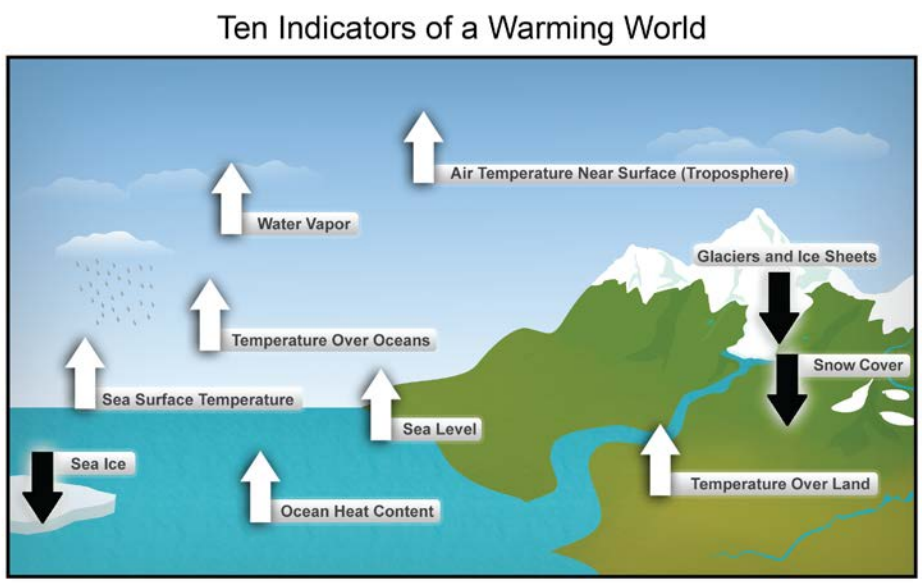
Overview and Report Findings

Climate change is already affecting the American people in far-reaching ways. Certain types of extreme weather events with links to climate change have become more frequent and/or intense, including prolonged periods of heat, heavy downpours, and, in some regions, floods and droughts. In addition, warming is causing sea level to rise, and glaciers and Arctic sea ice to melt, and oceans are becoming more acidic as they absorb carbon dioxide. Today, these and other aspects of climate change are disrupting people's lives and damaging our economy.

Climate change: present and future

Evidence for climate change abounds, from the top of the atmosphere to the depths of the oceans. Scientists and engineers from around the world have meticulously collected this evidence, using satellites and networks of weather balloons, thermometers, buoys, and other observing systems. Evidence of climate change is also visible in the observed and measured changes in location and behavior of species and functioning of ecosystems. Taken together, this evidence tells an unambiguous story: the planet is warming, and over the last half century, this warming has been driven primarily by human activity.

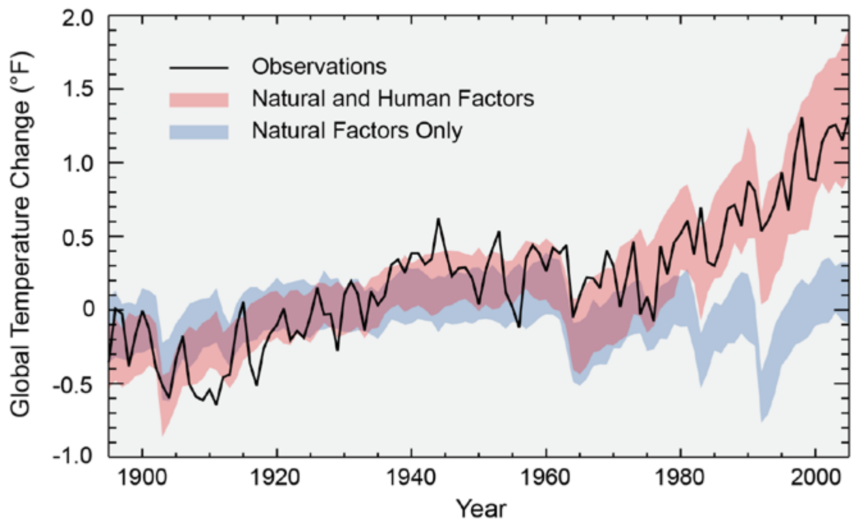


These are just some of the indicators measured globally over many decades that show that the Earth's climate is warming. White arrows indicate increasing trends; black arrows indicate decreasing trends. All the indicators expected to increase in a warming world are increasing, and all those expected to decrease in a warming world are decreasing.

Multiple lines of independent evidence confirm that human activities are the primary cause of the global warming of the past 50 years. The burning of coal, oil, and gas, and clearing of forests have increased the concentration of carbon dioxide in the atmosphere by more than 40% since the industrial revolution, and it has been known for almost two centuries that this carbon dioxide traps heat. Methane and nitrous oxide emissions from agriculture and other human activities add to the atmospheric burden of heat-trapping gases. Data show that natural factors like the sun and volcanoes cannot have caused the warming observed over the past 50 years. Sensors on satellites have measured the sun's output with great accuracy and found no overall increase during the past half century. Large volcanic eruptions during this period, such as Mount Pinatubo in 1991, have exerted a short-term *cooling* influence. In fact, if not for human activities, global climate would actually have cooled slightly over the past 50 years. The pattern of temperature change through the layers of the atmosphere, with warming near the surface and cooling higher up in the stratosphere, further confirms that it is the buildup of heat-trapping gases that has caused most of the Earth's warming over the past half century.

Because human-induced warming is superimposed on a background of natural variations in climate, warming is not uniform over time. Short-term fluctuations in the long-term upward trend are thus natural and expected. For example, a recent slowing in the rate of surface air temperature rise appears to be related to cyclic changes in the oceans and in the sun's energy output, as well as a series of small volcanic eruptions and other factors. Nonetheless, global temperatures are still on the rise and are expected to rise further.

Separating Human and Natural Influences on Climate

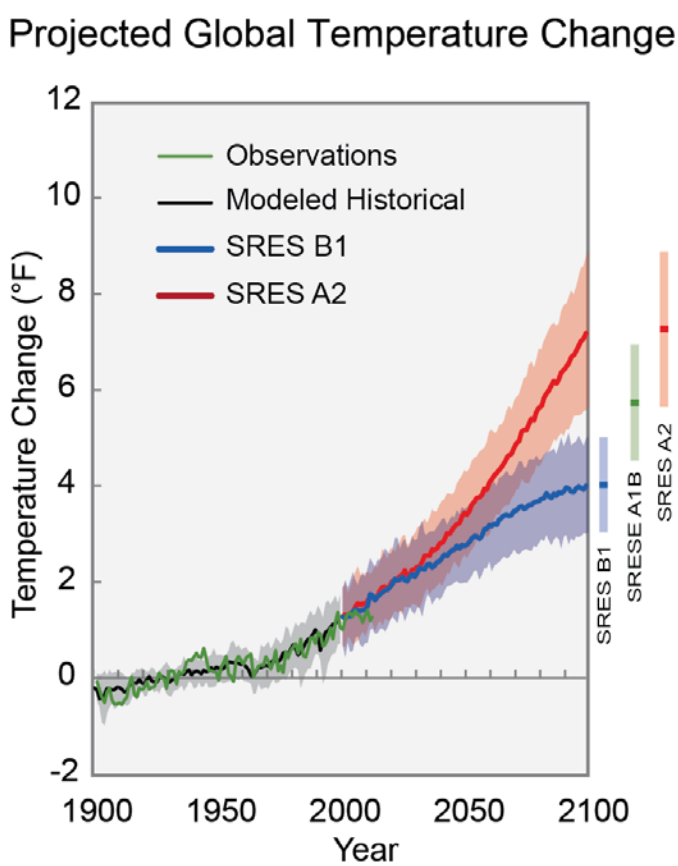


The blue band shows how global average temperature would have changed over the last century due to natural forces alone, as simulated by climate models. The red band shows model simulations of the effects of human and natural forces (including solar and volcanic activity) combined. The black line shows the actual observed global average temperatures. Only with the inclusion of human influences can models reproduce the observed temperature changes.

U.S. average temperature has increased by about 1.5°F since 1895, and most of this increase has occurred since 1970. The most recent decade was the nation's and the world's hottest on record, and 2012 was the hottest year on record in the continental United States. All U.S. regions have experienced warming in recent decades, but the extent of warming has not been uniform. In general, temperatures are rising more quickly in the north. Alaskans have experienced some of the largest increases in temperature between 1970 and present. People living in the Southeast have experienced some of the smallest temperature increases over this period.

Temperatures are projected to rise another 2°F to 4°F in most areas of the U.S. over the next few decades. Reductions in some short-lived human-induced emissions that contribute to warming, such as black carbon (soot) and methane, could reduce some of the projected warming over the next couple of decades, because, unlike carbon dioxide, these gases and particles have relatively short atmospheric lifetimes.

The amount of warming projected beyond the next few decades is directly linked to the cumulative global emissions of heat-trapping gases and particles. By the end of this century, a roughly 3°F to 5°F rise is projected under a lower emissions scenario, which would require substantial reductions in emissions (referred to as the "B1 scenario"), and a 5°F to 10°F rise for a higher emissions scenario assuming continued increases in emissions, predominantly from fossil fuel combustion (referred to as the "A2 scenario"). These projections are based on results from 16 climate models that used the two emissions scenarios in a formal inter-model comparison study. The range of model projections for each emissions scenario is the result of the differences in the ways the models represent key factors such as water vapor, ice and snow reflectivity, and clouds, which can either dampen or amplify the initial effect of human influences on temperature. The net effect of these feedbacks is expected to amplify warming. More information about the models and scenarios used in this report can be found in Appendix 5: Scenarios and Models. (Ch. 2)



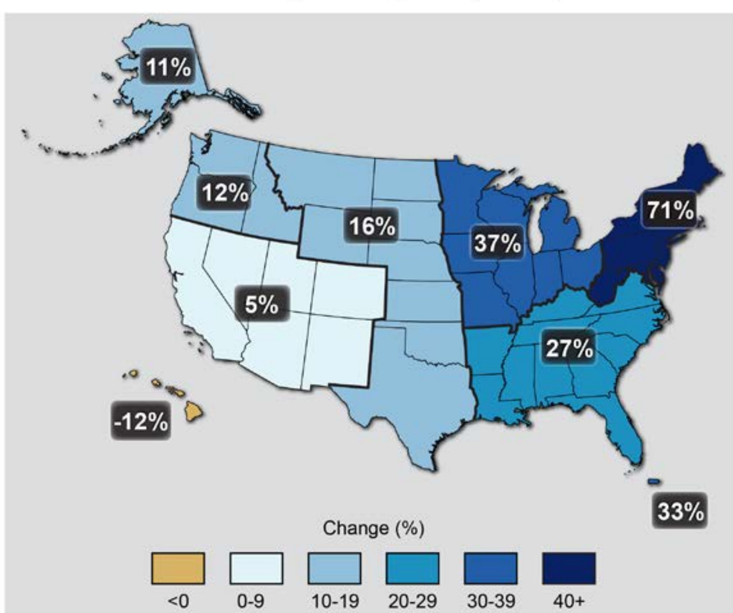
Projected warming under the two main emissions scenarios used in this assessment.

Prolonged periods of high temperatures and the persistence of high nighttime temperatures have increased in many locations over the past half century. High nighttime temperatures have widespread impacts because people, livestock, and wildlife get no respite from the heat. In some regions, prolonged periods of high temperatures associated with droughts contribute to conditions that lead to larger wildfires and longer fire seasons. As expected in a warming climate, recent trends show that extreme heat is becoming more common, while extreme cold is becoming less common. Evidence indicates that the human influence on climate has already roughly doubled the probability of extreme heat events such as the record-breaking summer heat experienced in 2011 in Texas and Oklahoma. The incidence of record-breaking high temperatures is projected to rise. (Ch. 2, 3, 6, 9, 20)

Human-induced climate change means much more than just hotter weather. Increases in ocean and freshwater temperatures, frost-free days, and heavy downpours have all been documented. Global sea level has risen, and there have been large reductions in snow-cover extent, glaciers, and sea ice. These changes and other climatic changes have affected and will continue to affect human health, water supply, agriculture, transportation, energy, coastal areas, and many other sectors of society, with increasingly adverse impacts on the American economy and quality of life. (Ch. 2, 3, 4, 5, 6, 9, 10, 12, 16, 20, 24, 25)

Some of the changes discussed in this report are common to many regions. For example, large increases in heavy precipitation have occurred in the Northeast, Midwest, and Great Plains, where heavy downpours have frequently led to runoff that exceeded the capacity of storm drains and levees, and caused flooding events and accelerated erosion. Other impacts, such as those associated with the rapid thawing of permafrost in Alaska, are unique to a particular U.S. region. Permafrost thawing is causing extensive damage to infrastructure in our nation's largest state. (Ch. 2, 12, 16, 18, 19, 20, 21, 22, 23)

Observed Change in Very Heavy Precipitation



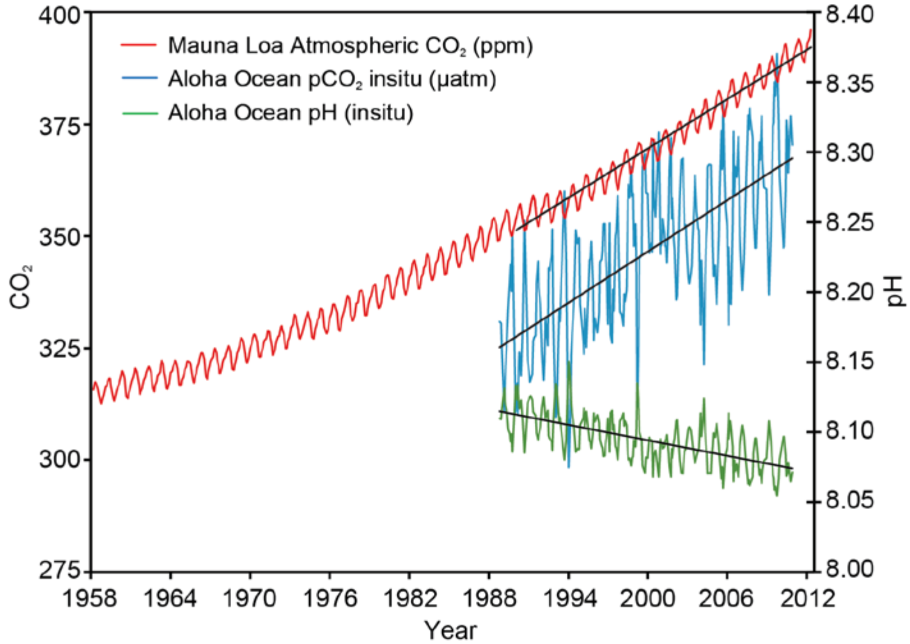
Percent changes in the amount of precipitation falling in very heavy events (the heaviest 1%) from 1958 to 2012 for each region. There is a clear national trend toward a greater amount precipitation being concentrated in very heavy events, particularly in the Northeast and Midwest.

Some impacts that occur in one region ripple beyond that region. For example, the dramatic decline of summer sea ice in the Arctic – a loss of ice cover roughly equal to half the area of the continental U.S. – exacerbates global warming by reducing the reflectivity of Earth's surface and increasing the amount of heat absorbed. Similarly, smoke from wildfires in one location can trigger poor air quality in far-away regions, and new evidence suggests the particulate matter affects atmospheric circulation and therefore weather patterns. Major storms and the higher storm surges exacerbated by sea level rise that hit the Gulf Coast affect the entire country through their cascading effects on oil and gas production and distribution. (Ch. 2, 4, 12, 16, 17, 18, 19, 20, 22, 25)

Water expands as it warms, causing global sea levels to rise; melting of land-based ice also raises sea level by adding water to the oceans. Over the past century, global average sea level has risen by about 8 inches. Since 1992, the rate of global sea level rise, as measured by both tide gauges and satellites, has been at least 50% greater than the rate observed since the early 1900s. Sea level rise, combined with coastal storms, has increased the risk of erosion, storm-surge damage, and flooding for coastal communities, especially along the Gulf Coast, the Atlantic seaboard, and in Alaska. Coastal infrastructure, including roads, rail lines, energy infrastructure, airports, port facilities, and military bases, are increasingly at risk from sea level rise and damaging storm surges. Sea level is projected to rise by another 1 to 4 feet in this century, although the rise in sea level in specific regions is expected to vary from this global average for a number of reasons. A wider range of scenarios, from 8 inches to more than 6 feet by 2100, has been used in risk-based analyses in this report. In general, higher emissions scenarios that lead to more warming would be expected to lead to higher amounts of sea level rise. The stakes are high, as nearly five million Americans and hundreds of billions of dollars of property are located in areas that are less than four feet above the local high-tide level. (Ch. 2, 4, 5, 10, 12, 16, 17, 20, 22, 25)

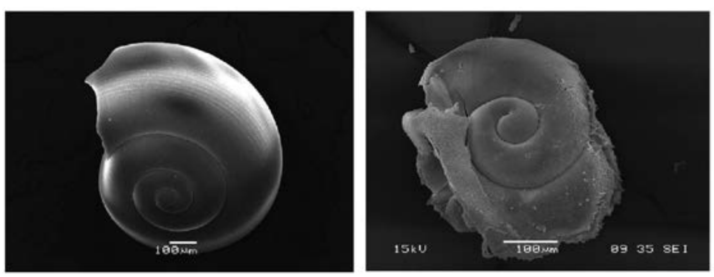
In addition to changing climate, increasing levels of carbon dioxide from the burning of fossil fuels and other human activities have a direct effect on the world's oceans. Carbon dioxide interacts with ocean water to form carbonic acid, increasing the ocean's acidity. Ocean surface waters have become 30% more acidic as they have absorbed large amounts of carbon dioxide from the atmosphere. This ocean acidification makes water more corrosive, reducing the capacity of marine organisms with shells or skeletons made of calcium carbonate (such as corals, krill, oysters, clams, and crabs) to survive, grow, and reproduce, which in turn will affect the marine food chain. (Ch. 2, 12, 23, 24, 25)

As Oceans Absorb CO_2, They Become More Acidic



The correlation between rising levels of carbon dioxide in the atmosphere with rising carbon dioxide levels and falling pH in the ocean. As carbon dioxide accumulates in the ocean, the water becomes more acidic (the pH declines).

Shells Dissolve in Acidified Ocean Water



Pteropods, or "sea butterflies," are eaten by a variety of marine species ranging from tiny krill to salmon to whales. The photos show what happens to a pteropod's shell in seawater that is too acidic. On the left is a shell from a live pteropod from a region in the Southern Ocean where acidity is not too high. The shell on the right is from a pteropod in a region where the water is more acidic.

Climate change: an added stress

Impacts related to climate change are already evident in many regions and sectors, and are expected to become increasingly disruptive across the nation throughout this century and beyond. Climate changes interact with other environmental and societal factors in ways that can either moderate or intensify these impacts.

Some climate changes currently have beneficial effects for specific sectors or regions. For example, current benefits of warming include longer growing seasons for agriculture and longer ice-free periods for shipping on the Great Lakes. At the same time, however, longer growing seasons, along with higher temperatures and carbon dioxide levels, can increase pollen production, intensifying and lengthening the allergy season. Longer ice-free periods on the Great Lakes can result in larger lake-effect snowfalls.

Observed climate change impacts vary across the regions of the U.S. Selected observed impacts emphasized in the regional chapters are shown below and many more are explored in detail in this report.

Northeast	Heat waves, coastal flooding due to sea level rise and storm surge, and river flooding due to more extreme precipitation events are affecting communities.
Southeast and Caribbean	Decreased water availability, exacerbated by population growth and land-use change, is causing increased competition for water. Risks associated with extreme events like hurricanes are increasing.
Midwest	Longer growing seasons and rising carbon dioxide levels are increasing yields of some crops, although these benefits have already been offset in some instances by occurrence of extreme events such as heat-waves, droughts, and floods.
Great Plains	Rising temperatures are leading to increased demand for water and energy and impacts on agricultural practices.
Southwest	Drought and increased warming have fostered wildfires and increased competition for scarce water resources for people and ecosystems.
Northwest	Changes in the timing of streamflow related to earlier snowmelt are reducing the supply of water in summer, causing far-reaching ecological and socioeconomic consequences.
Alaska	Summer sea ice is receding rapidly, glaciers are shrinking, and permafrost is thawing, causing damage to infrastructure and major changes to ecosystems. Impacts to Alaska native communities are increasing.
Hawaii and Pacific Islands	Increasingly constrained freshwater supplies, coupled with increased temperatures, are stressing both people and ecosystems, and decreasing food and water security.
Coasts	Coastal lifelines, such as water supply infrastructure and evacuation routes, are increasingly vulnerable to higher sea levels and storm surges, inland flooding, and other climate-related changes.
Oceans	The oceans are currently absorbing about a quarter of human-caused carbon dioxide emissions to the atmosphere and over 90% of the heat associated with global warming, leading to ocean acidification and the alteration of marine ecosystems.

Sectors affected by climate changes include agriculture, water, human health, energy, transportation, forests, and ecosystems. Climate change poses a major challenge to U.S. agriculture because of the critical dependence of agricultural systems on climate. Climate change has the potential to both positively and negatively affect the location, timing, and productivity of crop, livestock, and fishery systems at local, national, and global scales. The U.S. produces nearly $330 billion per year in agricultural commodities. This productivity is vulnerable to direct impacts on crops and livestock from changing climate conditions and extreme weather events and indirect impacts through increasing pressures from pests and pathogens. Climate change will also alter the stability of food supplies and create new food security challenges for the U.S. as the world seeks to feed nine billion people by 2050. While the agriculture sector has proven to be adaptable to a range of stresses as evidenced by continued growth in production and efficiency across the U.S., climate change poses a new set of challenges. (Ch. 2, 12, 13, 14, 18, 19)

Water quality and quantity are being affected by climate change. Changes in precipitation and runoff, combined with changes in consumption and withdrawal, have reduced surface and groundwater supplies in many areas. These trends are expected to continue, increasing the likelihood of water shortages for many uses. Water quality is diminishing, particularly due to sediment and contaminant concentrations after heavy downpours. Sea level rise, storms and storm surges, and changes in surface and groundwater use patterns are expected to compromise the sustainability of coastal freshwater aquifers and wetlands. In most U.S. regions, water resources managers and planners will encounter new risks, vulnerabilities, and opportunities that may not be properly managed with existing practices. (Ch. 2, 3, 12, 16, 17, 18, 19, 20, 21, 23)

Climate change affects human health in many ways. For example, increasingly frequent and intense heat events lead to more heat-related illnesses and deaths, and over time, worsen drought and wildfire risks, and intensify air pollution. Increasingly frequent extreme precipitation and associated flooding can lead to injuries and increases in water-borne disease. Rising sea surface temperatures have been linked with increasing levels and ranges of diseases. And rising sea levels intensify coastal flooding and storm surge, and thus exacerbate threats to public safety during storms. Certain groups of people are more vulnerable to the range of climate change related health impacts, including the elderly, children, the poor, and the sick. Others are vulnerable because of where they live, including those in floodplains, coastal zones, and some urban areas. Improving and properly supporting the public health infrastructure will be critical to managing the potential health impacts of climate change. (Ch. 2, 9, 11, 12, 13, 16, 18, 19, 20, 25)

Climate change also affects the living world, including people, through changes in ecosystems and biodiversity. Ecosystems provide a rich array of benefits and services to humanity, including habitat for fisheries and wildlife, drinking water storage and filtration, fertile soils for growing crops, buffering against a range of climate change impacts, and aesthetic and cultural values. These benefits are not always easy to quantify, but they support jobs, economic growth, health, and human well-being. Climate change driven disruptions to ecosystems have direct and indirect human impacts, including reduced water supply and quality, the loss of iconic species and landscapes, effects on food chains and the timing and success of species migrations, and the potential for extreme weather and climate events to destroy or degrade the ability of ecosystems to provide societal benefits. (Ch. 3, 6, 8, 12, 14, 23, 24, 25)

Human modifications of ecosystems and landscapes often increase their vulnerability to damage from extreme weather events, while simultaneously reducing their natural capacity to moderate the impacts of such events. For example, salt marshes, reefs, mangrove forests, and barrier islands defend coastal ecosystems and infrastructure, such as roads and buildings, against storm surges. The loss of these natural buffers due to coastal development, erosion, and sea level rise increases the risk of catastrophic damage during or after extreme weather events. Although floodplain wetlands are greatly reduced from their historical extent, those that remain still absorb floodwaters and reduce the effects of high flows on river-margin lands. Extreme weather events that produce sudden increases in water flow, often carrying debris and pollutants, can decrease the natural capacity of ecosystems to cleanse contaminants. (Ch. 3, 7, 8, 25)

The climate change impacts being felt in the regions and sectors of the United States are affected by global trends and economic decisions. In an increasingly interconnected world, U.S. vulnerability is linked to the fates of other nations. It is thus difficult to fully evaluate the impacts of climate change on the U.S. without considering consequences of climate change elsewhere.

Response Options

As the impacts of climate change are becoming more prevalent, Americans face choices. Especially because of past emissions of long-lived heat-trapping gases, some additional climate change and related impacts are now unavoidable. This is due to the long-lived nature of many of these gases, as well as the amount of heat absorbed and retained by the oceans and other responses within the climate system. The amount of future climate change, however, will still largely be determined by choices society makes about emissions. Lower emissions of heat-trapping gases and particles mean less future warming and less-severe impacts; higher emissions mean more warming and more severe impacts. Efforts to limit emissions or increase carbon uptake fall into a category of response options known as "mitigation," which refers to reducing the amount and speed of future climate change by reducing emissions of heat-trapping gases or removing carbon dioxide from the atmosphere. (Ch. 2, 26, 27)

The other major category of response options is known as "adaptation," and refers to actions to prepare for and adjust to new conditions, thereby reducing harm or taking advantage of new opportunities. Mitigation and adaptation actions are linked in multiple ways, including that effective mitigation reduces the need for adaptation in the future. Both are essential parts of a comprehensive climate change response strategy. The threat of irreversible impacts makes the timing of mitigation efforts particularly critical. This report includes chapters on Mitigation, Adaptation, and Decision Support that offer an overview of the options and activities being planned or implemented around the country as local, state, federal, and tribal governments, as well as businesses, organizations, and individuals begin to respond to climate change. These chapters conclude that while response actions are under development, current implementation efforts are insufficient to avoid increasingly negative social, environmental, and economic consequences. (Ch. 26, 27, 28)

Large reductions in global heat-trapping gas emissions similar to the lower emissions scenario (B1) analyzed in this assessment would reduce the risks of some of the worst impacts of climate change. The targets called for in international climate negotiations would require even larger reductions than those outlined in that scenario (Figure 1.1). Meanwhile, global emissions are still rising, and are on track to be even higher than the high emissions scenario (A2) analyzed in this report. The recent U.S. contribution to annual global emissions is about 16%, but the U.S. contribution to cumulative global emissions over the last century is much higher. Because carbon dioxide lasts for a long time in the atmosphere, it is the cumulative carbon emissions that determine the amount of global climate change. The recent reduction in use of coal and increase in natural gas for electricity generation, and governmental actions in city, state, regional, and federal programs to promote energy efficiency have contributed to reducing U.S. carbon emissions in the last few years. Some of these actions are motivated by climate concerns, sometimes with non-climate benefits, while others are motivated primarily by non-climate objectives. These U.S. actions and others that might be undertaken in the future are described in the Mitigation chapter of this report. The current actions are not sufficient to reduce total U.S. emissions to a level that would be consistent with the lower (B1) scenario used in this report. (Ch. 2, 4, 27)

With regard to adaptation, the pace and magnitude of observed and projected changes emphasize the need to be prepared for a wide variety and intensity of impacts. Because of the growing influence of human activities, the climate of the past is not a good basis for future planning. For example, building codes and landscaping ordinances could be updated to improve energy efficiency, conserve water supplies, protect against insects that spread disease (such as dengue fever), reduce susceptibility to heat stress, and improve protection against extreme events. The fact that climate change impacts are increasing points to the urgent need to develop and refine approaches that enable decision-making and increase flexibility and resilience in the face of ongoing and future impacts. Reducing non-climate related stresses that cause existing vulnerabilities can be an effective approach to climate change adaptation. (Ch. 2, 3, 5, 9, 11, 12, 13, 25, 26, 27, 28)

Adaptation considerations include local, state, regional, national, and international jurisdictional issues. For example, in managing water supplies to adapt to a changing climate, the implications of international treaties should be considered in the context of managing the Great Lakes, the Columbia River, and the Colorado River to deal with increased drought risk. Both “bottom up” community planning and “top down” national strategies may help regions deal with impacts such as increases in electrical brownouts, heat stress, floods, and wildfires. (Ch. 3, 7, 9, 10, 12, 18, 20, 21, 26, 28)

Proactively preparing for both climate variability and climate change can reduce impacts while also facilitating a more rapid and efficient response to changes as they happen. Such efforts are beginning at the federal, regional, state, tribal, and local levels, and in the corporate and non-governmental sectors, to build adaptive capacity and resilience to climate change impacts. Using scientific information to prepare for climate changes in advance can provide economic opportunities, and proactively managing the risks can reduce impacts and costs over time. (Ch. 28)

This report identifies a number of areas where improved scientific information or understanding would enhance the capacity to estimate future climate change impacts. For example, knowledge of the mechanisms controlling the rate of ice loss in Greenland and Antarctica is limited, making it difficult for scientists to narrow the range of expected future sea level rise. Research on ecological responses to climate change is also limited, as is understanding of social responses and how ecological and social responses will interact. (Ch. 29, Appendix 6)

A sustained climate assessment process could more efficiently collect and synthesize the rapidly evolving science and help supply timely and relevant information to decision-makers. Results from all of these efforts could continue to deepen our understanding of the interactions of human and natural systems in the context of a changing climate, enabling society to effectively respond and prepare for our future. (Ch. 30)

The cumulative weight of the scientific evidence contained in this report confirms that climate change is affecting the American people now, and that choices we make will affect our future and that of future generations.

Report Findings

These findings distill important results that arise from this assessment. They do not represent a full summary of all of the chapters' findings, but rather, a synthesis of particularly noteworthy conclusions.

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

Many independent lines of evidence confirm that human activities are affecting climate in unprecedented ways. U.S. average temperature has increased by about 1.5°F since record keeping began in 1895; most of this increase has occurred since about 1970. The most recent decade was the warmest on record. Because human-induced warming is superimposed on a naturally varying climate, rising temperatures are not evenly distributed across the country or over time. (Ch. 2, Appendices 3 and 4)

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

Changes in extreme weather events are the primary way that most people experience climate change. Human-induced climate change has already increased the number and strength of some of these extreme events. Over the last 50 years, much of the U.S. has seen an increase in prolonged periods of excessively high temperatures, more heavy downpours, and in some regions, more severe droughts. (Ch. 2, 16, 17, 18, 19, 20, 23, Appendices 3 and 4).

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

Heat-trapping gases already in the atmosphere have committed us to a hotter future with more climate-related impacts over the next few decades. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases that human activities emit globally, now and in the future. (Ch. 2, 27, Appendices 3 and 4)

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

Climate change is already affecting societies and the natural world. Climate change interacts with other environmental and societal factors in ways that can either moderate or intensify these impacts. The types and magnitudes of impacts vary across the nation and through time. Children, the elderly, the sick, and the poor are especially vulnerable. There is mounting evidence that harm to the nation will increase substantially in the future unless global emissions of heat-trapping gases are greatly reduced. (Ch. 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25)

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

Climate change is increasing the risks of heat stress, respiratory stress from poor air quality, and the spread of waterborne diseases. Extreme weather events often lead to fatalities and a variety of health impacts on vulnerable populations, including impacts on mental health, such as anxiety and post-traumatic stress disorder. Large-scale changes in the environment due to climate change and extreme weather events are increasing the risk of the emergence or reemergence of health threats that are currently uncommon in the U.S., such as dengue fever. (Ch. 2, 6, 9, 11, 12, 16, 19, 20, 22, 23)

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

Sea level rise, storm surge, and heavy downpours, in combination with the pattern of continued development in coastal areas, are increasing damage to U.S. infrastructure including roads, buildings, and industrial facilities, and are also increasing risks to ports and coastal military installations. Flooding along rivers, lakes, and in cities following heavy downpours, prolonged rains, and rapid melting of snowpack is exceeding the limits of flood protection infrastructure designed for historical conditions. Extreme heat is damaging transportation infrastructure such as roads, rail lines, and airport runways. (Ch. 2, 3, 5, 6, 11, 12, 16, 17, 18, 19, 20, 21, 22, 23, 25)

7. **Water supply reliability is jeopardized by climate change in a variety of ways that affect ecosystems and livelihoods.**

Surface and groundwater supplies in some regions are already stressed by increasing demand for water as well as declining runoff and groundwater recharge. In some regions, particularly the southern part of the country and the Caribbean and Pacific islands, climate change is increasing the likelihood of water shortages and competition for water among its many uses. Water quality is diminishing, particularly due to sediment and contaminant concentrations after heavy downpours. (Ch. 2, 3, 12, 16, 17, 18, 19, 20, 21, 23)

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

Some areas are already experiencing climate-related disruptions, particularly due to extreme weather events. While some U.S. regions and agricultural producers may be relatively resilient to climate change over the next 25 years or so, others will increasingly suffer from stresses due to extreme heat, drought, disease, and heavy downpours. From mid-century on, climate change is projected to have more negative impacts on crops and livestock across the country – a trend that would diminish the security of our food supply. (Ch. 2, 6, 12, 13, 14, 18, 19)

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

Chronic stresses such as extreme poverty are being exacerbated by climate change impacts such as reduced access to traditional foods, decreased water quality, and increasing exposure to health and safety hazards. In parts of Alaska, Louisiana, the Pacific Islands, and other coastal locations, climate change impacts (through erosion and inundation) are so severe that some communities are already relocating from historical homelands to which their traditions and cultural identities are tied. Particularly in Alaska, the rapid pace of temperature rise, ice and snow melt, and permafrost thaw is significantly affecting critical infrastructure and traditional livelihoods. (Ch. 12, 17, 20, 21, 22, 23, 25)

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

Climate change impacts on biodiversity are already being observed in alteration of the timing of critical biological events such as spring bud burst and substantial range shifts of many species. In the longer term, there is an increased risk of species extinction. These changes have social, cultural, and economic effects. Events such as droughts, floods, wildfires, and pest outbreaks associated with climate change (for example, bark beetles in the West) are already disrupting ecosystems. These changes limit the capacity of ecosystems, such as forests, barrier beaches, and wetlands, to continue to play important roles in reducing the impacts of these extreme events on infrastructure, human communities, and other valued resources. (Ch. 2, 3, 6, 7, 8, 10, 11, 14, 15, 19, 25)

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

More acidic waters inhibit the formation of shells, skeletons, and coral reefs. Warmer waters harm coral reefs and alter the distribution of many marine species. The rising temperature and changing chemistry of ocean water combine with other stresses, such as overfishing and coastal and marine pollution, to reduce marine-based food production and harm fishing communities. (Ch. 2, 12, 23, 24, 25)

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

Actions to reduce emissions, increase carbon uptake, adapt to projected changes, and increase resilience to impacts that are unavoidable can improve public health, economic development, ecosystem protection, and quality of life. (Ch. 6, 7, 8, 9, 10, 13, 15, 25, 26, 27, 28)