

Summary of Key Points

Greenhouse Gases

Human activities have substantially increased the amount of greenhouse gases in the atmosphere, leading to warming of the climate and many other changes around the world—effects that will persist over a long time.



U.S. Greenhouse Gas Emissions. In the United States, greenhouse gas emissions caused by human activities increased by 10 percent from 1990 to 2010. Carbon dioxide accounts for most of the nation’s emissions and most of this increase. Electricity generation is the largest source of greenhouse gas emissions in the United States, followed by transportation. Emissions per person have decreased slightly in the last few years.



Global Greenhouse Gas Emissions. Worldwide, emissions of greenhouse gases from human activities increased by 26 percent from 1990 to 2005. Emissions of carbon dioxide, which account for nearly three-fourths of total emissions, increased by 31 percent over this period. As with the United States, the majority of the world’s emissions result from energy production and use.



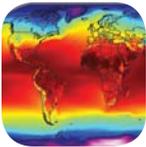
Atmospheric Concentrations of Greenhouse Gases. Concentrations of carbon dioxide and other greenhouse gases in the atmosphere have increased since the beginning of the industrial era. Almost all of this increase is attributable to human activities.¹ Historical measurements show that current levels of many greenhouse gases are higher than any levels recorded for hundreds of thousands of years, even after accounting for natural fluctuations.



Climate Forcing. Climate or “radiative” forcing is the measurement of how substances such as greenhouse gases affect the amount of energy absorbed by the atmosphere. An increase in radiative forcing means a heating effect, which leads to warming, while a decrease in forcing produces cooling. From 1990 to 2011, the total radiative forcing from greenhouse gases added by humans to the Earth’s atmosphere increased by 30 percent. Carbon dioxide has accounted for approximately 80 percent of this increase.

Weather and Climate

Variations in weather and climate cause changes in temperature, precipitation, and extreme event patterns, which can directly or indirectly affect many aspects of society.



U.S. and Global Temperature. Average temperatures have risen across the contiguous 48 states since 1901, with an increased rate of warming over the past 30 years. Seven of the top 10 warmest years on record have occurred since 1990. Recent compilations of the change in global average temperatures show a similar trend, and 2001–2010 was the warmest decade on record worldwide. Within the United States, temperatures in parts of the North, the West, and Alaska have increased the most.



High and Low Temperatures. Since the 1970s, unusually hot summer temperatures have become more common in the United States, and heat waves have become more frequent. In contrast, extremely cold winter temperatures have become less common. The most recent decade has had twice as many record high temperatures as record lows. The most severe heat waves in U.S. history remain those that occurred during the “Dust Bowl” in the 1930s.



U.S. and Global Precipitation. Total annual precipitation has increased in the United States and over land areas worldwide. Since 1901, precipitation has increased at an average rate of nearly 6 percent per century in the contiguous 48 states and more than 2 percent per century over land areas worldwide. However, shifting weather patterns have caused certain areas, such as Hawaii and parts of the Southwest, to experience less precipitation than usual.



Heavy Precipitation. In recent years, a higher percentage of precipitation in the United States has come in the form of intense single-day events. Nationwide, eight of the top 10 years for extreme one-day precipitation events have occurred since 1990. The occurrence of abnormally high annual precipitation totals (as defined by the National Oceanic and Atmospheric Administration) has also increased.



Drought. Average drought conditions across the nation have varied since records began in 1895. The 1930s and 1950s saw the most widespread droughts, while the last 50 years have generally been wetter than average. However, specific trends vary by region. A more detailed index developed recently shows that between 2000 and 2011, roughly 30 to 60 percent of the U.S. land area experienced drought conditions at any given time.



Tropical Cyclone Activity. Tropical storm activity in the Atlantic Ocean, Caribbean, and Gulf of Mexico has increased during the past 20 years. This increase is closely related to variations in sea surface temperature in the tropical Atlantic. However, changes in observation methods over time make it difficult to know for sure whether a long-term increase has occurred. Records collected since the late 1800s suggest that the actual number of hurricanes per year has not increased.

Oceans

Changes in ocean temperature, sea level, and seawater chemistry have implications for coastal communities and could substantially alter the biodiversity and productivity of ocean ecosystems.



Ocean Heat. Several studies have shown that the amount of heat stored in the ocean has increased substantially since the 1950s. Ocean heat content not only determines sea surface temperature, but also affects sea level and currents.



Sea Surface Temperature. Ocean surface temperatures increased around the world over the 20th century. Even with some year-to-year variation, the overall increase is statistically significant, and sea surface temperatures have been higher during the past three decades than at any other time since reliable observations began in the late 1800s.



Sea Level. When averaged over all the world's oceans, sea level has increased at a rate of roughly seven-tenths of an inch per decade since 1880. The rate of increase has accelerated in recent years to more than an inch per decade. Changes in sea level relative to the height of the land vary widely because the land itself moves. Along the U.S. coastline, sea level has risen the most relative to the land along the Mid-Atlantic coast and parts of the Gulf Coast. Sea level has decreased relative to the land in parts of Alaska and the Northwest.



Ocean Acidity. The ocean has become more acidic over the past 20 years because of increased levels of atmospheric carbon dioxide, which in turn dissolves in the water. Higher acidity has led to decreased availability of minerals such as aragonite, which is an important form of calcium carbonate that many marine animals use to build their skeletons and shells.

Snow and Ice

Climate change can dramatically alter the Earth's snow- and ice-covered areas, affecting vegetation and wildlife, water supplies and transportation, and communities in Arctic regions.



Arctic Sea Ice. Part of the Arctic Ocean is covered by ice year-round. The area covered by ice is typically smallest in September, after the summer melting season. The minimum extent of Arctic sea ice has decreased over time, and in September 2012 it was the smallest on record. Arctic ice has also become thinner, which makes it more vulnerable to additional melting.



Glaciers. Glaciers in the United States and around the world have generally shrunk since the 1960s, and the rate at which glaciers are melting has accelerated over the last decade. The loss of ice from glaciers has contributed to the observed rise in sea level.



Lake Ice. Lakes in the northern United States generally appear to be freezing later and thawing earlier than they did in the 1800s and early 1900s. The length of time that lakes stay frozen has decreased at an average rate of one to two days per decade.



Snowfall. Total snowfall has decreased in most parts of the country since widespread records began in 1930. One reason for this decline is that more than three-fourths of the locations studied have seen more winter precipitation fall in the form of rain instead of snow.



Snow Cover. The portion of North America covered by snow has decreased somewhat since 1972, based on weekly measurements taken throughout the year. However, there has been much year-to-year variability. During the years 2002–2011, the average area covered by snow was 3 percent (roughly 100,000 square miles) smaller than the average extent of snow cover during the first 10 years of measurement (1972–1981).



Snowpack. The depth of snow on the ground (snowpack) in early spring decreased at most measurement sites—some by more than 75 percent—between 1950 and 2000. However, a few locations in the western United States and Canada saw an increase in spring snowpack.

Society and Ecosystems

Climate change could require adaptation on larger and faster scales than in the past, presenting challenges to human well-being, the economy, and natural ecosystems.



Streamflow. Changes in temperature, precipitation, snowpack, and glaciers can affect the amount of water carried by rivers and streams and the timing of peak flow. Over the last 70 years, minimum and maximum flows have changed in many parts of the country—some higher, some lower. Three-fifths of the rivers and streams measured show peak winter-spring runoff happening at least five days earlier than it did in the past.



Ragweed Pollen Season. Warmer temperatures and later fall frosts allow ragweed plants to produce pollen later into the year, potentially prolonging allergy season for millions of people. The length of ragweed pollen season has increased at eight out of 10 locations studied in the central United States and Canada since 1995. The change becomes more pronounced from south to north.



Length of Growing Season. The average length of the growing season in the contiguous 48 states has increased by nearly two weeks since the beginning of the 20th century. A particularly large and steady increase has occurred over the last 30 years. The observed changes reflect earlier spring warming as well as later arrival of fall frosts. The length of the growing season has increased more rapidly in the West than in the East.



Leaf and Bloom Dates. Leaf growth and flower blooms are examples of natural events whose timing can be influenced by climate change. Observations of lilacs and honeysuckles in the contiguous 48 states suggest that first leaf growth is now occurring a few days earlier than it did in the early 1900s. Lilac and honeysuckle bloom dates vary greatly from year to year, which makes it difficult to determine whether a statistically meaningful change has taken place.



Bird Wintering Ranges. Some birds shift their range or alter their migration habits to adapt to changes in temperature or other environmental conditions. Long-term studies have found that bird species in North America have shifted their wintering grounds northward by an average of 35 miles since 1966, with a few species shifting by several hundred miles. On average, bird species have also moved their wintering grounds farther from the coast, consistent with rising inland temperatures.



Heat-Related Deaths. Over the past three decades, more than 7,000 Americans were reported to have died as a direct result of heat-related illnesses, such as heat stroke. The annual death rate rises when accounting for other deaths in which heat was reported as a contributing factor. Considerable year-to-year variability in the data and certain limitations of this indicator make it difficult to determine whether the United States has experienced long-term trends in the number of deaths classified as “heat-related.”