

# Global Climate Change Impacts in the United States

U.S. Global Change Research Program

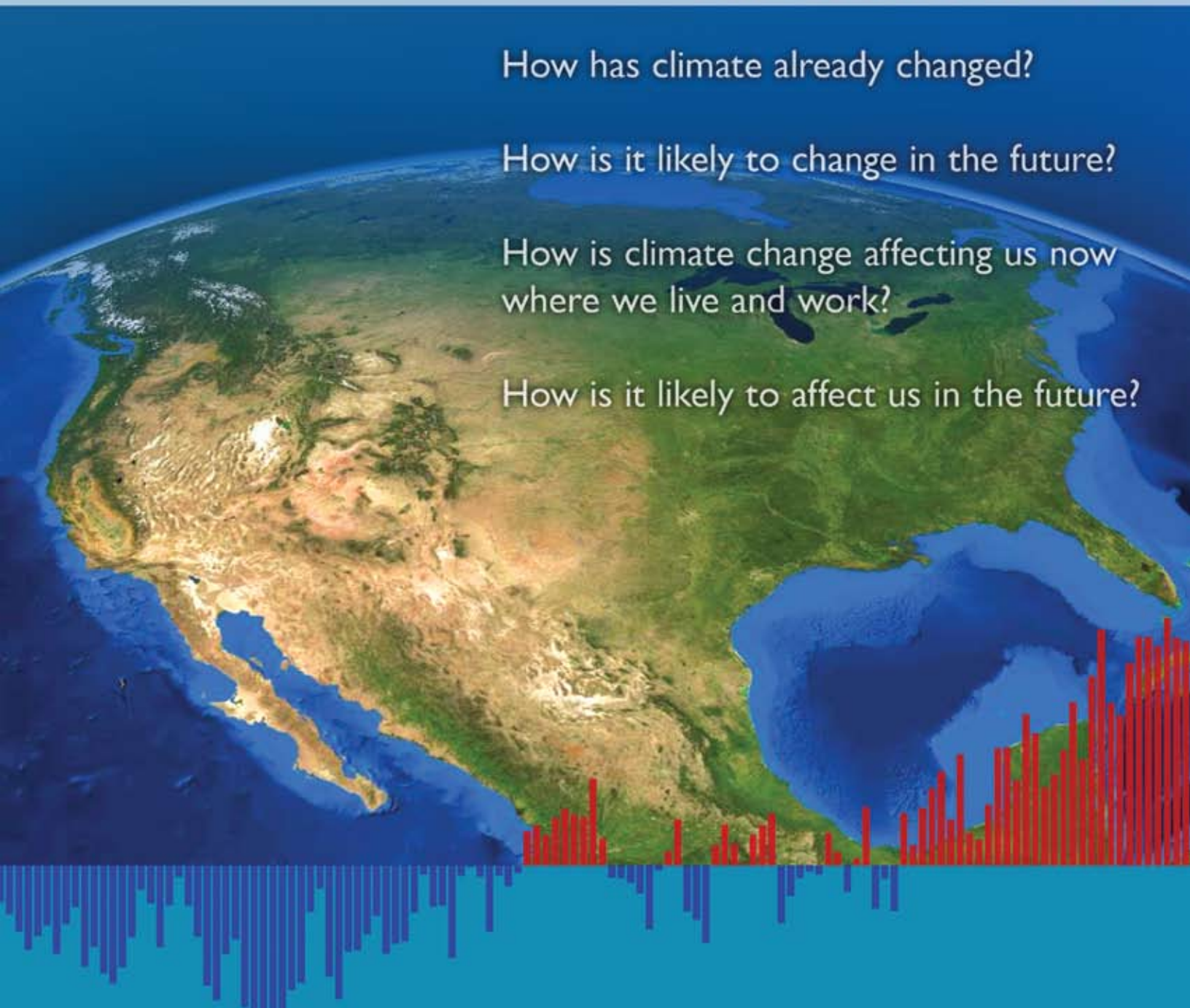
## HIGHLIGHTS

How has climate already changed?

How is it likely to change in the future?

How is climate change affecting us now  
where we live and work?

How is it likely to affect us in the future?



# Highlights of *Global Climate Change Impacts in the United States*

This booklet highlights key findings of *Global Climate Change Impacts in the United States*, a state of knowledge report about the observed and projected consequences of climate change for our nation and people. It is an authoritative scientific report written in plain language, with the goal of better informing public and private decision making at all levels.

The report draws from a large body of scientific information including the set of 21 synthesis and assessment products from the U.S. Global Change Research Program, the assessments of the Intergovernmental Panel on Climate Change, and much more. It also includes new information published since these assessments were released.

While the primary focus of the report is on the impacts of climate change in the United States, it also discusses some of the actions society is already taking or can take to respond to the climate challenge. These include limiting climate change by, for example, reducing emissions of heat-trapping gases or increasing their removal from the atmosphere.

The importance of our current choices about heat-trapping emissions is underscored by comparing impacts resulting from higher versus lower emissions scenarios. Choices about emissions made now will have far-reaching consequences for climate change impacts, with lower emissions reducing the magnitude of climate change impacts and the rate at which they appear.

The report also identifies examples of options currently being pursued to cope with or adapt to the impacts of climate change and/or other environmental issues. One example of adaptation is included in this booklet. There is generally insufficient information at present to evaluate the effectiveness, costs, and benefits of potential adaptation actions.

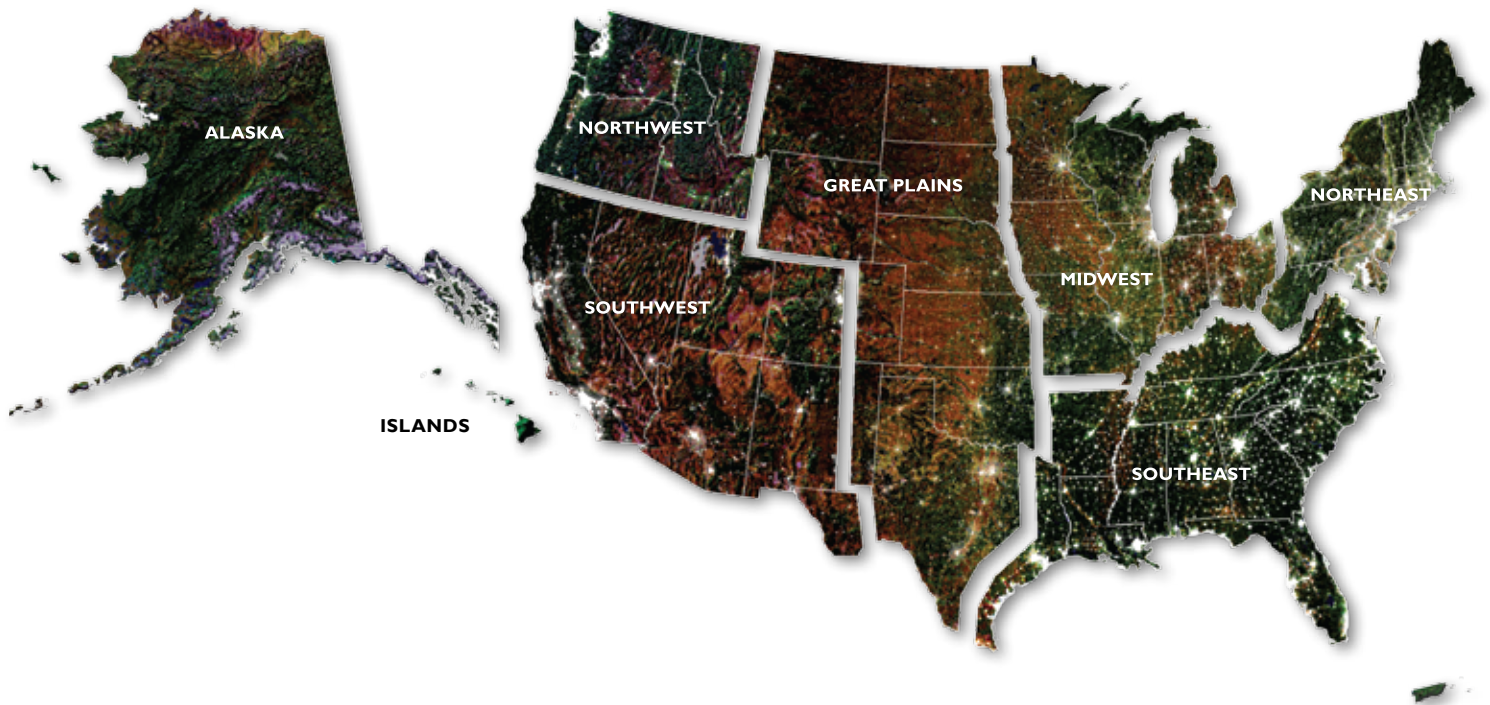
This booklet includes a brief overview of the 10 key findings of the report, using examples from the report to illustrate each finding. References for material in this booklet, including figures, can be found in the full report.

The full report can be found online at  
[www.globalchange.gov/usimpacts](http://www.globalchange.gov/usimpacts)

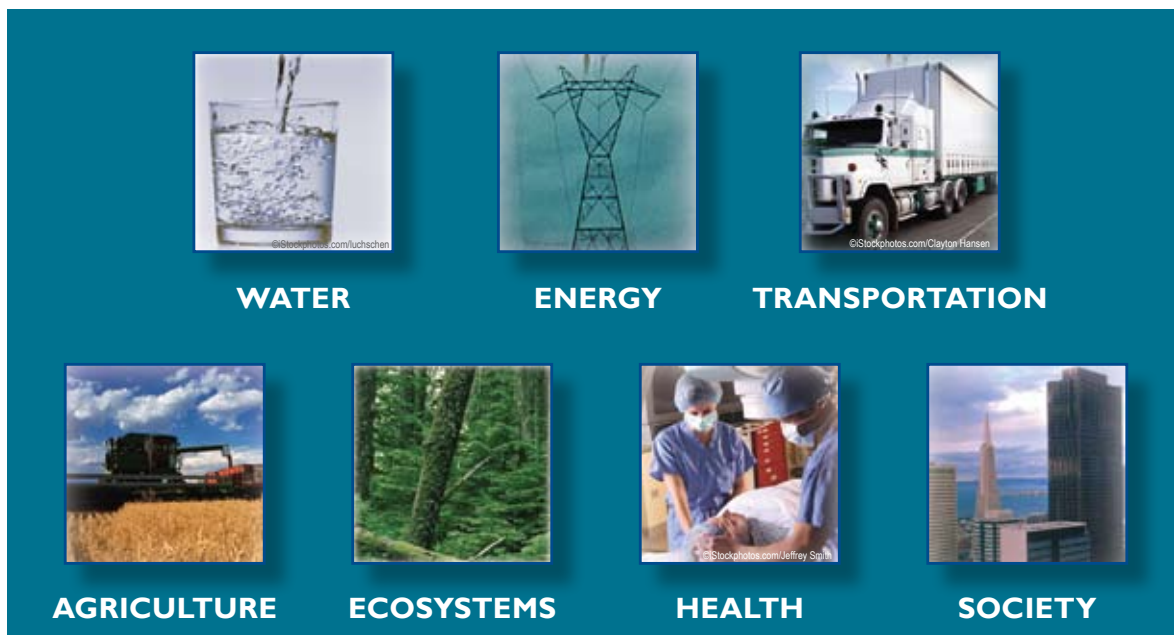
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## **Global Climate Change Impacts in the United States describes current and future impacts of climate change on various U.S. regions and sectors.**

There are both important commonalities and important differences in the climate-related issues and consequences faced around the country. For example, water is a key issue in all regions, but the specific changes and impacts vary. Regional perspectives are thus critical to thinking through responses to the changes that will be faced around the nation.



While the impacts of climate change clearly vary among the regions, there are issues of national importance that transcend regional boundaries. Seven such “sectors” (shown below) are considered in this report, providing a more integrated national picture of impacts, although one with regional differences.



# Impacts of Climate Change

Climate change is apparent now across our nation. Trends observed in recent decades include rising temperatures, increasing heavy downpours, rising sea level, longer growing seasons, reductions in snow and ice, and changes in the amounts and timing of river flows. These trends are projected to continue, with larger changes resulting from higher amounts of heat-trapping gas emissions, and smaller changes from lower amounts of these emissions. The observed changes in climate are already causing a wide range of impacts, and these impacts are expected to grow. Select examples follow.

## Sea Ice and Permafrost

Risks and costs in Alaska increase as thawing of permafrost damages roads, buildings, and forests, and declining sea ice increases coastal erosion and threatens the existence of some communities.



## Forests

Forest growth is generally projected to increase in much of the East, but decrease in much of the West as water becomes even scarcer. Major shifts in species are expected, such as maple-beech-birch forests being replaced by oak-hickory in the Northeast. Insect infestations and wildfires are projected to increase as warming progresses.



## Coldwater Fish

Salmon, trout, and other coldwater fish will face additional stresses as water temperatures rise and summer streamflows decline. Ecosystems and the tourism and recreation they support will be adversely affected.



## Interacting Stresses

Population shifts and development choices are making more Americans vulnerable to the impacts of climate change. An aging populace and continued population shifts to the Southeast, Southwest, and coastal cities amplify risks associated with extreme heat, sea-level rise, storm surge, and increasing water scarcity in some regions.



## Coral Reefs

Rising water temperatures and ocean acidification threaten coral reefs and the rich ecosystems they support. These and other climate-related impacts on coastal and marine ecosystems will have major implications for tourism and fisheries.



### Heavy Downpours

More rain is already coming in very heavy events, and this trend is projected to increase across the nation. Such events are harmful to transportation infrastructure, agriculture, water quality, and human health.



### Coastal Communities

Sea-level rise and storm surge will increase threats to homes and infrastructure including water, sewer, transportation, and communication systems. Many barrier islands and coastal marshes that protect the coastline and support healthy ecosystems will be lost.



### Agriculture

Increasing heat, pests, floods, weeds, and water stress will present increasing challenges for crop and livestock production.



### Heat Waves

Heat waves will become more frequent and intense, increasing threats to human health and quality of life, especially in cities.



### Water and Energy Interactions

As warming increases competition for water, the energy sector will be strongly affected because power plants require large amounts of water for cooling.



### Water Supply

Water supplies in the rapidly growing Southwest will become increasingly scarce, calling for difficult trade-offs among competing uses.



### Energy Supply

Warming will decrease demand for heating energy in winter and increase demand for cooling energy in summer. The latter will result in significant increases in electricity use and higher peak demand in most regions.



## Responding to Climate Change

Responses to climate change fall into two major categories. “Mitigation” focuses on reducing emissions of heat-trapping gases or increasing their uptake to reduce the amount and speed of climate change. “Adaptation” refers to changes made to better respond to present or future climate conditions in order to reduce harm or take advantage of opportunities. Both are necessary elements of a comprehensive response strategy.

# 1 Global warming is unequivocal and primarily human-induced

Global temperature has increased over the past 50 years. This observed increase is due primarily to human-induced emissions of heat-trapping gases.

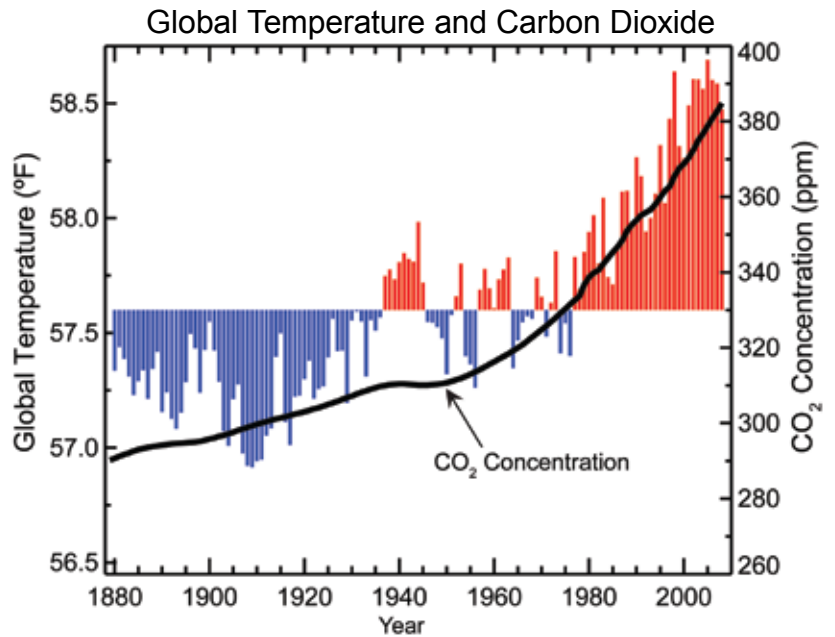
The emissions responsible for human-induced warming come primarily from the burning of fossil fuels (coal, oil, and gas) with additional contributions from the clearing of forests and agricultural activities.

Global average temperature has risen by about 1.5°F since 1900. By 2100, it is projected to rise another 2 to 11.5°F. Increases at the lower end of this range are more likely if global heat-trapping gas emissions are cut substantially. If emissions continue to rise at or near current rates, temperature increases are more likely to be near the upper end of the range.

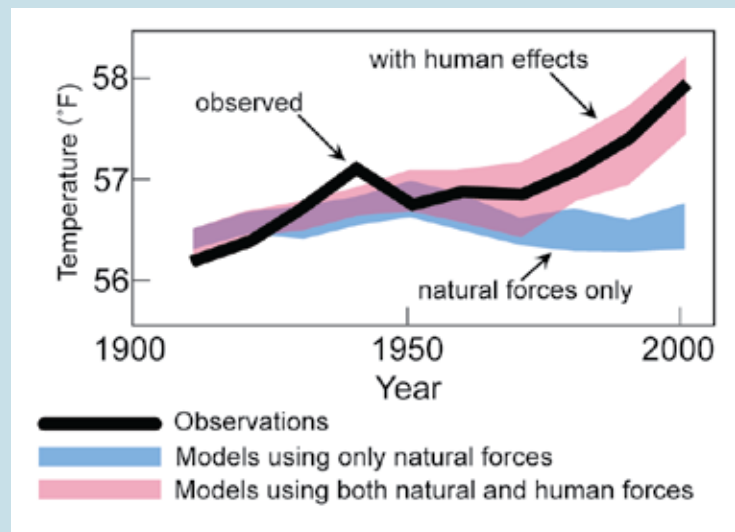
As a result of human activities, the present carbon dioxide concentration of about 385 ppm is about 30 percent above its highest level over at least the last 800,000 years. In the absence of strong control measures, emissions projected for this century would result in the carbon dioxide concentration increasing to a level that is roughly 2 to 3 times the highest level occurring over the last 800,000 or more years.

Human activities have been clearly linked to many aspects of climate change including:

- Temperature
- Precipitation
- Ocean heat content
- Atmospheric moisture
- Arctic sea ice



Separating Human and Natural Influences on Climate



As the blue band indicates, without human influences, global average temperature would actually have cooled slightly over recent decades. With human influences, it has risen strongly (black line), consistent with expectations from climate models (pink band).

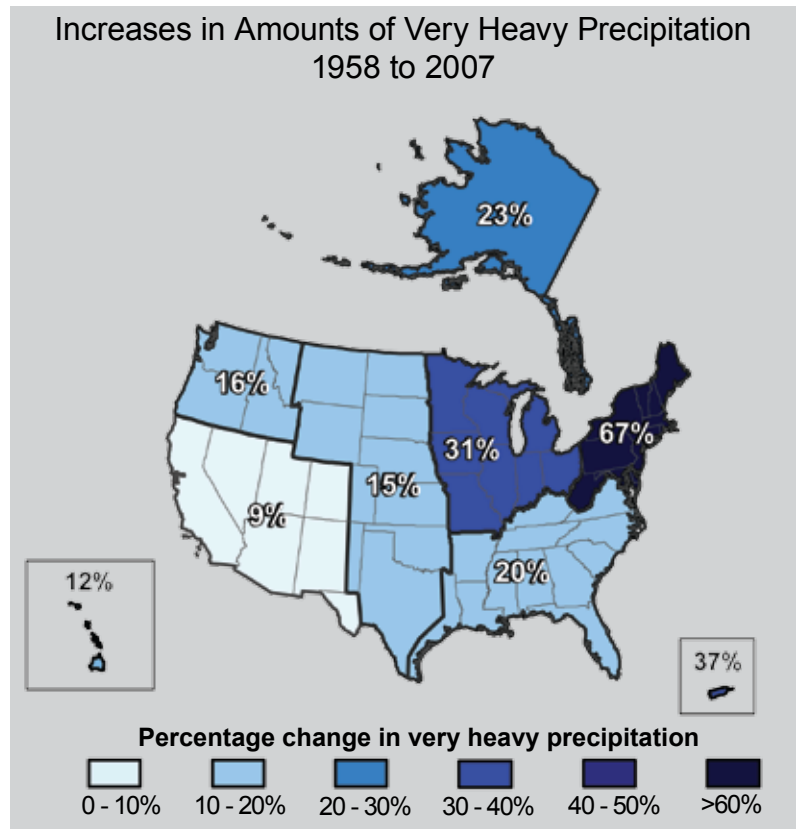
# 2 Climate changes are underway in the United States and are projected to grow

## Changes observed in the U.S. include:

- Temperature rise
- Sea-level rise
- Increase in heavy downpours
- Rapidly retreating glaciers
- Thawing permafrost
- Longer growing season
- Longer ice-free season in the ocean and on lakes and rivers
- Earlier snowmelt
- Changes in river flows

## Heavy Downpours

One of the most striking changes in climate observed over the United States has been an increase in the frequency and intensity of heavy downpours. This increase was responsible for most of the observed increase in overall precipitation during the last 50 years. The amount of precipitation falling in the heaviest 1 percent of rain events increased nearly 20 percent. During the past 50 years, the largest increases in heavy precipitation occurred in the Northeast and the Midwest.

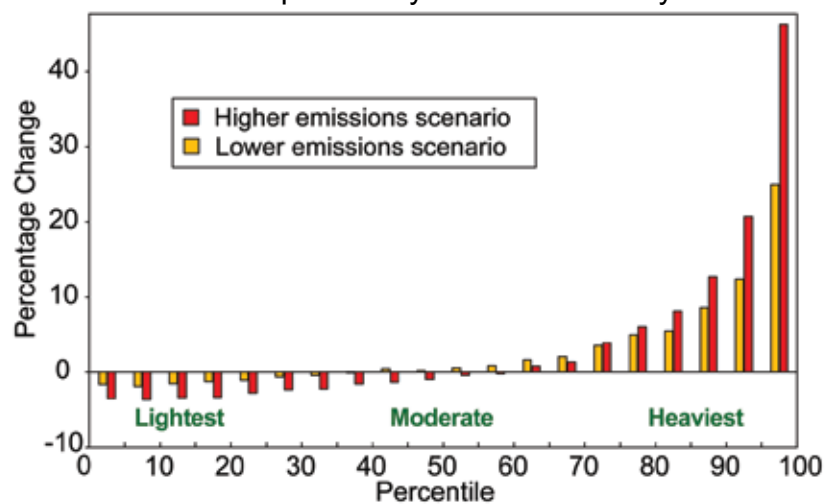


Climate models project continued increases in the heaviest downpours during this century, while the lightest precipitation is projected to decrease. The chart below shows the projected changes in each category of precipitation, from lightest to heaviest, under increasing emissions of heat-trapping gases. Much larger increases in heavy downpours are projected under higher emissions scenarios than under lower emissions scenarios.

## A note on the emissions scenarios:

None of the emissions scenarios used in this report assumes any policies specifically designed to address climate change. All, including the lower emissions scenario, assume increases in heat-trapping gas emissions for at least the next few decades, though at different rates. The “lower emissions scenario” used in this report is the B1 scenario from the Intergovernmental Panel on Climate Change (IPCC). The “higher emissions scenario” is A2. Elsewhere, a third “even higher emissions scenario” is used, IPCC’s A1FI.

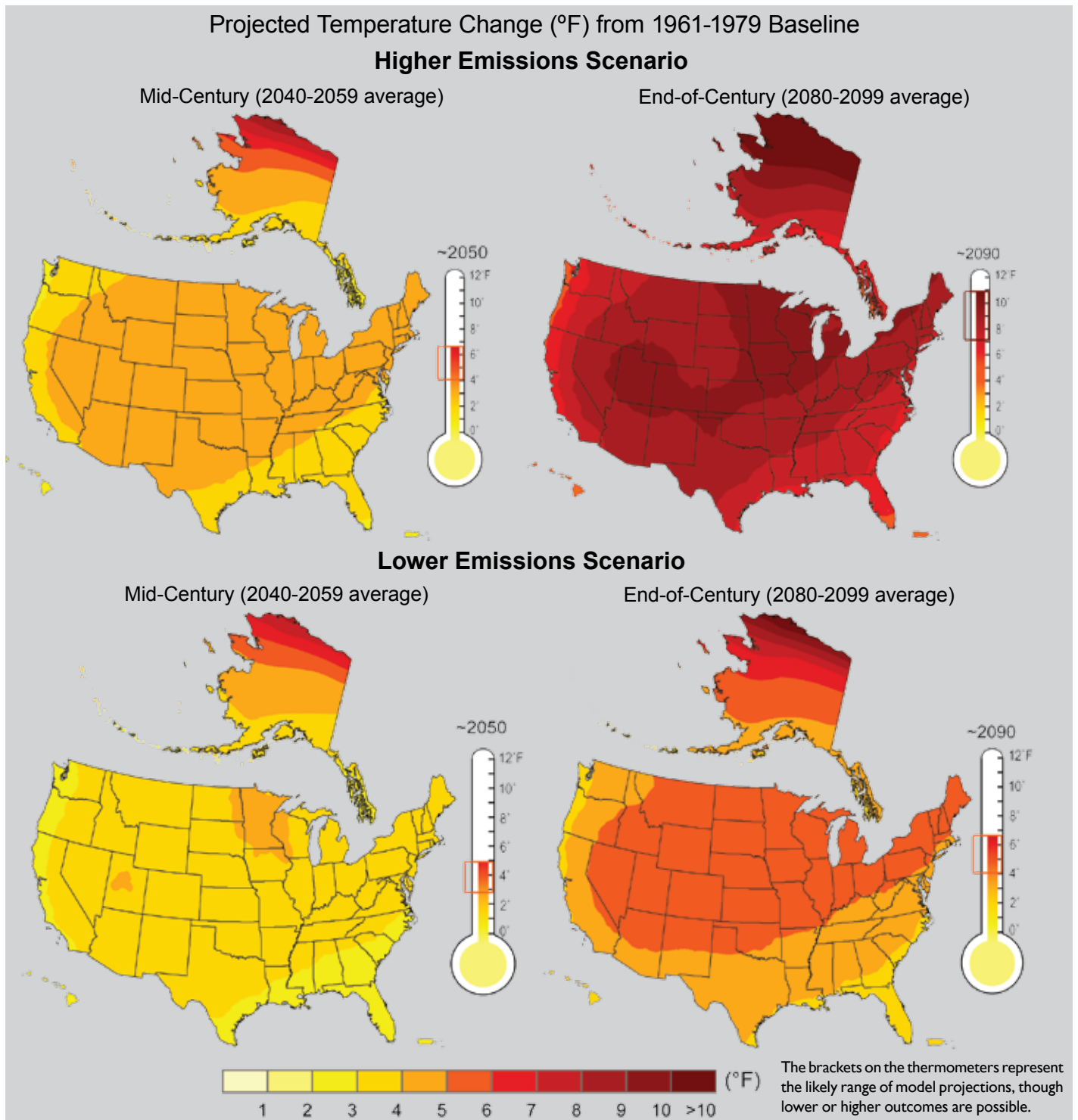
## Projected Changes in Light, Moderate, and Heavy Precipitation by Late this Century



# 2 Climate changes are underway in the U.S. and are projected to grow

## Rising Temperature

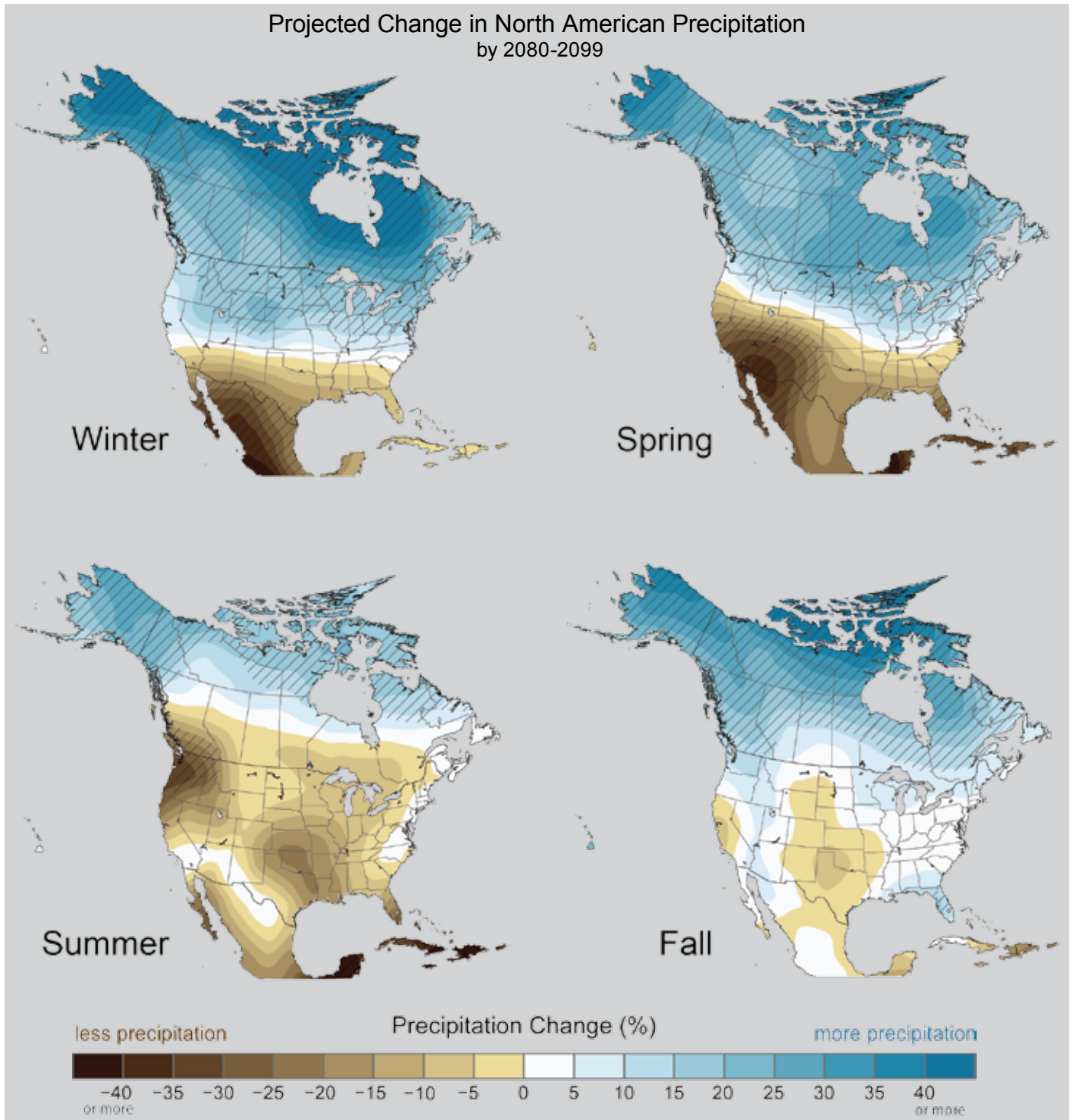
U.S. average temperature has increased by about 2°F over the past 50 years, which is more than the global average temperature increase. In the next couple of decades, another degree or so of temperature rise is projected. The maps below show projected temperature increases for the middle and the end of this century, under both higher and lower emissions scenarios. As the maps illustrate, the higher the emissions, the higher the temperature increases. If actual emissions are lower than those represented in the lower emissions scenario, temperature increases would be smaller than those shown on the bottom set of maps.





### Changing Precipitation Patterns

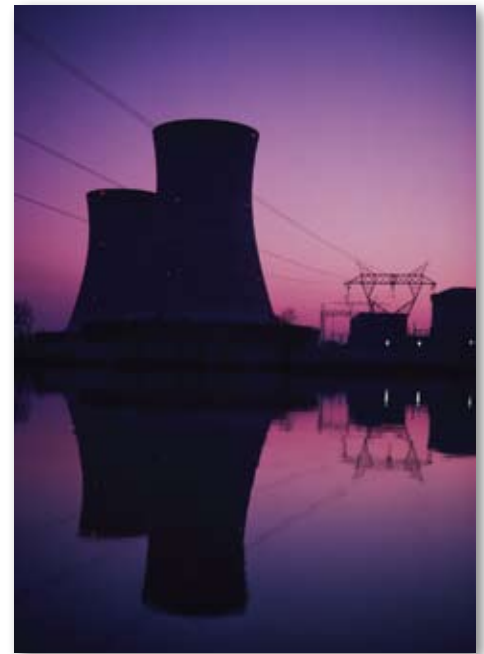
The maps below show projected future changes in precipitation relative to the recent past as simulated by 15 climate models. The simulations are for late this century, under a higher emissions scenario, with blue indicating increasing precipitation, and brown indicating decreasing precipitation. For example, in the spring, climate models agree that northern areas are likely to get wetter, and southern areas drier. There is less confidence in exactly where the transition between wetter and drier areas will occur. Confidence in the projections is highest in the hatched areas.



# 3 Widespread climate-related impacts are occurring now and are expected to increase

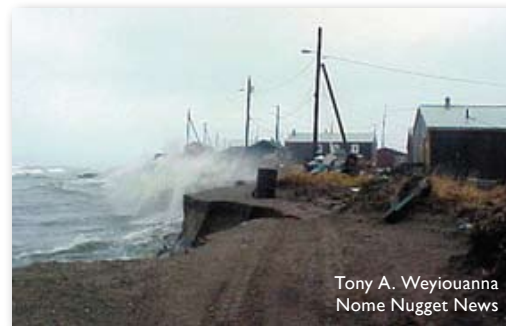
## Energy Supply and Use

- Warming will be accompanied by decreases in demand for heating energy and increases in demand for cooling energy. The latter will result in significant increases in electricity use and higher peak demand in most regions.
- Energy production is likely to be constrained by rising temperatures and limited water supplies in many regions.
- Energy production and delivery systems are exposed to sea-level rise and extreme weather events in vulnerable regions.
- Climate change is likely to affect some renewable energy sources across the nation, such as hydropower production in regions subject to changing patterns of precipitation or snowmelt.



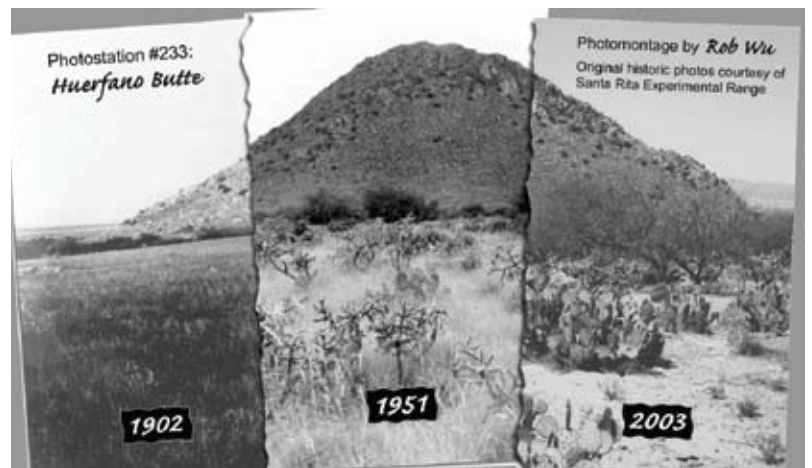
## Society

- Population shifts and development choices are making more Americans vulnerable to the expected impacts of climate change.
- Vulnerability is greater for people who have few resources and few choices.
- City residents and city infrastructure have unique vulnerabilities to climate change.
- Climate change affects communities through changes in climate-sensitive resources that occur both locally and at great distances.
- Insurance is one of the industries particularly vulnerable to increasing extreme weather events such as severe storms, but it can also help society manage the risks.
- The United States is connected to a world that is unevenly vulnerable to climate change and thus will be affected by impacts in other parts of the globe.



## Ecosystems

- Ecosystem processes, such as those that control growth and decomposition, have been affected by climate change.
- Large-scale shifts have occurred in the ranges of species and the timing of the seasons and animal migration, and are very likely to continue.
- Fires, insect pests, disease pathogens, and invasive weed species have increased, and these trends are likely to continue.
- Deserts and drylands are likely to become hotter and drier, feeding a self-reinforcing cycle of invasive plants, fire, and erosion.
- Coastal and near-shore ecosystems are already under multiple stresses. Climate change and ocean acidification will exacerbate these stresses.
- Arctic sea ice ecosystems are already being adversely affected by the loss of summer sea ice and further changes are expected.
- The habitats of some mountain species and coldwater fish, such as salmon and trout, are very likely to contract in response to warming.
- Some of the benefits ecosystems provide to society will be threatened by climate change, while others will be enhanced.



Near Tucson, Arizona

## Transportation

- Sea-level rise and storm surge will increase the risk of major coastal impacts, including both temporary and permanent flooding of airports, roads, rail lines, and tunnels.
- Flooding from increasingly intense downpours will increase the risk of disruptions and delays in air, rail, and road transportation, and damage from mudslides in some areas.
- The increase in extreme heat will limit some transportation operations and cause pavement and track damage. Decreased extreme cold will provide some benefits such as reduced snow and ice removal costs.
- Increased intensity of strong hurricanes would lead to more evacuations, infrastructure damage and failure, and transportation interruptions.
- Arctic warming will continue to reduce sea ice, lengthening the ocean transport season, but also resulting in greater coastal erosion due to waves. Permafrost thaw in Alaska will damage infrastructure. The ice road season will become shorter.



# 3 Widespread climate-related impacts are occurring now and are expected to increase

## NORTHWEST

- Declining snowpack reduces summer streamflows, straining water resources including those needed for hydroelectric power
- Increasing wildfires, insects, and species shifts pose challenges for ecosystems and the forest products industry
- Rising water temperatures and declining summer streamflows threaten salmon and other coldwater fish species
- Sea-level rise increases erosion and land loss

## GREAT PLAINS

- Increasing temperature, evaporation, and drought frequency compound water scarcity problems
- Agriculture, ranching, and natural lands are stressed by limited water supplies and rising temperatures
- Alteration of key habitats such as prairie potholes affects native plants and animals

## ALASKA

## ALASKA

- Summers get hotter and drier, with increasing evaporation outpacing increased precipitation
- Wildfires and insect problems increase
- Lakes decline in area
- Permafrost thawing damages infrastructure
- Coastal storms increase risks to villages and fishing fleets
- Shifts in marine species affect fisheries

## ISLANDS

## ISLANDS

- Likely reductions in freshwater availability have significant impacts
- Sea-level rise and storms threaten island communities
- Climate changes affecting coastal and marine ecosystems have major implications for tourism and fisheries

## NORTHWEST

## GREAT PLAINS

## SOUTHWEST

## SOUTHWEST

- Scarce water supplies call for trade-offs among competing uses
- Increasing temperature, drought, wildfire, and invasive species accelerate landscape transformation
- Increased frequency and altered timing of flooding increases risks to people, ecosystems, and infrastructure
- Unique tourism and recreation opportunities are likely to suffer

### MIDWEST

- Heat waves, air quality problems, and insect and waterborne diseases increase
- Reduced water levels in the Great Lakes affect shipping, infrastructure, beaches, and ecosystems under a higher emissions scenario
- More periods of both floods and water deficits occur
- Floods, droughts, insects, and weeds challenge agriculture
- Diseases and invasive species threaten native fish and wildlife

### NORTHEAST

- Extreme heat and declining air quality are likely to pose increasing health risks
- Production of milk, fruits, and maple syrup is likely to be adversely affected
- More frequent flooding due to sea-level rise, storm surge, and heavy downpours
- Reduced snow negatively affects winter recreation
- Lobster fishery continues northward shift; cod fishery further diminished

### NORTHEAST

### MIDWEST

### SOUTHEAST

### SOUTHEAST

- Increases in air and water temperatures stress people, plants, and animals
- Decreased water availability is very likely to affect the economy and natural systems
- Sea-level rise and increases in hurricane intensity and storm surge cause serious impacts
- Thresholds are likely to be crossed, causing major disruptions to ecosystems and the benefits they provide to people
- Severe weather events and reduced availability of insurance will affect coastal communities

### COASTS

- Significant sea-level rise increases risks to coastal cities
- More spring runoff and warmer water will increase the seasonal reduction of oxygen in coastal ecosystems
- Coral reefs will be affected by higher temperatures and ocean acidification
- Changing ocean currents will affect coastal ecosystems

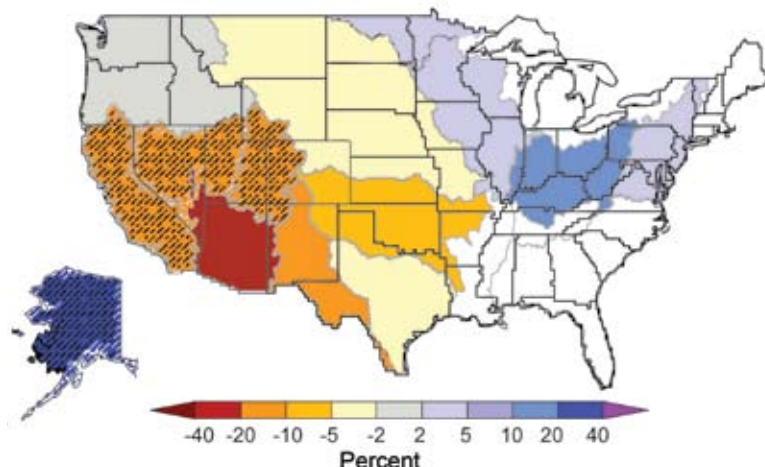
# 4 Climate change will stress water resources

Water is an issue in every region, but the nature of the potential impacts varies. Drought – related to reduced precipitation, increased evaporation, and increased water loss from plants – is an important issue in many regions, especially in the West. Floods and water quality problems are likely to be amplified by climate change in most regions. Declines in mountain snowpack are important in the West and Alaska where snowpack provides vital natural water storage.

## Climate change affects water resources:

- Water cycle is altered, affecting where, when, and how much water is available
- Floods and droughts become more common and intense as regional and seasonal precipitation patterns change and rainfall is more concentrated into heavy events with longer dry periods in between
- Less snow, more rain
- Wet areas get wetter, dry areas get drier
- Mountain snowpack declines, timing of runoff shifts to earlier in spring, and flows are lower in summer
- Increased competition for water supplies

## Projected Changes in Annual Runoff



Runoff is the amount of precipitation that is not evaporated, stored as snowpack or soil moisture, or filtered down to groundwater. Projected changes in median runoff for 2041-2060, relative to a 1901-1970 baseline, are mapped by water resource region. Colors indicate percentage changes in runoff. Hatched areas indicate greater confidence due to strong agreement among model projections. White areas indicate divergence among model projections.

# 5 Crop and livestock production will be increasingly challenged

- Many crops show positive responses to elevated carbon dioxide and low levels of warming, but higher levels of warming often negatively affect growth and yields.
- Extreme events such as heavy downpours and droughts are likely to reduce crop yields because excesses or deficits of water have negative impacts on plant growth.
- Weeds, diseases, and insect pests benefit from warming, and weeds also benefit from a higher carbon dioxide concentration, increasing stress on crop plants and requiring more attention to pest and weed control.
- Forage quality in pastures and rangelands generally declines with increasing carbon dioxide concentration because of the effects on plant nitrogen and protein content, reducing the land's ability to supply adequate livestock feed.
- Increased heat, disease, and weather extremes are likely to reduce livestock productivity.

## Weed Growth is Promoted and Herbicide Loses Effectiveness at Higher CO<sub>2</sub>



Current CO<sub>2</sub>  
(380 ppm)

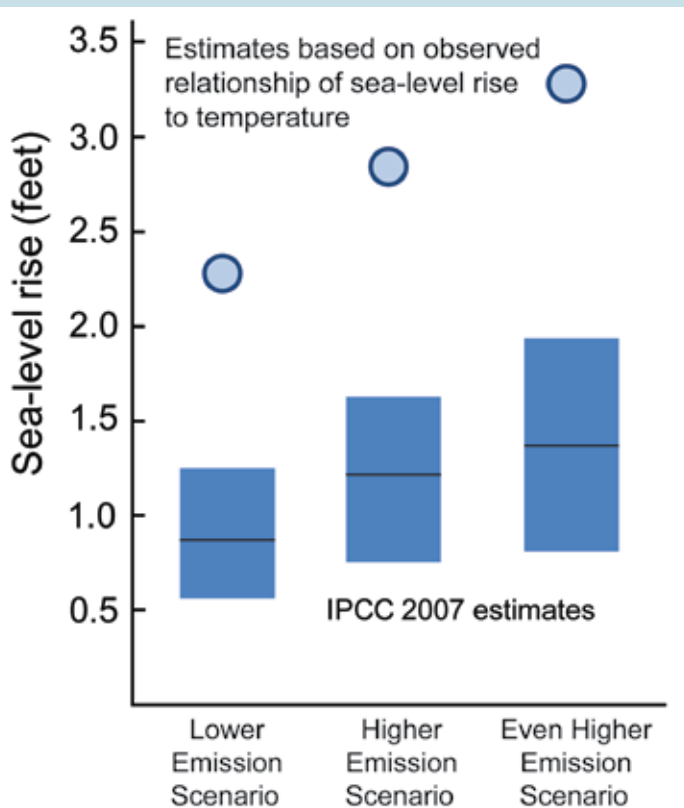
Potential Future CO<sub>2</sub>  
(680 ppm)

# 6 Coastal areas are at increasing risk from sea-level rise, storm surge, and other climate-related stresses

## Coastal impacts include:

- Sea-level rise leads to erosion and loss of land
- Storm surge causes flooding
- Increased pollution due to more runoff from the land
- Ocean acidification threatens coral reefs and shellfish

## Projected Sea-Level Rise



Based on the state of the science at the time, in 2007 the Intergovernmental Panel on Climate Change (IPCC) projected a rise of the world's oceans from 8 inches to 2 feet by the end of this century (range shown as bars). However, they could not quantify the contributions to sea-level rise due to changes in ice sheet dynamics. More recent research has attempted to quantify this contribution by estimating future sea level based on its observed relationship to temperature. For example, the projections indicated by the light blue circles in the figure above estimate global average sea-level rise of almost 3.5 feet by the end of this century under a high emissions scenario. In areas where the land is sinking, such as the Atlantic and Gulf Coasts of the United States, sea-level rise will be higher than the global average.

Global sea level is rising due to the warming-induced expansion of ocean water, accelerated melting of most of the world's glaciers, and loss of ice from the Greenland and Antarctic ice sheets. Additional warming will cause further sea-level rise over this century and beyond.

Rising sea level is already eroding shorelines, drowning wetlands, and threatening homes, businesses, and infrastructure. The destructive potential of Atlantic hurricanes has increased in recent decades in association with increasing sea surface temperatures, and it is likely that hurricane rainfall and wind speeds will increase in response to global warming. Coastal water temperatures have risen and the geographic distributions of marine species have shifted.

Precipitation increases on land have increased river runoff, polluting coastal waters with more nitrogen and phosphorous, sediments, and other contaminants. Ocean acidification resulting from the uptake of carbon dioxide by ocean waters threatens corals, shellfish, and other living things that form their shells and skeletons from calcium carbonate.

All of these forces converge and interact at the coasts, making these areas particularly sensitive to the impacts of climate change.



Jack Pellette/NWS

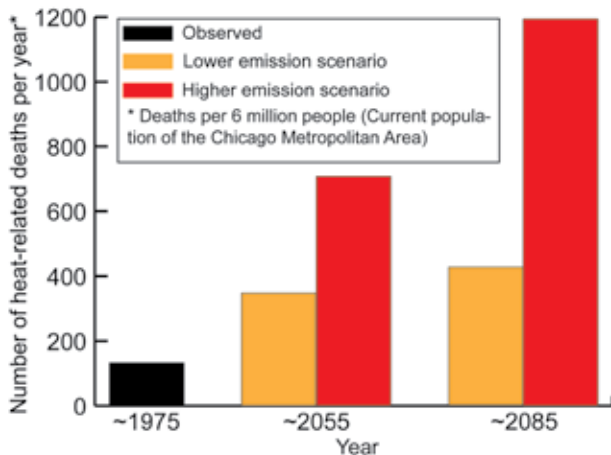
# 7 Threats to human health will increase

## Major health risks include:

- Heat stress
- Waterborne diseases (due to heavy downpours and higher temperatures)
- Poor air quality
- Extreme weather events
- Diseases caused by insects and rodents
- Pollen increase
- Children, the elderly, and the poor are most vulnerable to climate-related health effects

Climate change poses unique challenges to human health including heat waves and severe storms, ailments caused or exacerbated by air pollution and airborne allergens, and many climate-sensitive infectious diseases. Whether or not increased health risks due to climate change are realized will depend largely on societal responses and underlying vulnerability. The probability of exacerbated health risks due to climate change points to a need to maintain a strong public health infrastructure to help limit future impacts.

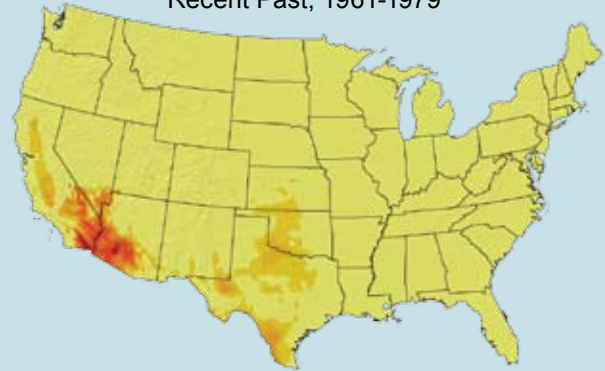
### Projected Increase in Heat-Related Deaths in Chicago



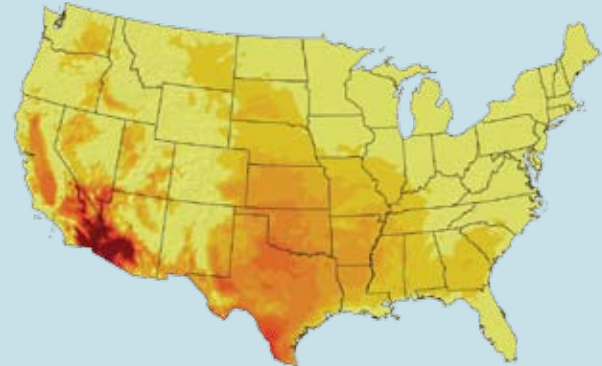
Increases in heat-related deaths are projected in cities around the nation, especially under higher emissions scenarios. This analysis included some adaptation measures. The graph shows the projected number of deaths per year, averaged over a three-decade period around 1975, 2055, and 2085 for the City of Chicago under lower and higher emissions.

## Number of Days Over 100°F

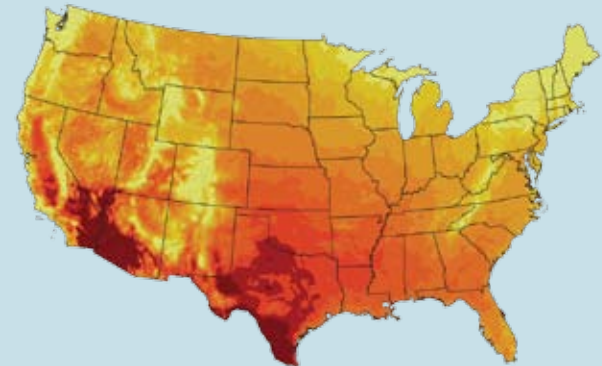
### Recent Past, 1961-1979



### Lower Emissions Scenario, 2080-2099



### Higher Emissions Scenario, 2080-2099



High air temperatures are uncomfortable, stressful, and increase the risk of heat-related illnesses. The number of days in which the temperature exceeds 100°F by late this century, compared to the 1960s and 1970s, is projected to increase strongly across the United States.



# 8 Climate change will interact with many social and environmental stresses

Social trends can increase our vulnerability to climate change. Recent trends include concentration of development along vulnerable coasts, aging of the U.S. population, increasing urbanization, and population growth in the South and West. Overlaying projections of future climate change and its impacts on expected changes in U.S. population and development patterns reveals a critical insight: More Americans will be living in the areas that are most vulnerable to the effects of climate change, from sea-level rise and hurricanes in the Southeast, to water scarcity in the Southwest.

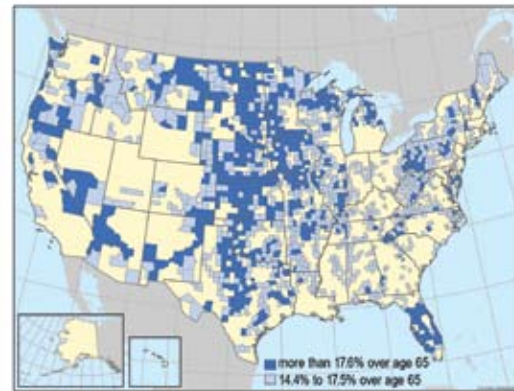
Pollution and the resulting poor air quality is one of many human-caused stresses that interact with climate change to amplify impacts. The combination of air pollution with heat, drought, and stagnant air negatively affects human health and quality of life in cities.

## Geographic Vulnerability of U.S. Residents to Selected Climate-Related Health Impacts

Location of Hurricane Landfalls, 1995 to 2000



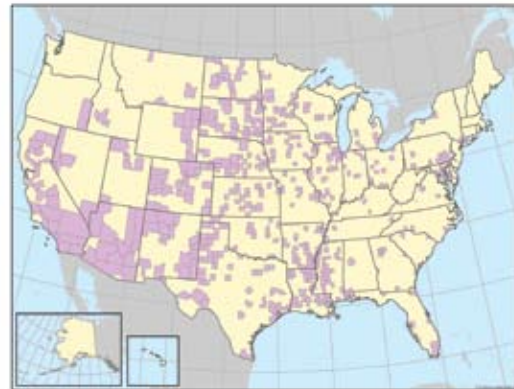
Percentage of Population Aged 65 or Older, 2000



Locations of Extreme Heat Events, 1995 to 2000



West Nile Virus Cases, 2004



Maps indicating U.S. counties, or in some cases states, with existing vulnerability to climate-sensitive health outcomes. These examples demonstrate both the diversity of climate-sensitive health outcomes and the geographic variability of where they occur.

# 9 Thresholds will be crossed, leading to large changes in climate and ecosystems

There are a variety of thresholds in the climate system and ecosystems. These thresholds determine, for example, the presence of sea ice and permafrost, and the survival of species, from fish to insect pests, with implications for society. With further climate change, the crossing of additional thresholds is expected.

Land subsidence (sinking) associated with the thawing of **permafrost** in Alaska, in addition to damaging forests and other natural systems, presents substantial challenges to engineers attempting to preserve infrastructure.

**Cod** in the North Atlantic are adapted to annual average temperatures near the seafloor ranging from 36 to 54°F. Large populations of cod are generally not found above the 54°F threshold. Temperature also influences the location and timing of spawning, which in turn affect the growth and survival of young cod. Increases in bottom temperatures above 47°F are projected to lead to a decline in growth and survival. Projections of warming indicate that both the 47°F and the 54°F thresholds will be met or exceeded in this century under a higher emissions scenario.

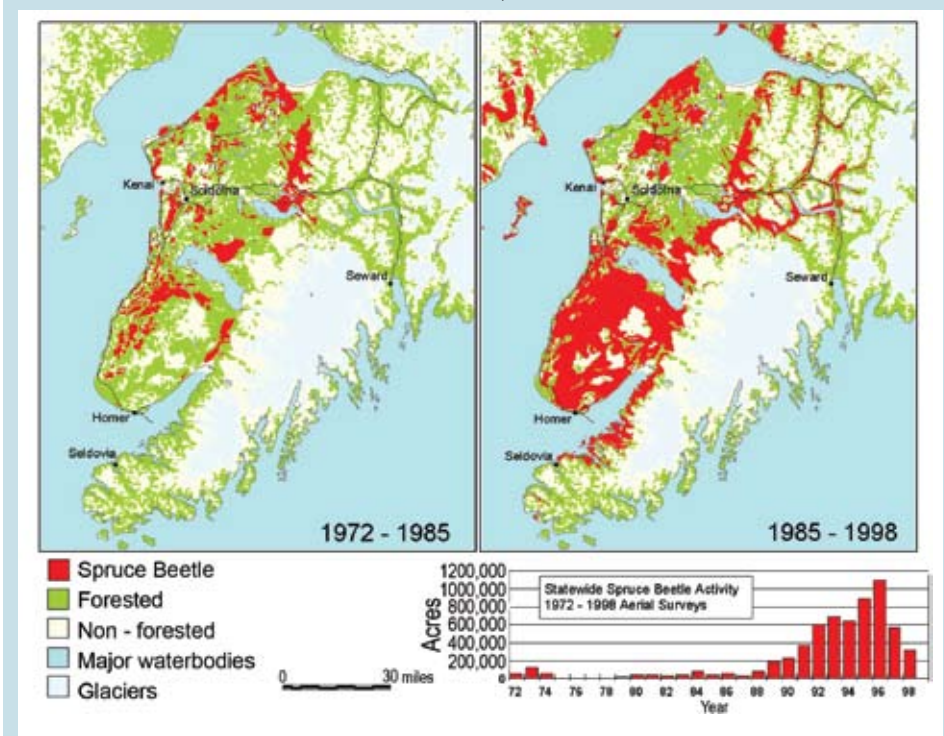
**Lobster** catches in the southern part of the Northeast region have declined sharply in the past decade, associated with a temperature-sensitive bacterial shell disease. The southern extent of the commercial lobster harvest appears to be limited by this disease, the effects of which are expected to increase with rising near-shore water temperatures.

Crossing key temperature thresholds has contributed to major **insect outbreaks** that have destroyed millions of acres of trees in the United States. First, warmer winters allow larger populations of insects to survive the cold season that normally limits their numbers. Second, the longer warm season allows them to develop

faster, sometimes completing two life cycles instead of one in a single growing season. Third, warmer conditions allow insects' ranges to expand northward. Fourth, drought stress reduces trees' ability to resist insect attack (for example, by pushing back against boring insects with the pressure of their sap).

Spruce beetle, pine beetle, spruce budworm, and woolly adelgid (which attacks eastern hemlocks) are just some of the insects that are proliferating in the United States, causing devastation in many forests. These outbreaks are projected to increase with ongoing warming. Trees killed by insects also provide more dry fuel for wildfires.

Alaska Spruce Beetle Infestation  
Kenai Peninsula, 1972 to 1998



# 10 Future climate change and its impacts depend on choices made today

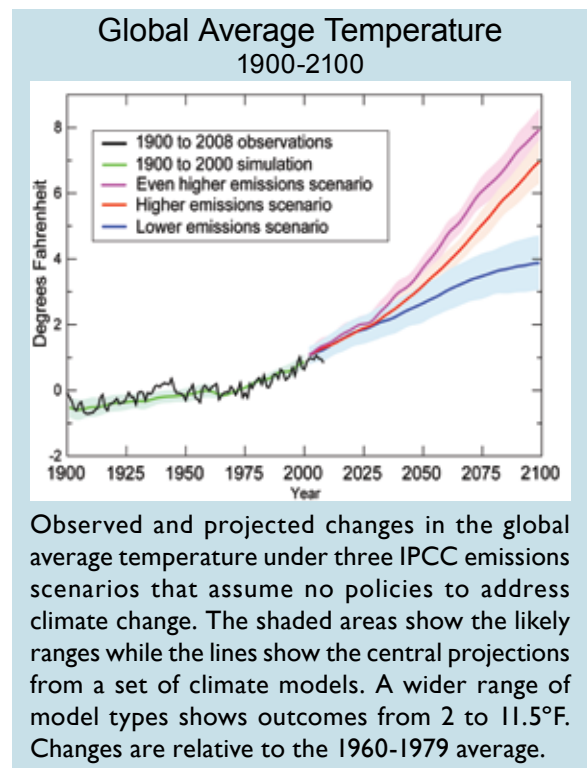
The amount and rate of future climate change depends primarily on current and future human-caused emissions of heat-trapping gases and airborne particles. Responses involve reducing emissions to limit future warming, and adapting to the changes that are unavoidable.

Human-induced climate change is happening now, and impacts are already apparent. Greater impacts are projected, particularly if heat-trapping gas emissions continue unabated. Previous assessments have established these facts, and this report confirms, solidifies, and extends these conclusions for the United States. It reports the latest understanding of how climate change is already affecting important sectors and regions. In particular, it reports that some climate change impacts appear to be increasing faster than previous assessments had suggested.

Choices about emissions now and in the coming years will have far-reaching consequences for climate change impacts. A consistent finding of this assessment is that the rate and magnitude of future climate change and resulting impacts depend critically on the level of global atmospheric heat-trapping gas concentrations. Lower emissions of heat-trapping gases will delay the appearance of climate change impacts and lessen their magnitude. Unless the rate of emissions is substantially reduced, impacts are expected to become increasingly severe for more people and places.

Similarly, there are choices to be made about adaptation strategies that can help to reduce or avoid some of the undesirable impacts of climate change. One such example is shown below and other examples appear in the full report. There is much to learn about the effectiveness of the various types of adaptation responses and how they will interact with each other and with mitigation actions.

As our nation strives to develop effective strategies to respond to climate change, it is essential to have the latest and best scientific information about the impacts of climate change in the United States. The report highlighted in this booklet provides that information.



## Adaptation Example: Raising a Sewage Treatment Plant in Boston

Boston's Deer Island sewage treatment plant was designed and built taking future sea-level rise into consideration. Because the level of the plant relative to the level of the ocean at the outfall is critical to the amount of rainwater and sewage that can be treated, the plant was built 1.9 feet higher than it would otherwise have been to accommodate the amount of sea-level rise projected to occur by 2050, the planned life of the facility.



The planners recognized that the future would be different from the past and they decided to plan for the future based on the best available information. They assessed what could be easily and inexpensively changed at a later date versus those things that would be more difficult and expensive to change later. For example, increasing the plant's height would be less costly to incorporate in the original design, while protective barriers could be added at a later date, as needed, at a relatively small cost.

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