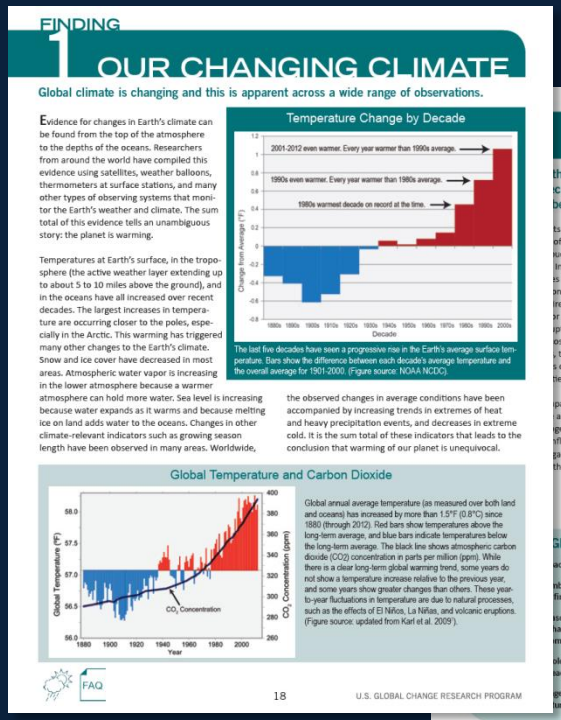
- Decision Support
- Mitigation
- Adaptation
- Research Needs
- Sustained Assessment

Appendices

- Process
- Information Quality
- Climate Science Supplement
- Frequently Asked Questions
- Scenarios and Models
- Future Assessment Topics

Climate change, once considered an issue for a distant future, has moved firmly into the present

A Sampling of results from the NCA3 Report


FINDING 1

OUR CHANGING CLIMATE

Global climate is changing and this is apparent across a wide range of observations.

Evidence for changes in Earth's climate can be found from the top of the atmosphere to the depths of the oceans. Researchers from around the world have compiled this evidence using satellites, weather balloons, thermometers at surface stations, and many other types of observing systems that monitor the Earth's weather and climate. The sum total of this evidence tells an unambiguous story: the planet is warming.

Temperatures at Earth's surface, in the troposphere (the active weather layer extending up to about 5 to 10 miles above the ground), and in the oceans have all increased over recent decades. The largest increases in temperature are occurring closer to the poles, especially in the Arctic. This warming has triggered many other changes to the Earth's climate. Snow and ice cover have decreased in most areas. Atmospheric water vapor is increasing in the lower atmosphere because a warmer atmosphere can hold more water. Sea level is increasing because water expands as it warms and because melting ice on land adds water to the oceans. Changes in other climate-relevant indicators such as growing season length have been observed in many areas. Worldwide, the observed changes in average conditions have been accompanied by increasing trends in extremes of heat and heavy precipitation events, and decreases in extreme cold. It is the sum total of these indicators that leads to the conclusion that warming of our planet is unequivocal.

Temperature Change by Decade

2001-2012 even warmer. Every year warmer than 1990s average.

1990s even warmer. Every year warmer than 1980s average.

1980s warmest decade on record at the time.

Change from Average (°F)

Decade

The last five decades have seen a progressive rise in the Earth's average surface temperature. Bars show the difference between each decade's average temperature and the overall average for 1901-2000. (Figure source: NOAA NCDC).

Global Temperature and Carbon Dioxide

Global Temperature (°F)

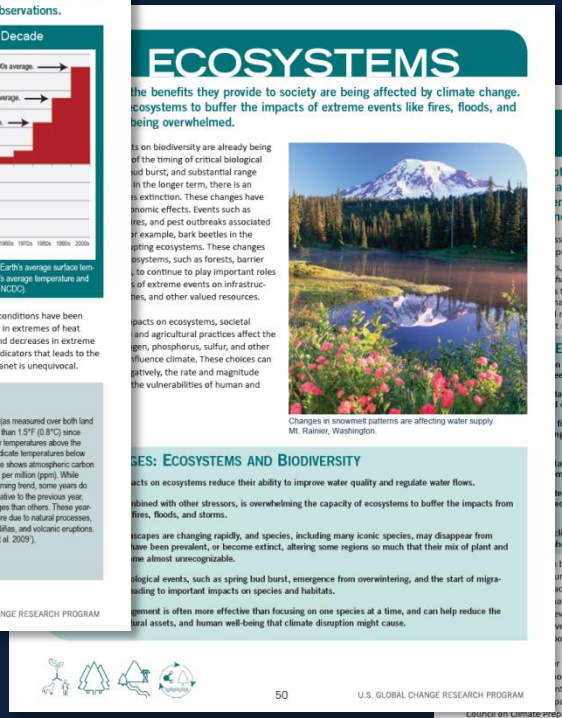
CO_2 Concentration (ppm)

CO_2 Concentration

Year

Global annual average temperature (as measured over both land and oceans) has increased by more than 1.5°F (0.8°C) since 1880 (through 2012). Red bars show temperatures above the long-term average, and blue bars indicate temperatures below the long-term average. The black line shows atmospheric carbon dioxide (CO_2) concentration in parts per million (ppm). While there is a clear long-term global warming trend, some years do not show a temperature increase relative to the previous year, and some years show greater changes than others. These year-to-year fluctuations in temperature are due to natural processes, such as the effects of El Niños, La Niñas, and volcanic eruptions. (Figure source: updated from Karl et al. 2009).

FAQ


ECOSYSTEMS

…the benefits they provide to society are being affected by climate change. …cosystems to buffer the impacts of extreme events like fires, floods, and …being overwhelmed.

…ts on biodiversity are already being …of the timing of critical biological …ud burst, and substantial range …in the longer term, there is an …s extinction. These changes have …onomic effects. Events such as …res, and pest outbreaks associated …r example, bark beetles in the …upting ecosystems. These changes …osystems, such as forests, barrier …, to continue to play important roles …s of extreme events on infrastruc…ties, and other valued resources.

…pacts on ecosystems, societal …and agricultural practices affect the …gen, phosphorus, sulfur, and other …fluence climate. These choices can …gatively, the rate and magnitude …the vulnerabilities of human and

Changes in snowmelt patterns are affecting water supply. Mt. Rainier, Washington.

…GES: ECOSYSTEMS AND BIODIVERSITY

…acts on ecosystems reduce their ability to improve water quality and regulate water flows.

…mbined with other stressors, is overwhelming the capacity of ecosystems to buffer the impacts from …fires, floods, and storms.

…scapes are changing rapidly, and species, including many iconic species, may disappear from …have been prevalent, or become extinct, altering some regions so much that their mix of plant and …me almost unrecognizable.

…ological events, such as spring bud burst, emergence from overwintering, and the start of migra…ading to important impacts on species and habitats.

…gement is often more effective than focusing on one species at a time, and can help reduce the …ural assets, and human well-being that climate disruption might cause.


RESPONSES

…otation (to address and prepare for impacts) and mitigation (to reduce …ange, for example by cutting emissions) is becoming more widespread, …mentation efforts are insufficient to avoid increasingly negative social, …nd economic consequences.

…ssions, increase carbon uptake, adapt to a changing climate, and increase resilience to impacts that …prove public health, economic development, ecosystem protection, and quality of life.

…s, the focus moved from *"Is climate changing?"* to *"Can society manage unavoidable changes and …hanges?"*[1,2] Research demonstrates that both mitigation (efforts to reduce future climate changes) …s to reduce the vulnerability of society to climate change impacts) are needed in order to minimize …han-caused climate change and to adapt to the pace and ultimate magnitude of changes that will …l mitigation are closely linked; adaptation efforts will be more difficult, more costly, and less likely …t mitigation actions are not taken.[1,4]

…ES: ADAPTATION

…n planning is occurring in the public and private sectors and at all levels of government; however, …een implemented and those that have appear to be incremental changes.

…tation of adaptation include limited funding, policy and legal impediments, and difficulty in antici… …f changes at local scales.

…fits all' adaptation, but there are similarities in approaches across regions and sectors. Sharing …ng by doing, and iterative and collaborative processes including stakeholder involvement, can help

…tation actions often fulfill other societal goals, such as sustainable development, disaster risk …ments in quality of life, and can therefore be incorporated into existing decision-making processes.

…te change is exacerbated by other stresses such as pollution and habitat fragmentation. Adaptation …equires assessment of the composite threats as well as tradeoffs amongst costs, benefits, and risks

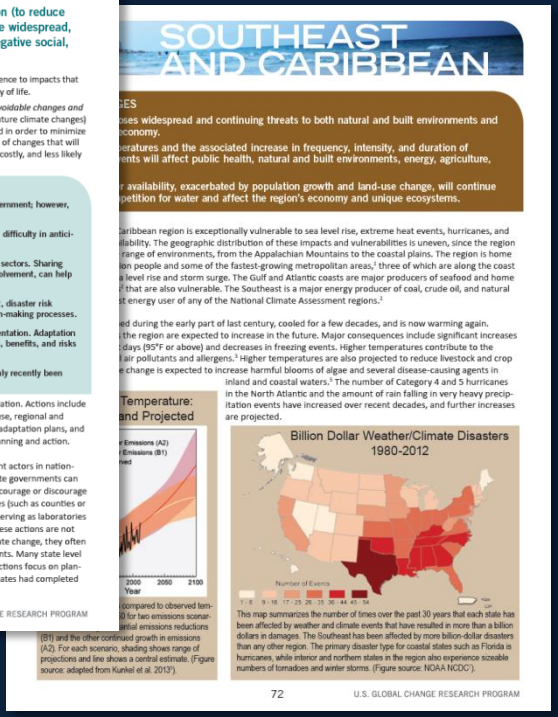
…limate change adaptation has seldom been evaluated, because actions have only recently been …hensive evaluation metrics do not yet exist.

…be implemented reactively, after …ur, or proactively, to prepare for a …ctively preparing can reduce the …ate change impacts, such as increas…events, shifting zones for agricultural …vels, while also facilitating a more …onse to changes as they happen.

…r 2013 Executive Order calls for, …odernizing federal programs to …nt investments, managing lands and …paredness and resilience, creating a Council on Climate Preparedness and Resilience, and the creation of a State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience.[6] Federal agencies are all required to plan for adaptation. Actions include coordinated efforts at the White House, regional and cross-sector efforts, agency-specific adaptation plans, and support for local-level adaptation planning and action.

STATE: States have become important actors in national climate change related efforts. State governments can create policies and programs that encourage or discourage adaptation at other governance scales (such as counties or regions)[7] through regulation and by serving as laboratories for innovation.[8] Although many of these actions are not specifically designed to address climate change, they often include climate adaptation components. Many state level climate change-specific adaptation actions focus on planning. As of winter 2012, at least 15 states had completed

FAQ


SOUTHEAST AND CARIBBEAN

…SES

…oses widespread and continuing threats to both natural and built environments and …economy.

…eratures and the associated increase in frequency, intensity, and duration of …ents will affect public health, natural and built environments, energy, agriculture,

…r availability, exacerbated by population growth and land-use change, will continue …petition for water and affect the region's economy and unique ecosystems.

…aribbean region is exceptionally vulnerable to sea level rise, extreme heat events, hurricanes, and …lability. The geographic distribution of these impacts and vulnerabilities is uneven, since the region …range of environments, from the Appalachian Mountains to the coastal plains. The region is home …on people and some of the fastest-growing metropolitan areas,[1] three of which are along the coast …a level rise and storm surge. The Gulf and Atlantic coasts are major producers of seafood and home …that are also vulnerable. The Southeast is a major energy producer of coal, crude oil, and natural …st energy user of any of the National Climate Assessment regions.[2]

…ed during the early part of last century, cooled for a few decades, and is now warming again. …the region are expected to increase in the future. Major consequences include significant increases …days (95°F or above) and decreases in freezing events. Higher temperatures contribute to the …air pollutants and allergens.[3] Higher temperatures are also projected to reduce livestock and crop …e change is expected to increase harmful blooms of algae and several disease-causing agents in inland and coastal waters.[5] The number of Category 4 and 5 hurricanes in the North Atlantic and the amount of rain falling in very heavy precipitation events have increased over recent decades, and further increases are projected.

…Temperature: …nd Projected

…r Emissions (A2) …r Emissions (B1) …ved

2000 2050 2100

Year

…compared to observed tem… …0 for two emissions scenar… …ential emissions reductions (B1) and the other continued growth in emissions (A2). For each scenario, shading shows range of projections and line shows a central estimate. (Figure source: adapted from Kunkel et al. 2013).

Billion Dollar Weather/Climate Disasters 1980-2012

Number of Events

1 - 8 9 - 16 17 - 25 26 - 35 36 - 44 45 - 54

This map summarizes the number of times over the past 30 years that each state has been affected by weather and climate events that have resulted in more than a billion dollars in damages. The Southeast has been affected by more billion-dollar disasters than any other region. The primary disaster type for coastal states such as Florida is hurricanes, while interior and northern states in the region also experience sizeable numbers of tornadoes and winter storms. (Figure source: NOAA NCDC).

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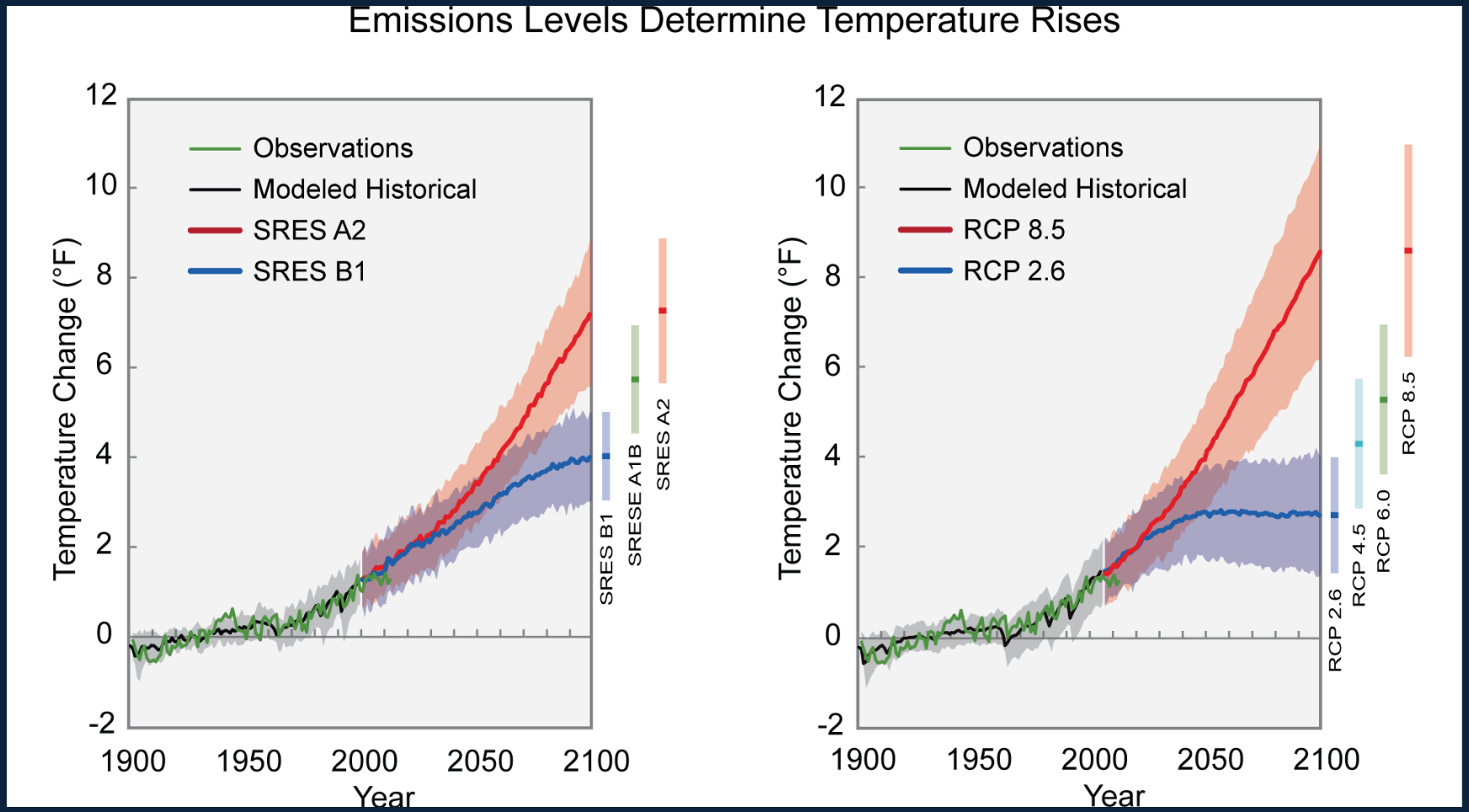
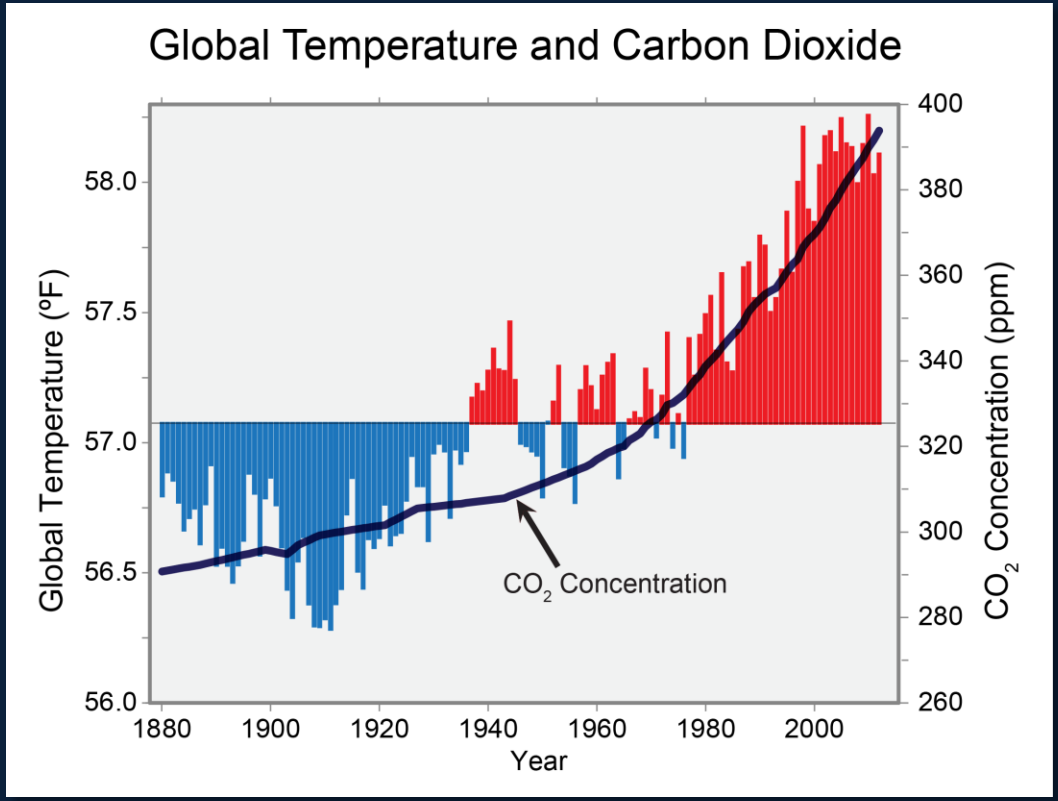
Scenarios


Emissions Levels Determine Temperature Rises
Temperature Change (°F)
Year
Observations
Modeled Historical
SRES A2
SRES B1
SRES B1
SRESE A1B
SRES A2
RCP 8.5
RCP 2.6
RCP 2.6
RCP 4.5
RCP 6.0
RCP 8.5

Report Finding 1

Global climate is changing and this is apparent across the US 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.



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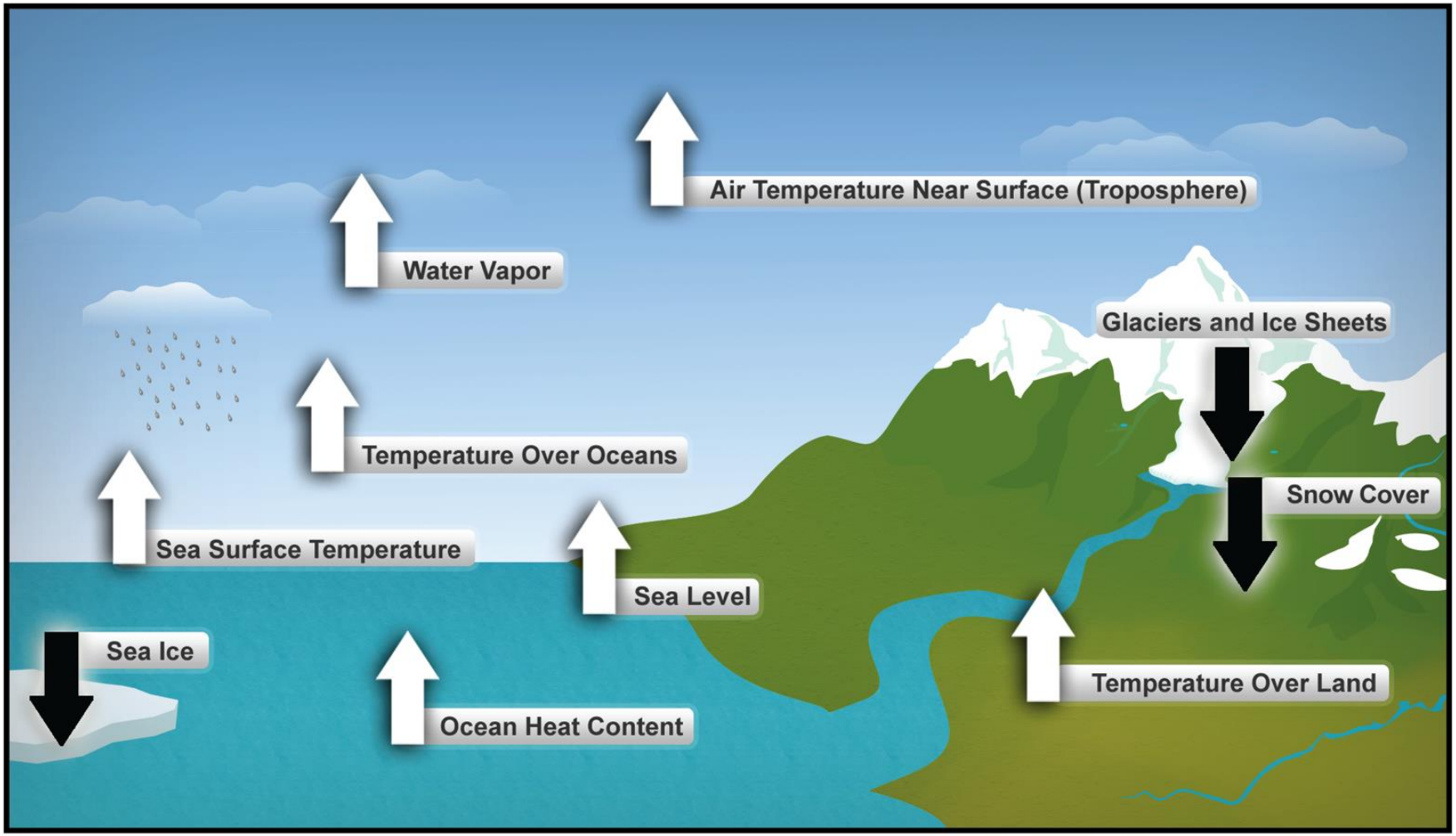
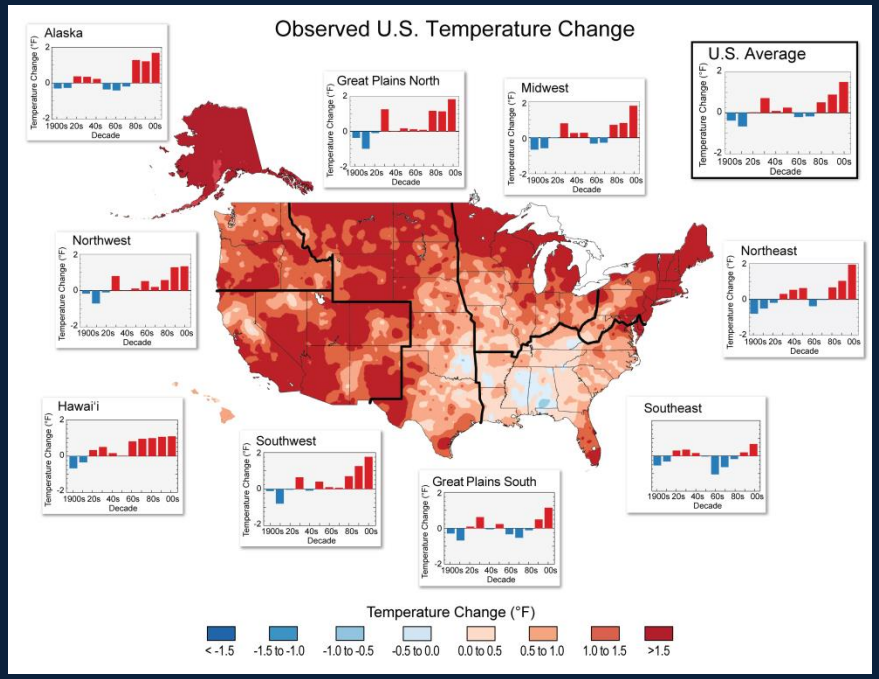
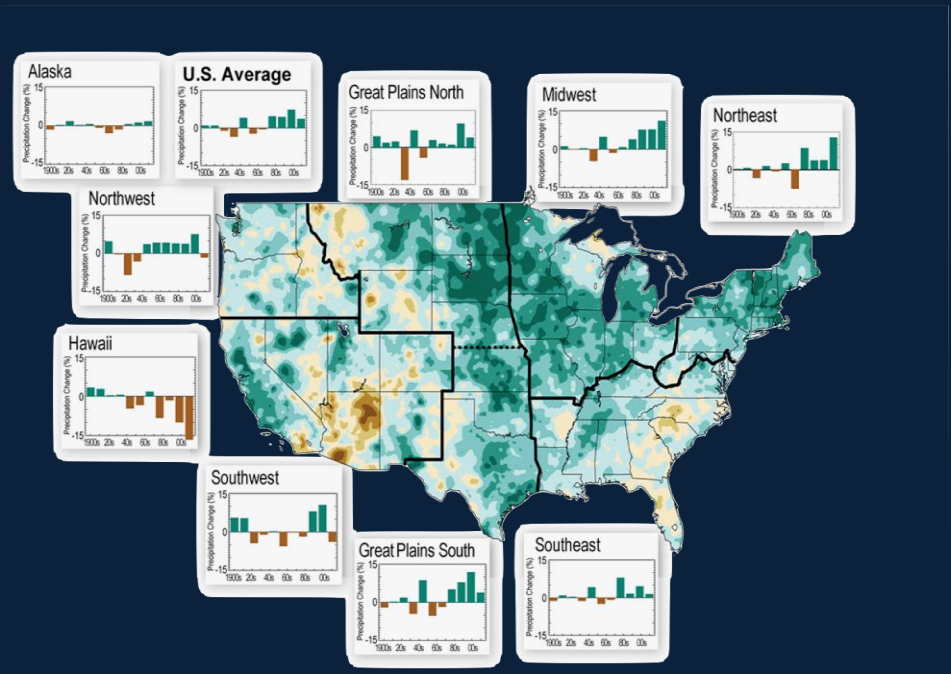
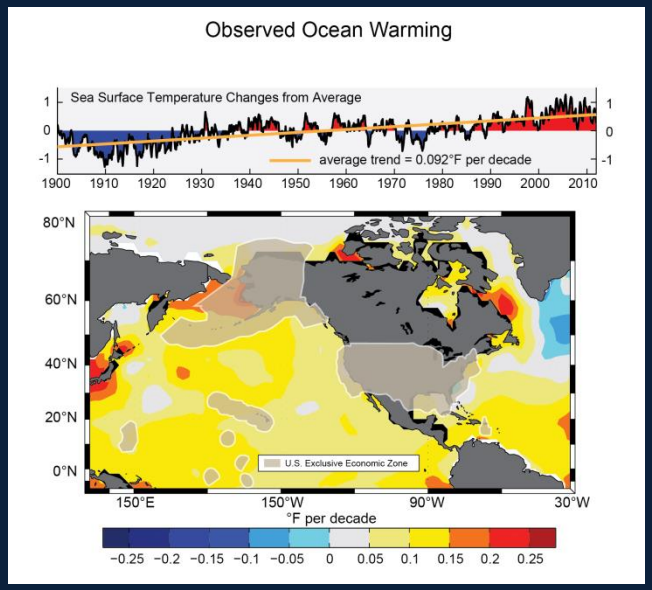
Ten Indicators of a Warming World

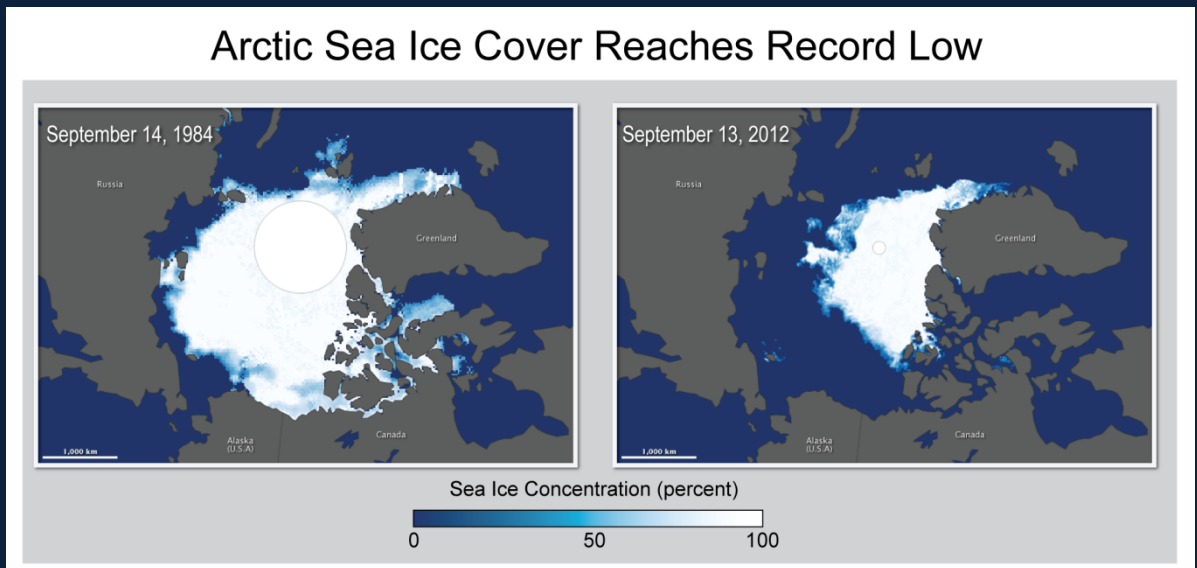


Our Changing Climate



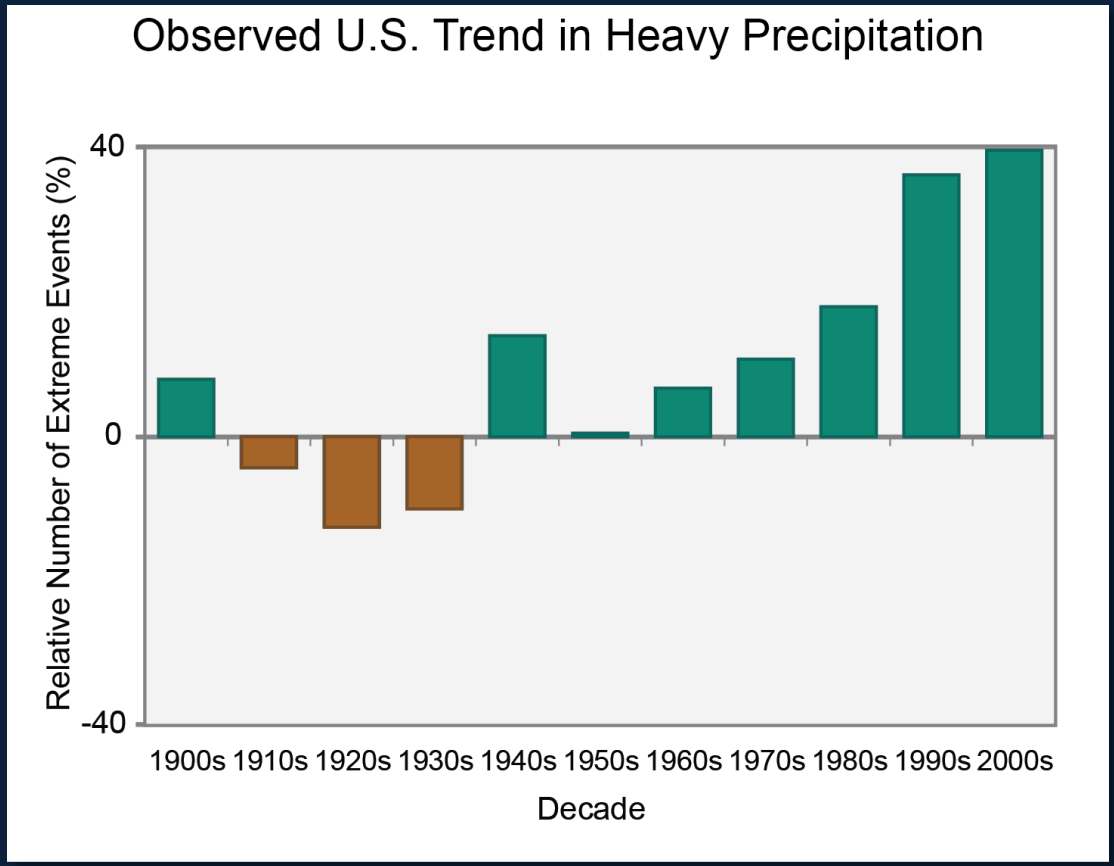




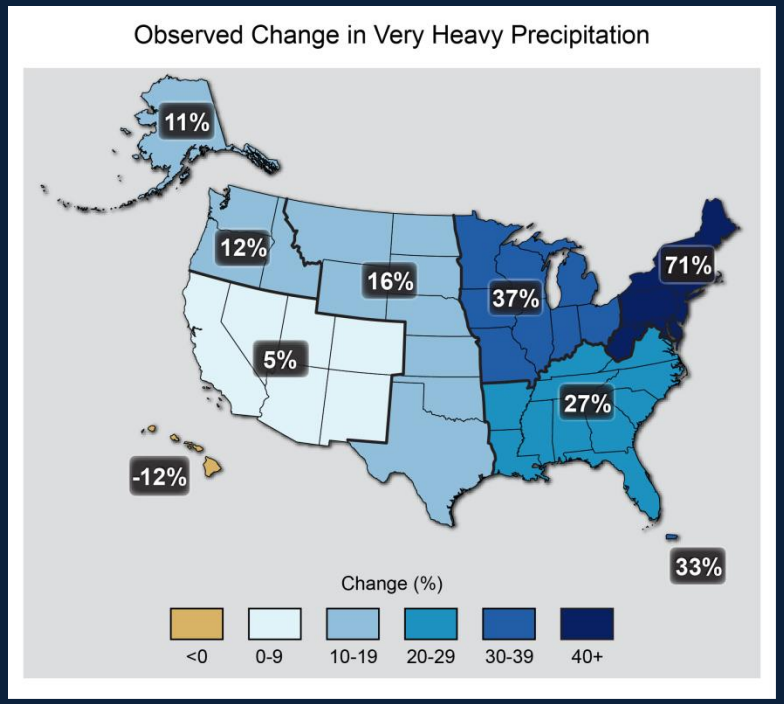


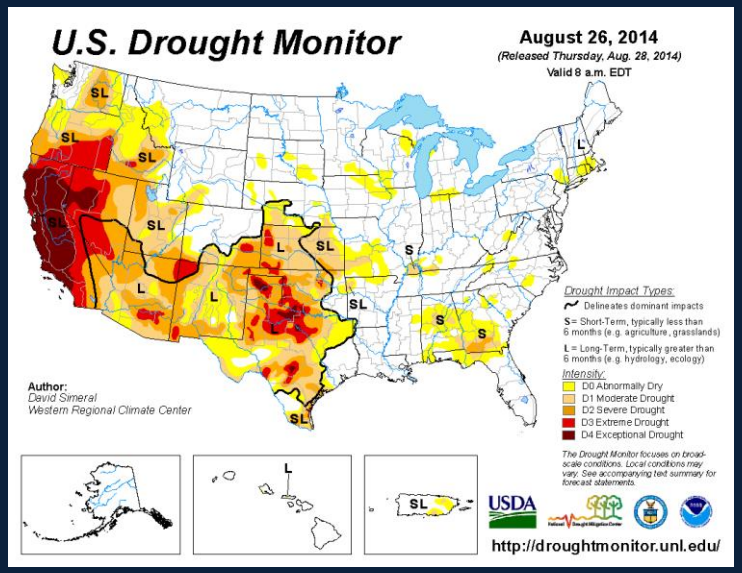
Report Finding 2

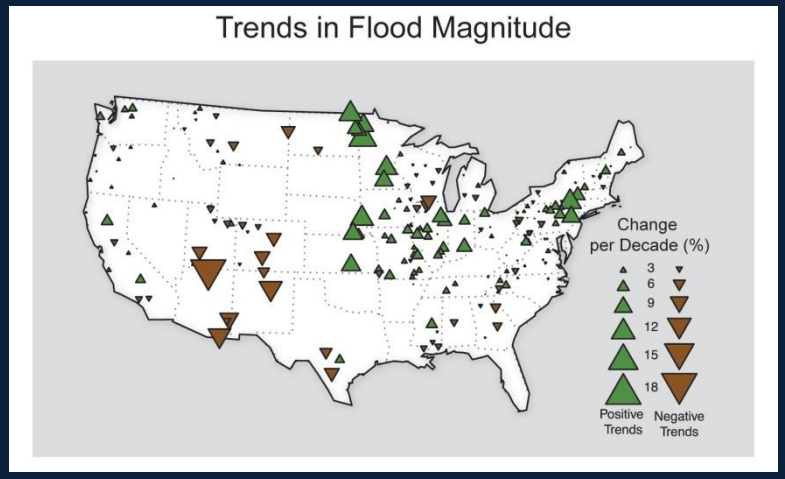
Some extreme weather and climate events have increased in recent decades, and new and stronger evidence confirms that some of these increases are related to human activities.

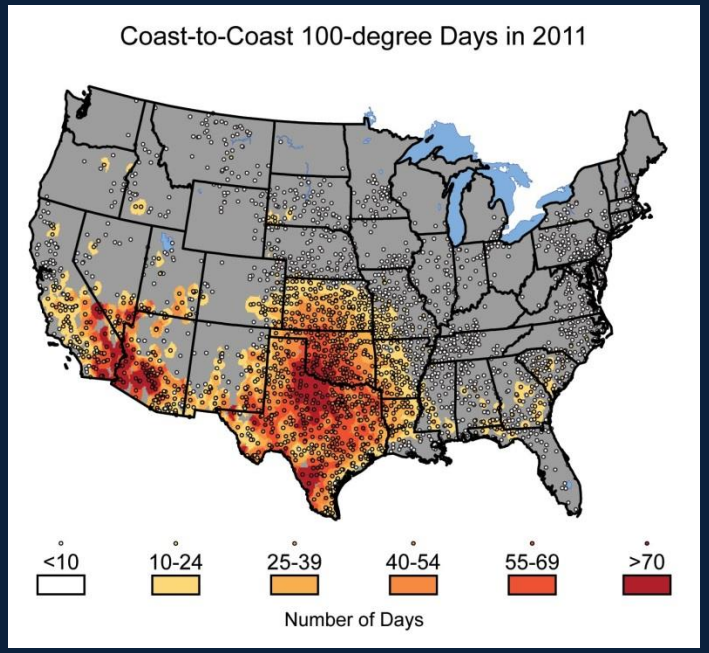


Extreme Weather



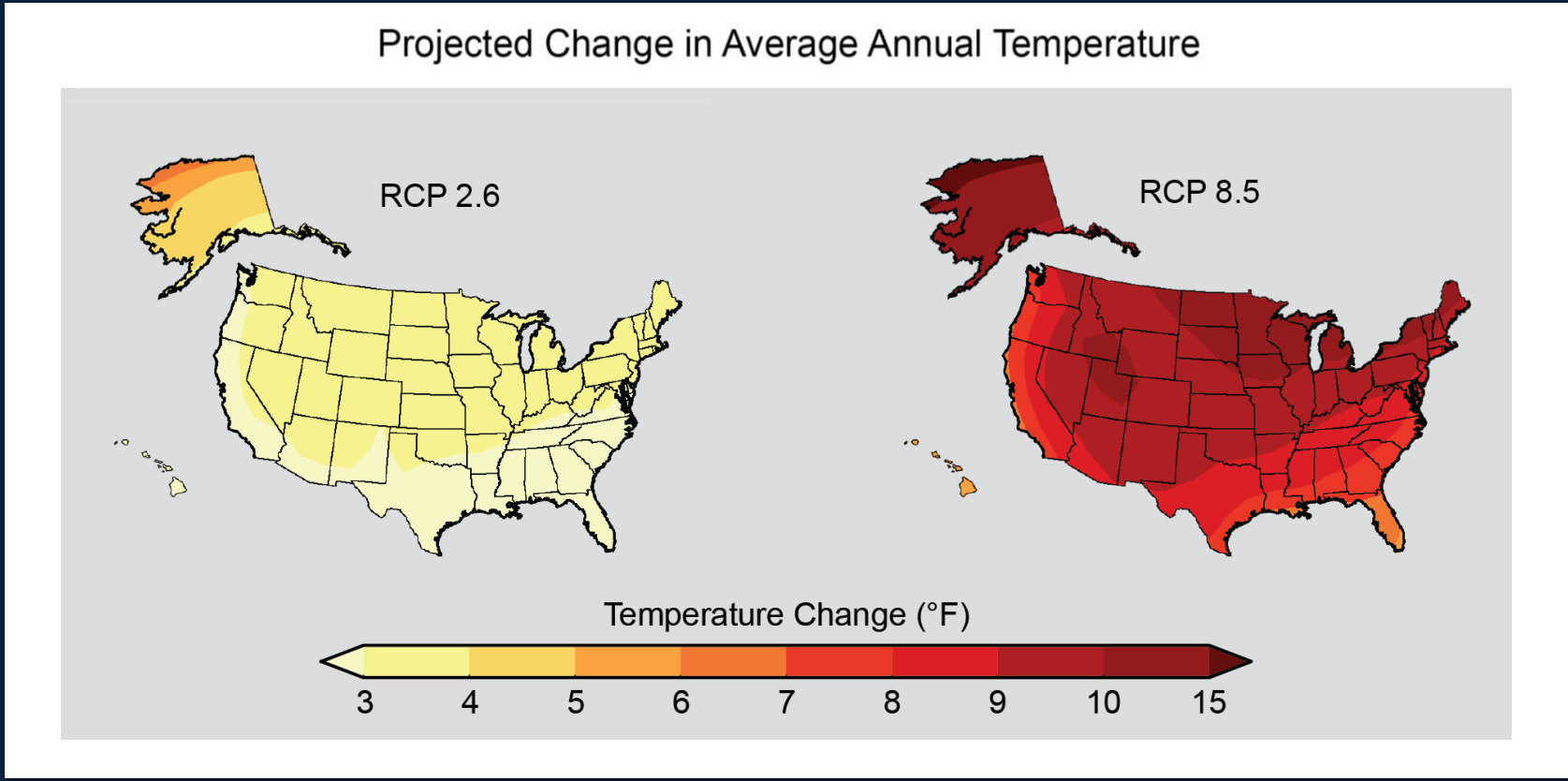




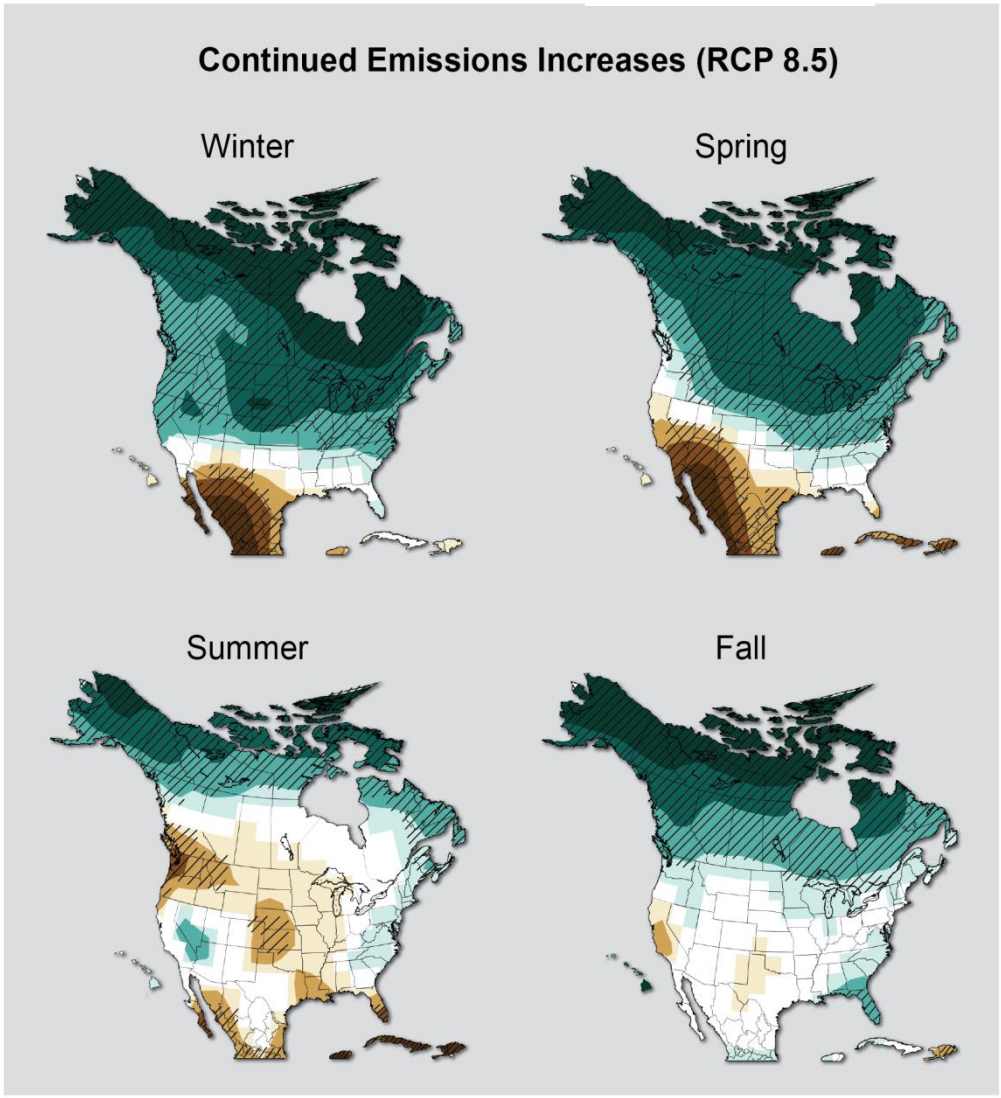


Report Finding 3

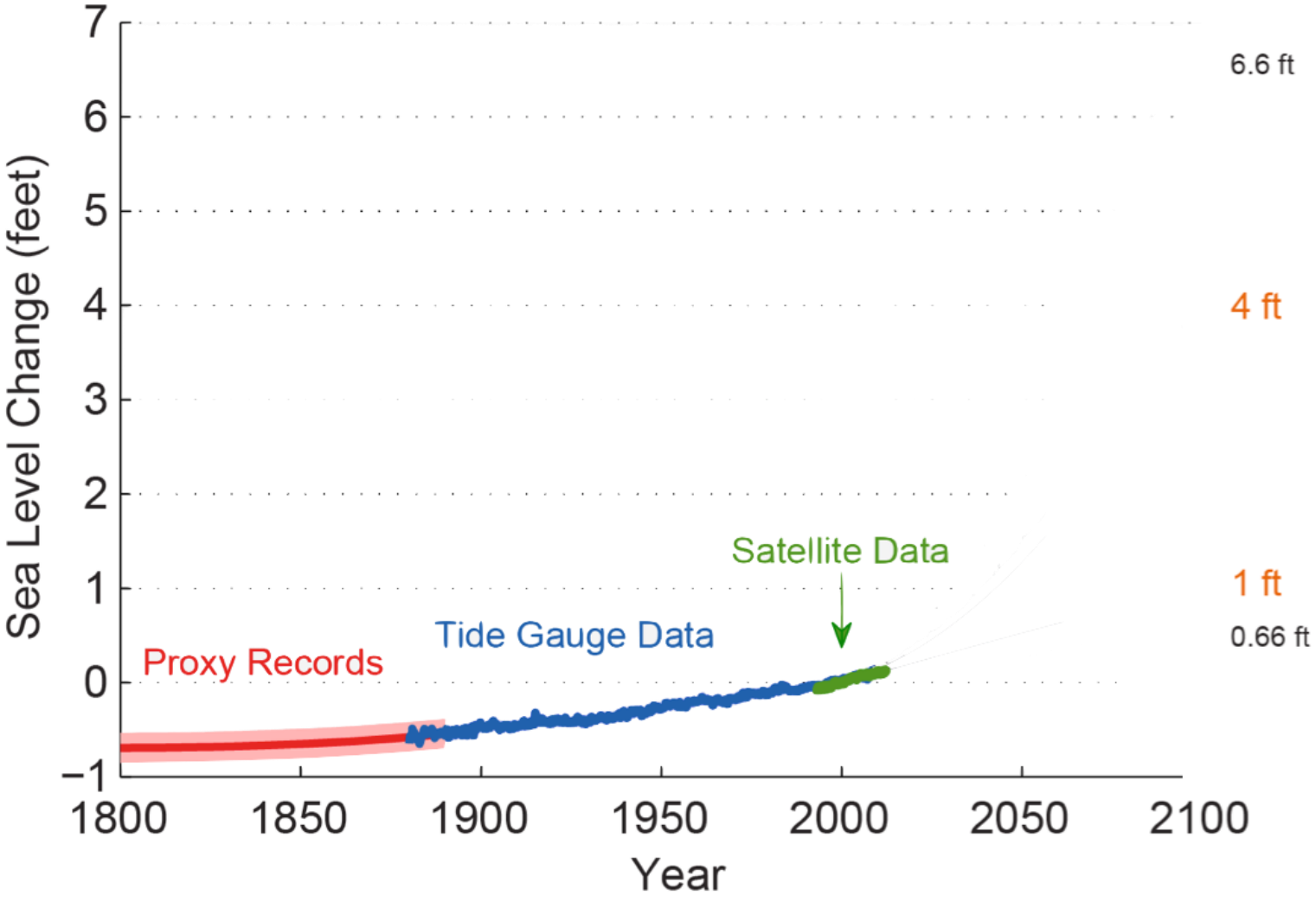
Human-induced climate change is projected to continue, and it will accelerate significantly if emissions of heat-trapping gases continue to increase.



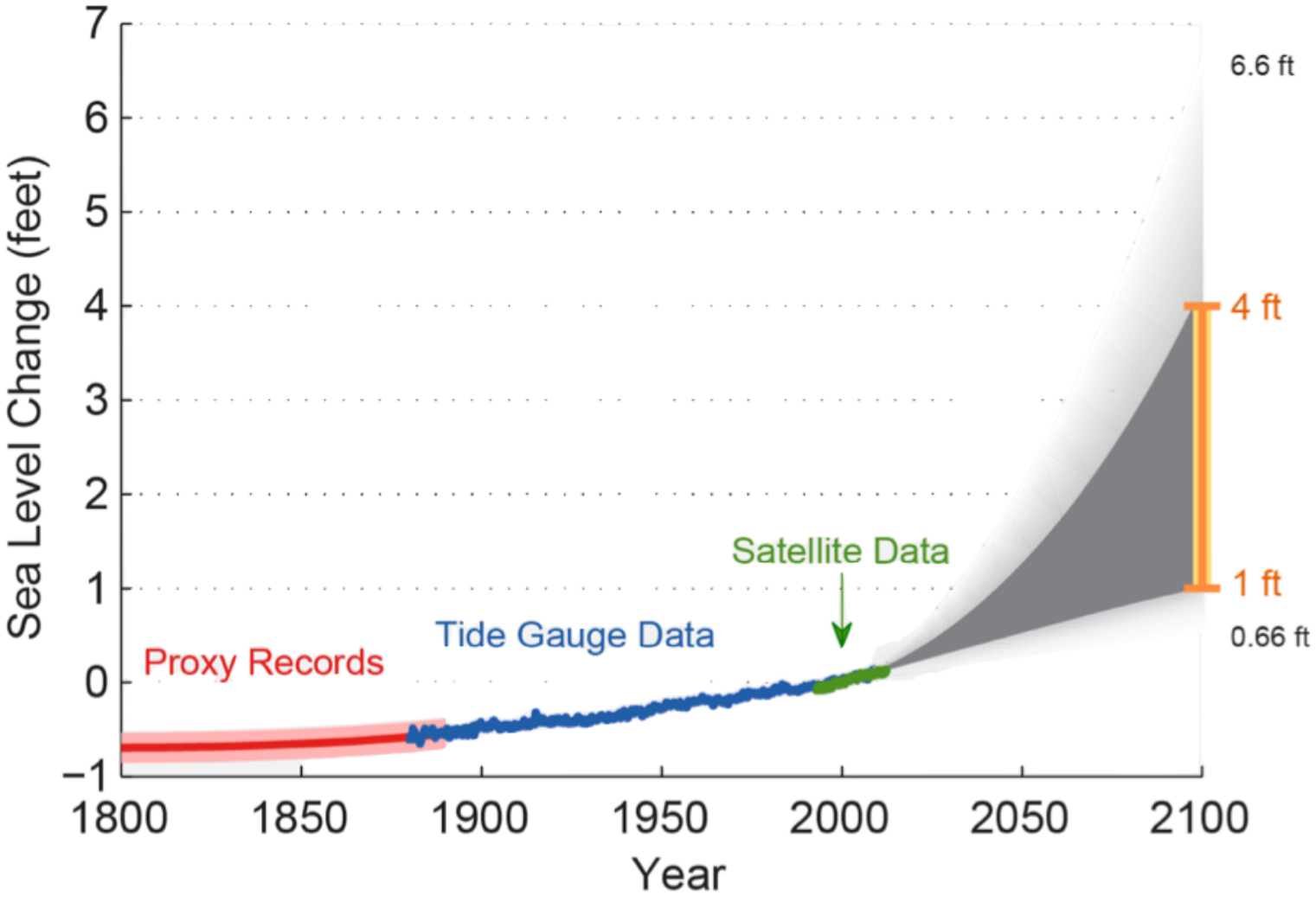
Projected Change in Precipitation

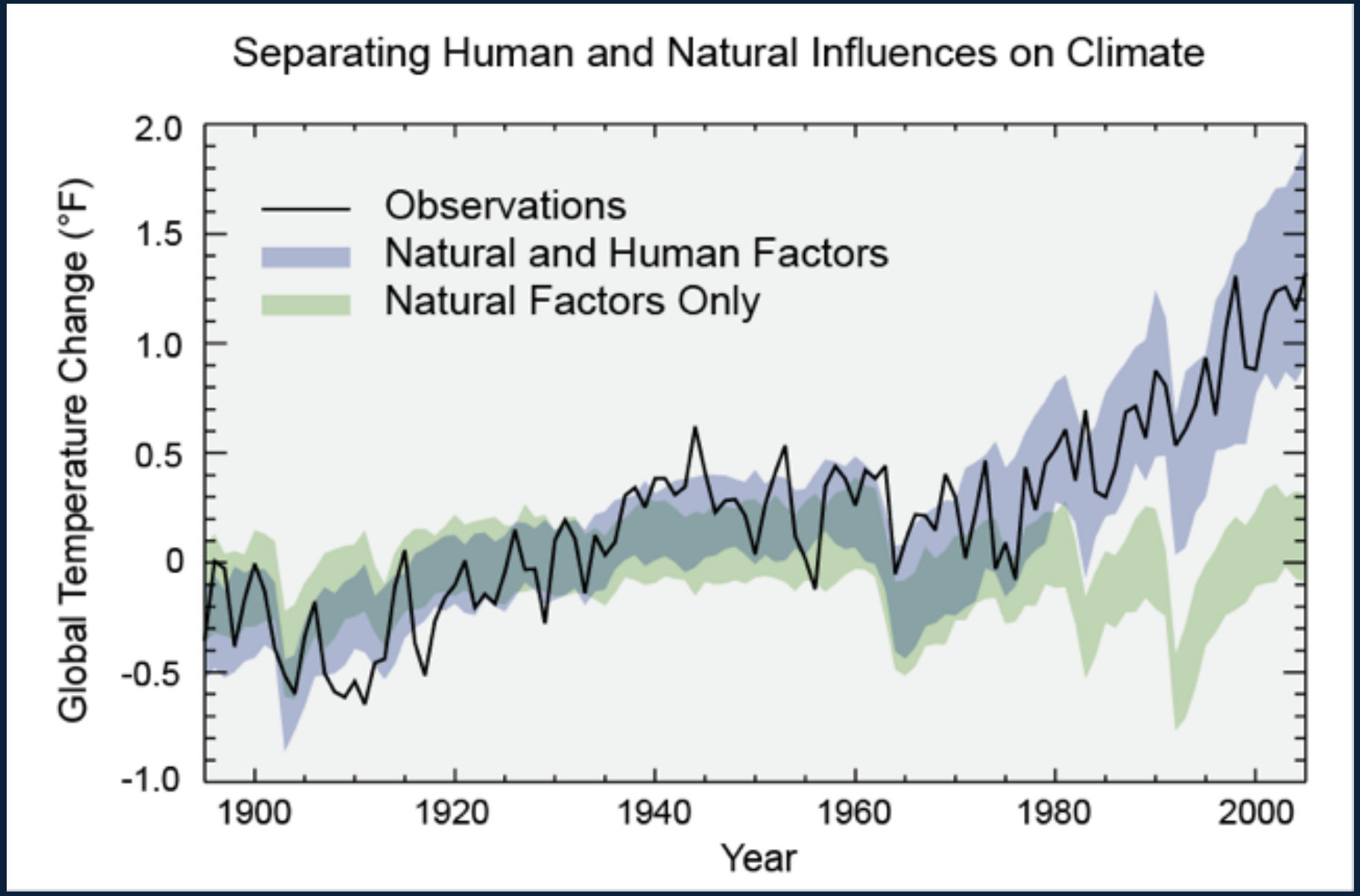


PAST CHANGES IN GLOBAL SEA LEVEL



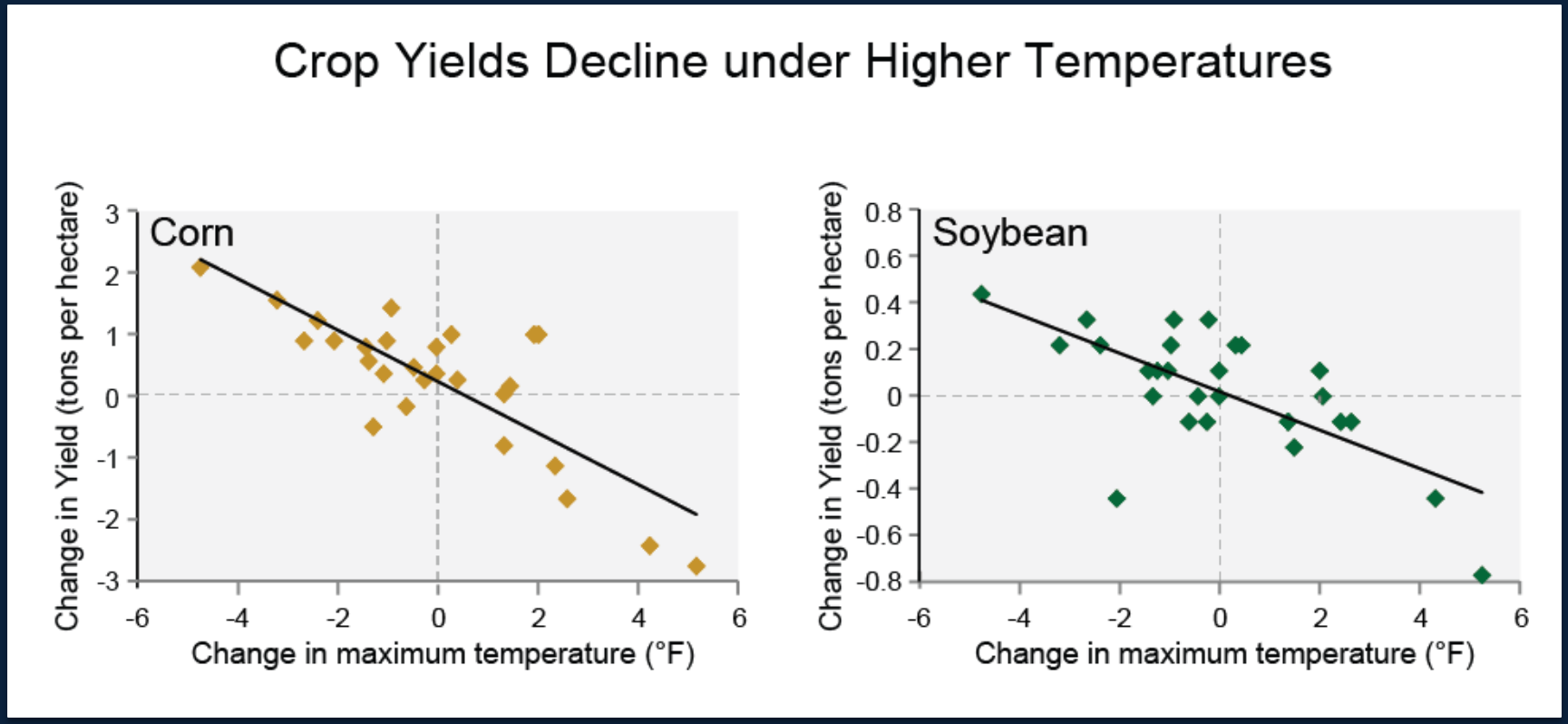
PROJECTED CHANGES IN GLOBAL SEA LEVEL



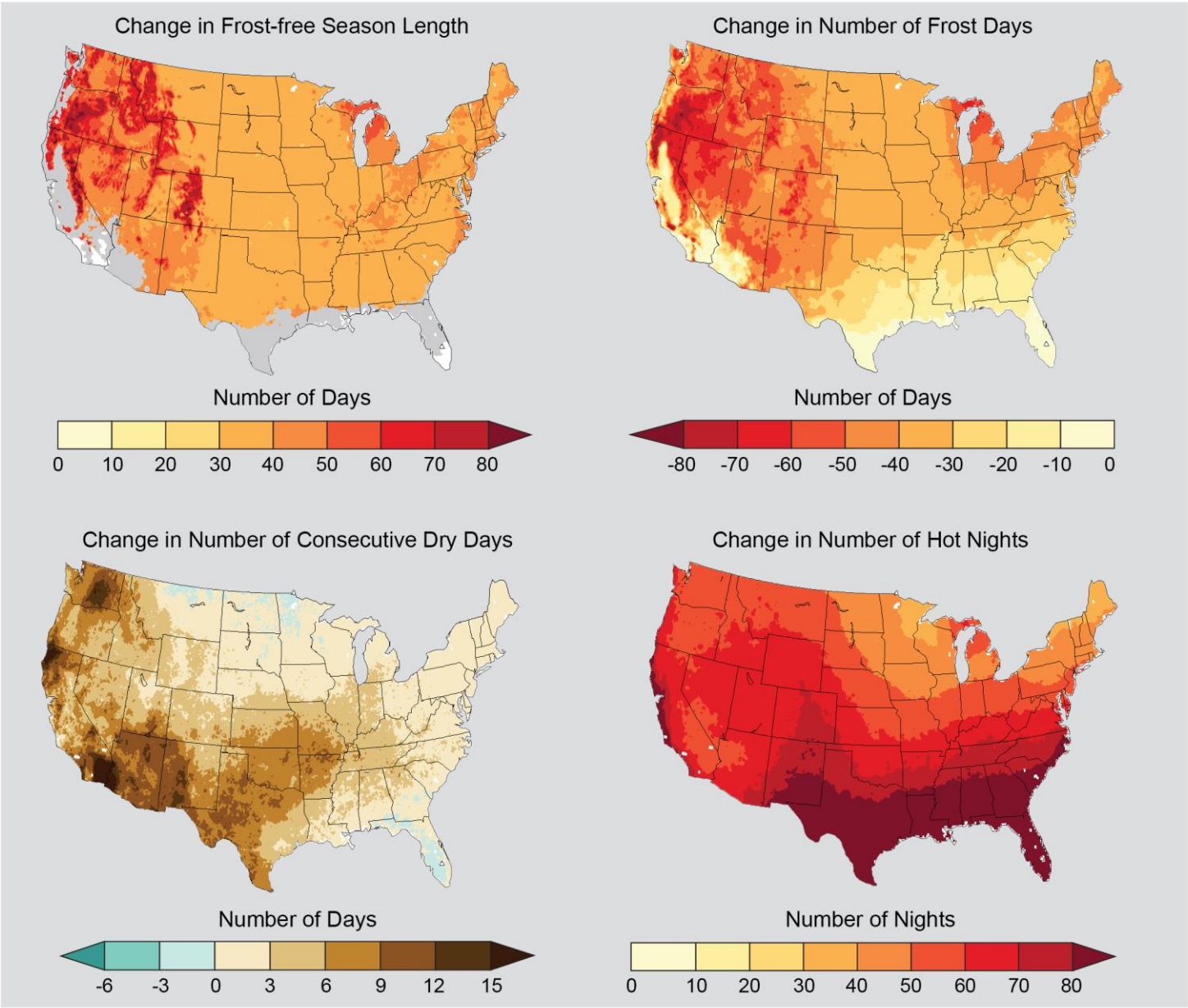

Separating Human and Natural Influences on Climate
Global Temperature Change (°F)
2.0
1.5
1.0
0.5
0
-0.5
-1.0
Observations
Natural and Human Factors
Natural Factors Only
1900
1920
1940
1960
1980
2000
Year

Report Finding 8

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

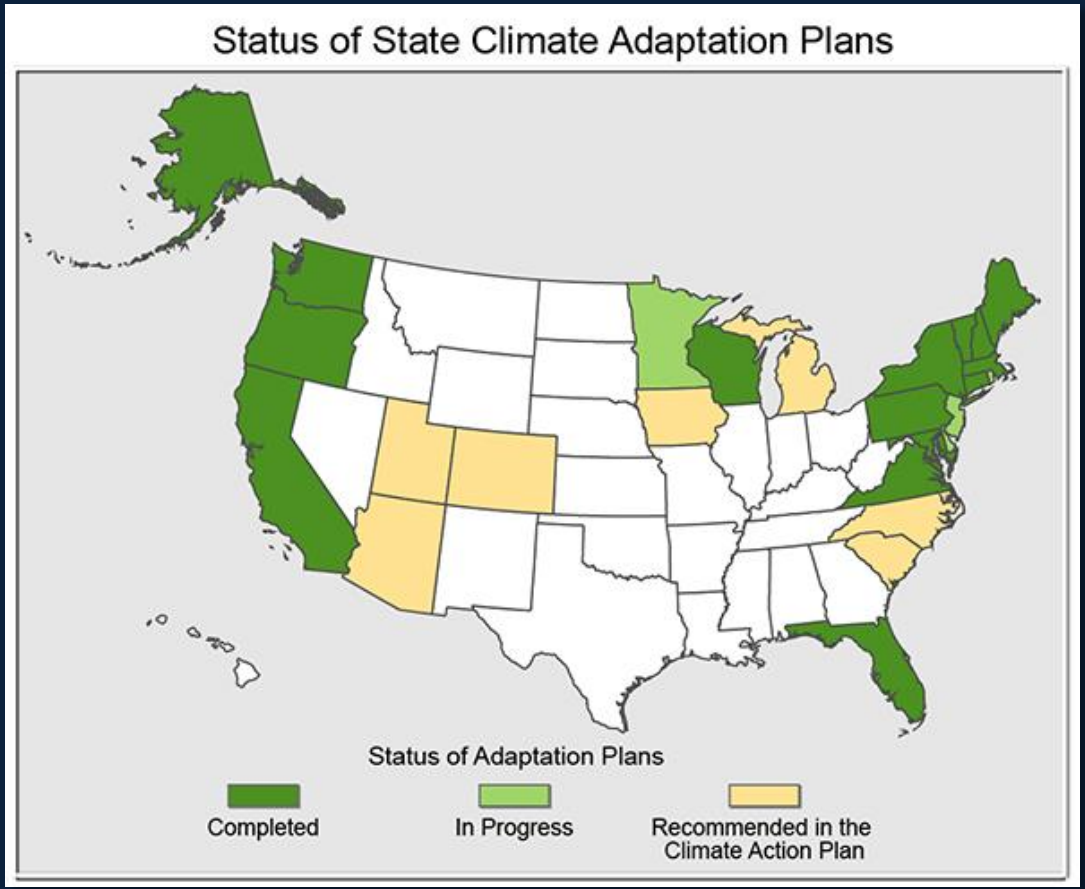


Projected Changes in Key Climate Variables Affecting Agricultural Productivity



Report Finding 12

Planning for adaptation and mitigation is becoming more widespread but current implementation efforts are insufficient to avoid increasingly negative social, environmental, and economic consequences.



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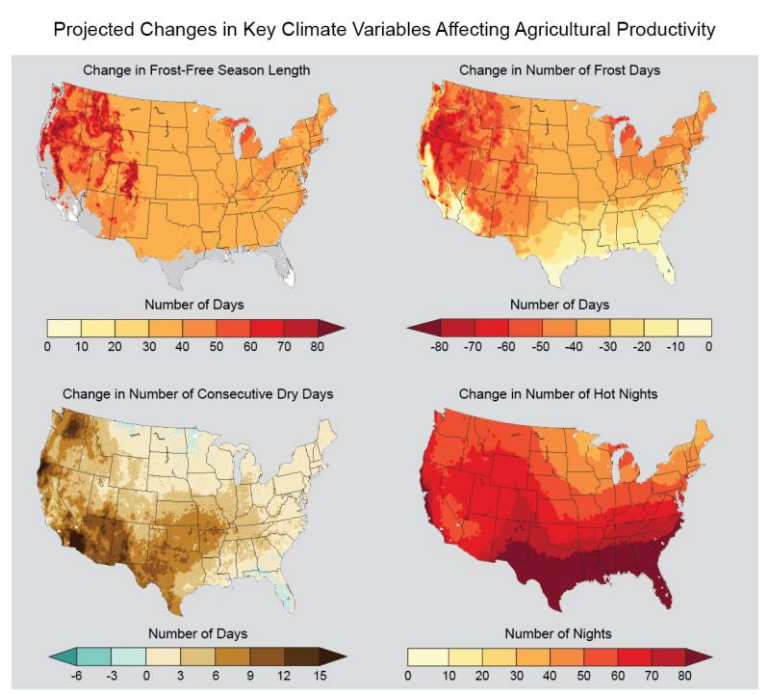
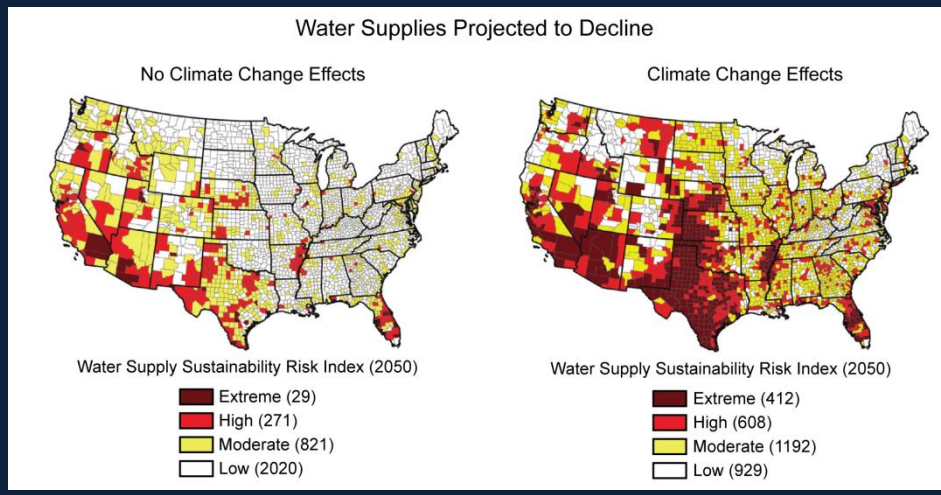
Widespread Impacts



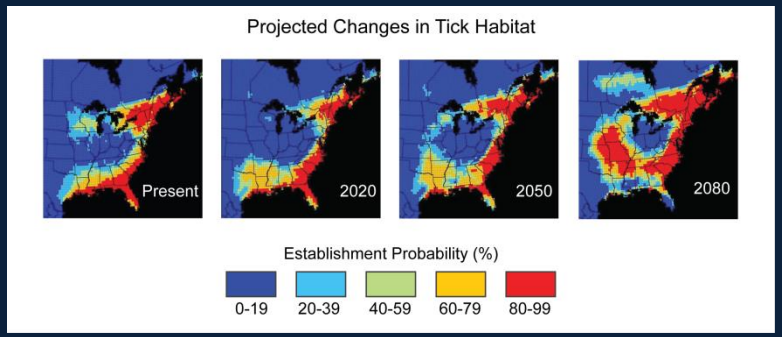
Agriculture



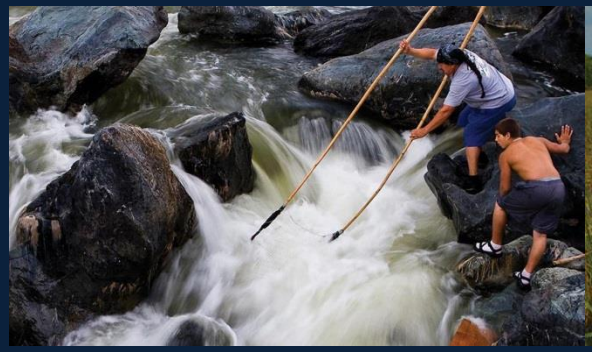
Water Supply

Infrastructure

Human Health

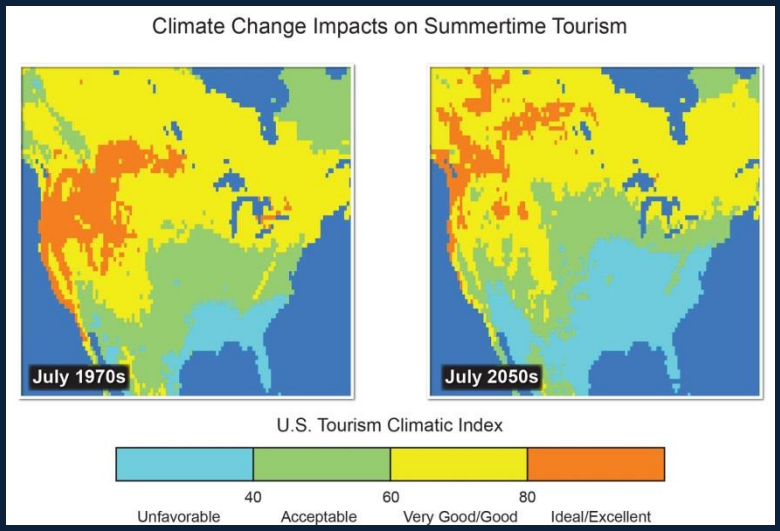


Widespread Impacts



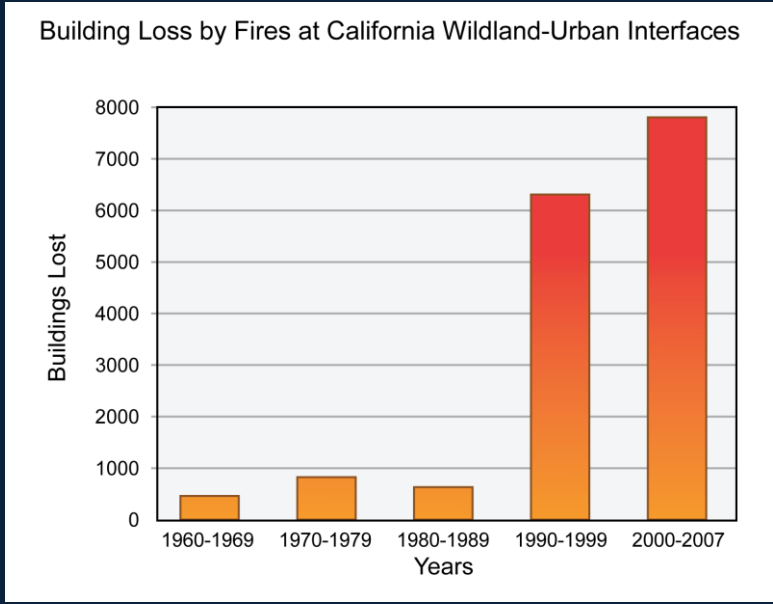
Indigenous Peoples

Urban Areas

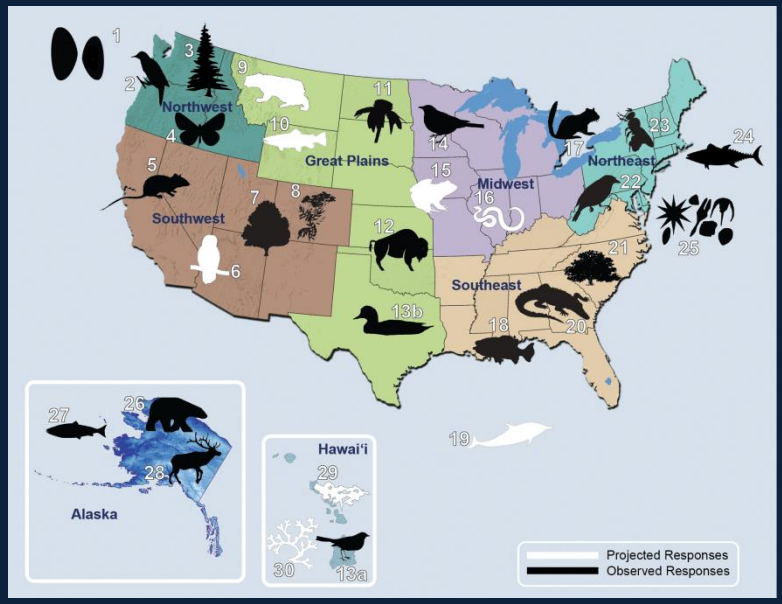


Rural Communities

Widespread Impacts



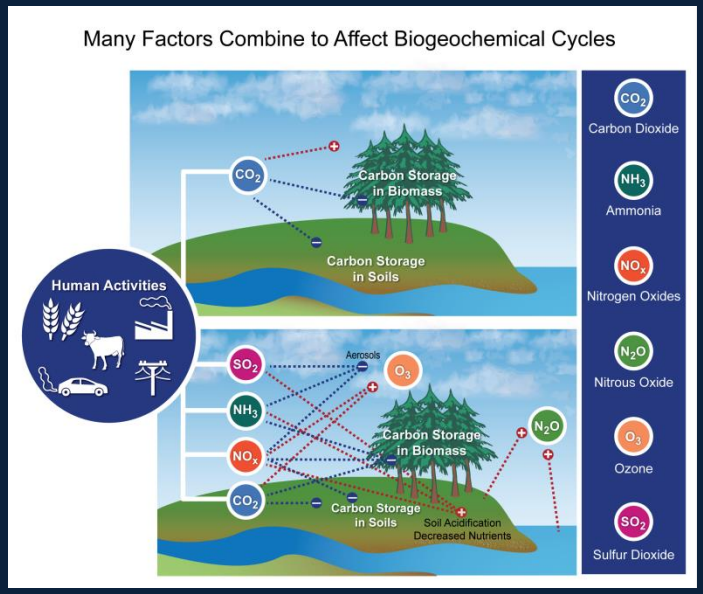
Forests

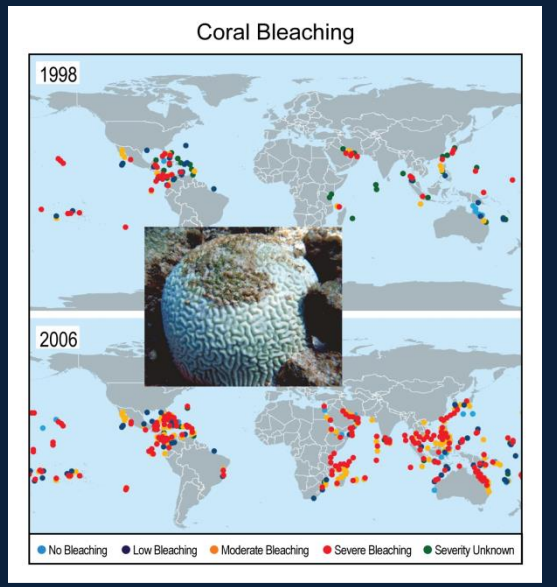


Ecosystems

Oceans

Biogeochemical Cycles

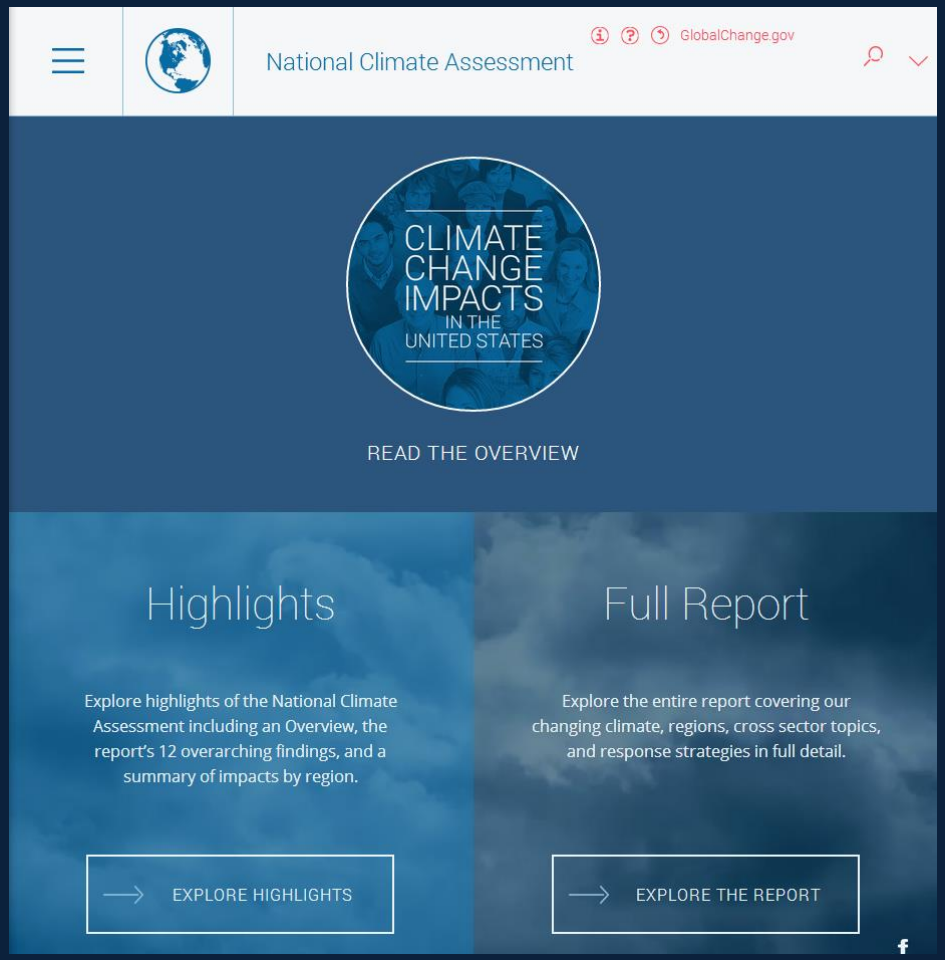




Global climate is projected to continue to change over this century and beyond, but there is still time to act to limit the amount of change and the extent of damaging impacts

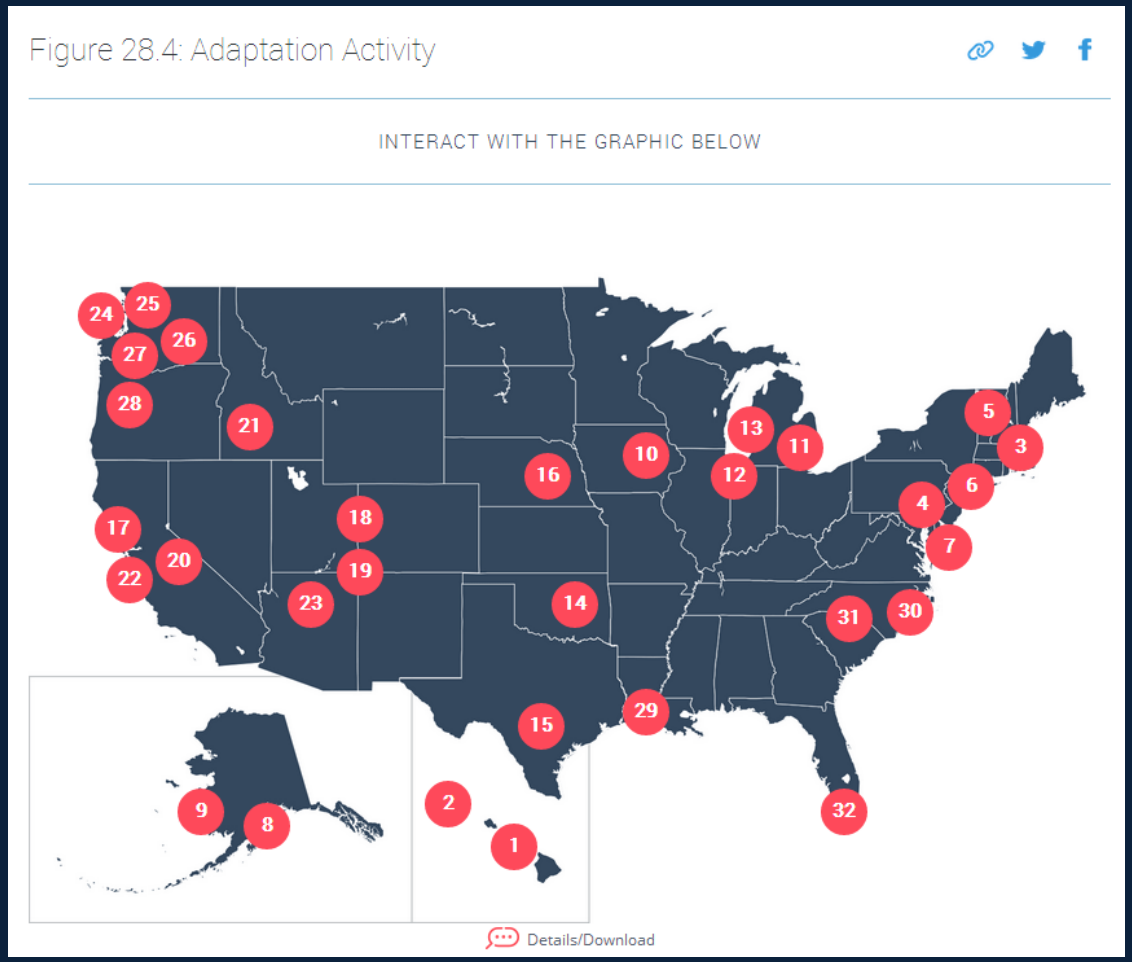
Interactive Tools

(these graphics are hyperlinked)



Interactive Tools

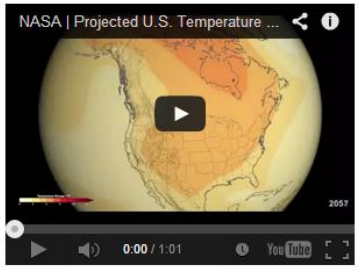
(these graphics are hyperlinked)

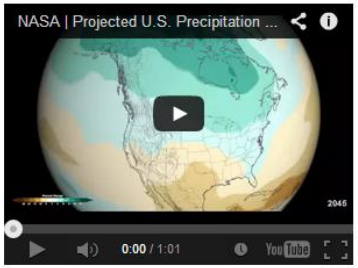


Visualizations developed for the National Climate Assessment

In support of USGCRP's Third National Climate Assessment, NASA produced the visualizations below of 21st century climate scenarios for the United States.

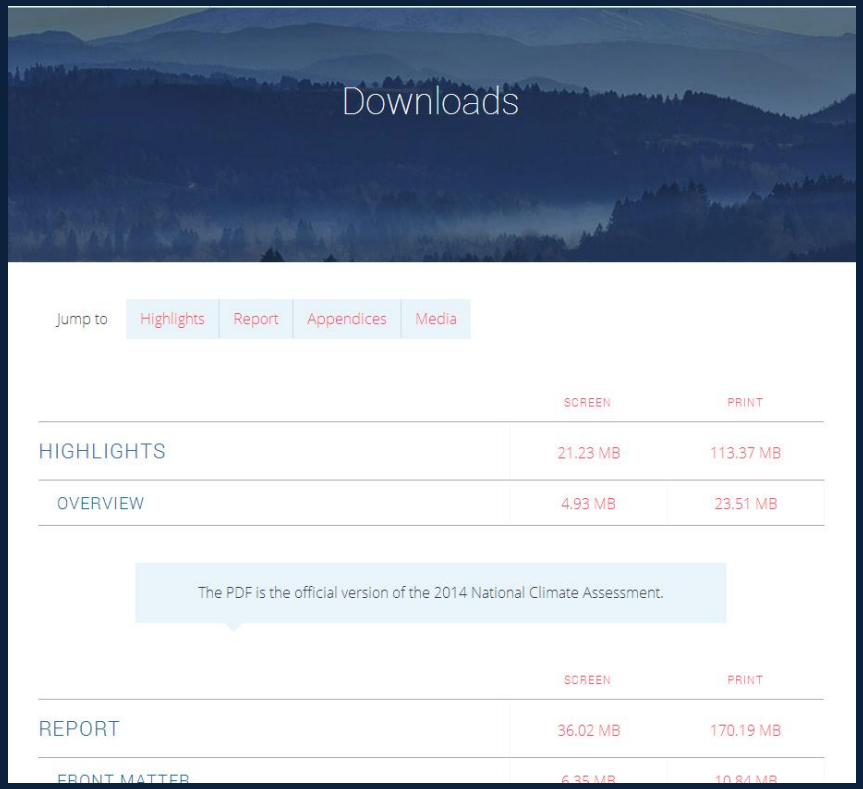
- Temperature side-by-side comparisons + supporting info
- Precipitation side-by-side comparisons + supporting info

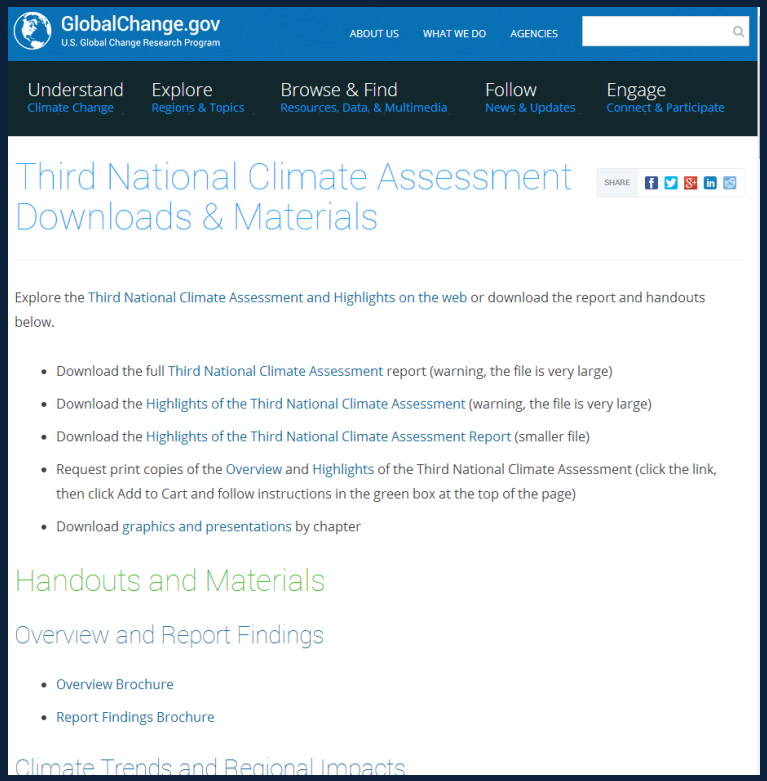


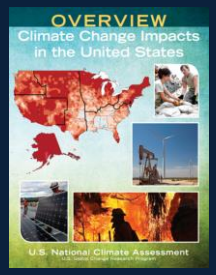


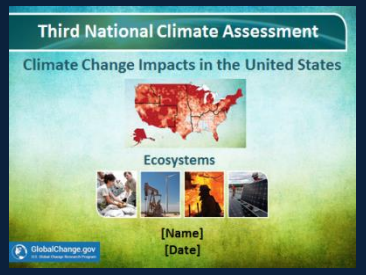
Downloadable Resources

(main graphics are hyperlinked)









Teaching Resources

(these graphics are hyperlinked)

- Ten regional support pages
- Resources by chapter key message
  - Guiding questions
  - Key figures
  - Other resources
  - Lesson plans
  - Videos & visualizations
- General resources

Keep Exploring!

http://nca2014.globalchange.gov

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