

The Impacts of Climate Change: An Overview

Global warming caused by greenhouse gas emissions can no longer be viewed as just a problem for the future. Global temperatures have been steadily rising over the past century or more, and most of the observed warming since the mid-20th century is very likely due to anthropogenic (human-caused) emissions.¹ In 2006, the continental United States experienced the second-hottest year in the past 112 years,² and globally 2005 was the hottest year on record.³ This warming is having damaging impacts today on our environment, health, and livelihoods, and is worsening already dangerous events such as hurricanes, sea-level rise, heat waves, and drought.

The Intergovernmental Panel on Climate Change (IPCC) estimates that if the warming trend continues and the world does not dramatically reduce global warming pollution, under the worst emissions scenario global temperatures could increase by 4°C by the end of the century, with the potential to go as high as 6.4°C.⁴ The IPCC predicts more harmful effects with such temperature increases. For example, a warming of 4°C could lead to the extinction of 40-70% of all species studied worldwide to-date, perhaps within this century.⁵ Increased mortality from heat waves, floods, and droughts, including severe impacts in the United States, are also predicted. (See also the Pew Environment Group's fact sheet, "Key Findings of the IPCC Fourth Assessment Report, 2007.")

Major Global Trends

- *Glacier Loss, Shrinking Sea Ice, and Sea-Level Rise*

Over the last one hundred years, sea levels have been rising at an increasing rate due to thermal expansion (the warming of ocean waters), the melting of glaciers and ice caps, and, very likely, also due to melting of the Antarctic and Greenland ice sheets.⁶ Worldwide glacial retreat increases the flood risk in coastal areas and decreases fresh water supply. In the fall of 2007, Arctic sea ice reached the lowest minimum extent ever recorded, continuing the trend of diminishing sea ice extent since the 1980s and having serious consequences for Arctic wildlife habitat.⁷

Sea levels have already risen at an average rate of about 1.7 centimeters (or 0.67 inches) per year since 1900,⁸ and around 3.1 centimeters (or 1.2 inches) per year since 1993,⁹ for a total rise of about 0.17 meters (or 6.7 inches) over the last one hundred years.¹⁰ The IPCC estimates that a 4°C-rise in temperatures could increase global sea levels an additional 0.26 to 0.59 meters (or 0.85 to 1.9 feet).¹¹ Densely-populated and low-lying deltas, as well as small islands, are especially vulnerable to sea-level rise. A recent analysis found that 300 million people inhabit 40 deltas around the world, and by 2050, one million people in just three major deltas (the Ganges-Brahmaputra delta in Bangladesh, the Mekong delta in Vietnam and the Nile delta in Egypt) will be directly impacted by land loss and coastal erosion.¹² (See also the Pew Environment Group's fact sheet, "National Security and Global Stability in a Warming Climate.")

- *Intense Drought and Severe Heat Waves*

The percentage of Earth's land area stricken by serious drought more than doubled from the 1970s to the early 2000s, and experts attribute nearly half that of change to rising temperatures.¹³ Higher temperatures and decreased precipitation in some areas have contributed to increased drought, as well as changes in sea surface temperatures, wind patterns, snowpack and snow cover.¹⁴

The Earth is also experiencing warmer and fewer cold days and nights, and warmer and more frequent hot days and nights, as well as a rise in the number of heat waves.¹⁵ Prolonged heat waves are a serious threat to human health, especially for the elderly and for people with heart and respiratory problems. One of the most recent examples of dangerous heat waves is the 2003 European heat wave that killed some 35,000 people. Researchers examining that heat wave found it to be far outside the normal range of variability, concluding that “human influence has at least doubled the risk of a heat wave exceeding this threshold magnitude.”¹⁶ In 2007, a Swiss study found that heat waves in Europe have increased in duration to an average of 3 days, with some lasting up to 4.5 days.¹⁷

- *Stronger Hurricanes*

Evidence is mounting that increases in sea surface temperatures and related climatic changes are contributing to increasingly severe hurricanes. In 2005, the journal *Nature* published statistical findings that warmer ocean temperatures caused by global warming are increasing the intensity of hurricanes.¹⁸ Also in 2005, *Science* published a separate study that reported that the occurrence of Category 4 and 5 hurricanes — the strongest categories — has doubled over the last 35 years as sea surface temperatures have increased.¹⁹ The key findings of the *Science* study were later confirmed in a follow-up study in 2006.²⁰ And, a 2007 study by the Georgia Institute of Technology in Atlanta suggested that global warming is increasing the frequency of hurricanes in the Atlantic. The number of Atlantic hurricanes that form each year has doubled over the past century and global warming is largely to blame. The increases coincide closely with rises in sea surface temperatures in the eastern Atlantic tropics.²¹

- *Ocean Acidification*

When atmospheric carbon dioxide (CO₂) is absorbed by the oceans it reacts with seawater to form carbonic acid. Historically, oceans have been able to take up CO₂ without consequence and as part of the natural carbon cycle. But since industrial activity and the burning of fossil fuels have increased emissions, oceans are now unable to adequately absorb the additional atmospheric CO₂. The result has been excess carbonic acid in our oceans, also known as ocean acidification.²² At present, ocean chemistry is changing at least 100 times more rapidly than it has changed during the 650,000 years preceding our industrial era. And, if current emission trends continue, computer models show that the ocean will undergo acidification to an extent and at rates that have not occurred for tens of millions of years.²³

Acidification makes growth and reproduction difficult for many skeleton and shell-building marine species. Corals and microscopic plants and animals at the bottom of the food chain are found to be particularly at risk, with potential consequences for other species that depend on their health. Over time, the acidification could result in major negative impacts on a variety of marine life, with anticipated adverse consequences on commercial fish stocks and the tourism industry. A joint study by the National Oceanographic and Atmospheric Administration, the National Science Foundation, and the U.S. Geological Survey found that “rising atmospheric carbon dioxide (CO₂) concentrations... will affect some of the most fundamental biological and geochemical processes of the sea.”²⁴

Impacts in the United States and North America

- Extreme temperature events in the U.S. are becoming more frequent, with minimum and maximum temperatures increasing in the second half of the 20th century, particularly in urban areas. Multi-day extreme heat waves are also increasing.²⁵ As global warming emissions continue to rise, Americans are likely to face greater risks of injury and mortality due to higher pollution levels, more intense storms, elevated pollen levels, increased likelihood of water and insect-borne diseases, and more frequent and more intense heat waves. Children, the elderly, and the poor are considered to be the most vulnerable to adverse health impacts. On average, the frequency of heat waves in the Midwestern cities of Chicago, Cincinnati, and St. Louis is projected to increase by 36%.²⁶

- Coastal communities and habitats are becoming increasingly vulnerable to wetland loss, beach erosion, property and infrastructure damage, saltwater intrusion, and other problems as human development continues apace in areas seeing rising sea-levels and more intense storms and storm surges. Current adaptation and response readiness are low. Storm impacts are likely to be more severe especially along the Gulf and Atlantic coasts, where any increase in destructiveness of coastal storms threatens significant loss of life and property damage. Alaskan coastlines, too, are already facing significant challenges as some villages require protection or relocation due to encroaching seas.²⁷
- The American West has been experiencing less snowfall, smaller snow packs, and earlier snowmelt as a result of climate change. Snowpack levels have been below average for most of the last sixteen years in the Columbia, Colorado, Missouri, and Rio Grande basins.²⁸ Streamflow in the many watersheds in the West has been declining for decades.²⁹ And, the fraction of annual precipitation falling as rain (rather than snow) increased at 74% of western mountain areas studied from 1949 to 2004.³⁰ Western and southwestern states, already facing increased water scarcity, are expected to experience inadequate and unreliable water supplies as snow pack and streamflow diminish further and evaporation increases, with added stress in the Southwest caused by decreases in precipitation.³¹
- North American forests face more destruction from the increasing incidence of wildfire, insect infestation, and disease, with longer periods of high fire risk and larger areas of burning.³² Wildfires can carry significant impact on state economies. A 1991 fire in Oakland, California caused losses of around \$2.2 billion (in 2005 dollars), and wildfires in San Diego and San Bernardino Counties in 2003 damaged \$2 billion worth of property and infrastructure.³³
- Warmer summertime waters in the Chesapeake Bay and other estuarine systems, and earlier onset of warm temperatures, may lead to an increase in hypoxia, also known as “dead zones,” where reduced concentrations of dissolved oxygen leads to stress and death in aquatic plants and animals.³⁴

¹ IPCC Fourth Assessment Report (IPCC). 2007. Working Group II (WGII), “Summary for Policymakers” (SPM), p. 9. <www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf>.

² 1998 was the hottest year on record in the U.S., 0.1°F warmer than 2006. See: National Climatic Data Center (NCDC), National Oceanic and Atmospheric Administration (NOAA). June 21, 2007. *2006 Annual Climate Review: U.S. Summary*. <www.ncdc.noaa.gov/oa/climate/research/2006/ann/us-summary.html>.

³ 2006 was the fifth warmest year globally, though “statistically insignificant” from 2005. See: NCDC, NOAA. January 11, 2007. *Climate of 2006 – Annual Report*. <www.ncdc.noaa.gov/oa/climate/research/2006/ann/global.html>.

⁴ Relative to 1980-1999. The 4°C is the ‘best estimate’ of the temperature increase that will result from continued fossil-fuel intensive economic growth (the A1FI scenario). See: IPCC. 2007. Working Group I (WGI), SPM, p. 13, Table SPM.3. <www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf>.

⁵ IPCC WGII, “Chapter 4: Ecosystems, their properties, goods and services,” p. 242. <www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter4.pdf>.

⁶ IPCC WGI SPM, pp. 5-7.

⁷ National Snow and Ice Data Center (NSIDC). October 1, 2007. “Arctic Sea Ice Shatters All Previous Lows.” <nsidc.org/news/press/2007_seaiceminimum/20071001_pressrelease.html>.

⁸ IPCC WGI, “Chapter 5: Observations: Oceanic Climate Change and Sea Level,” pp. 387 and 409. <www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter5.pdf>.

⁹ IPCC. 2007. *Climate Change 2007: Synthesis Report*, SPM, p. 1. <www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf>.

¹⁰ IPCC WGI SPM, p. 7.

¹¹ Relative to 1980-1999. IPCC WGI SPM, p. 13.

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- ¹⁵ *Ibid.*
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- ²⁷ IPCC WGII, “Chapter 14: North America,” pp. 622-623. <www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter14.pdf>.
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