Climate Change

How climate change can affect human and natural systems

A summary of key impacts of increasing global temperatures identified by the 2007 IPCC report:

Water
- Billions of people will be exposed to stresses on their water supplies.
- Climate change will exacerbate water stress in some regions and alleviate it in others.
- Developing nations with little capacity to manage water resources will be hardest hit.
- Areas that depend on water supplies stored in glaciers and snow cover (more than 16% of world population) face scarcities as glaciers continue to melt and eventually disappear.

Food
- Increased temperatures, heat waves, precipitation changes, drought, and pests will harm agricultural production over much of the globe, though some regions will benefit.

Coasts
- Coastal populations will be exposed to more flooding, erosion, and inundation from rising sea levels and more intense storms, especially in low-lying areas and on small islands.

Health
- Rising temperatures and heat waves will increase the number of heat-related deaths (outweighing a decrease in deaths from cold exposure).
- Higher ozone levels will increase the frequency of cardiopulmonary disease.
- Climate changes will help spread vector-borne and pathogenic diseases such as malaria, dengue fever, and cholera.
- Increased flooding will harm human health directly, and also indirectly—by facilitating the spread of disease and damaging health infrastructure.

Ecosystems
- About 20% to 30% of plant and animal species are at increased risk of extinction.
- Progressive acidification of the oceans will have negative impacts on marine organisms critical to the ocean food web.
- Widespread mortality of biodiverse coral reefs is expected.
- Decreased rainfall in some regions will increase the risk of wildfires.

Economic Costs
- Damages from climate change are likely to be significant and increase over time. Global mean losses could be 1% to 5% of gross domestic product for a likely 4°C warming over the next century.

The IPCC 2007 report assesses the state of our understanding of climate change. It represents six years of work by 800 contributing authors, 420 lead authors, and 2,500 scientific reviewers, from 130 countries. Here is a summary of significant findings of the report:

While natural forces have influenced Earth’s climate (and always will), human-induced changes in atmospheric greenhouse gas levels are playing an increasingly dominant role.

The significant increase in average global temperatures over the past half-century can be attributed to human activities with a certainty of more than 90 percent.

Temperature rises have already affected various natural systems in many regions.

Continued greenhouse gas emissions at or above current rates would cause further warming and induce climate changes during the 21st century that would very likely be larger than those observed during the 20th century.
Precipitation patterns have changed
WHOI geochemist Scott Donny and colleagues are leading efforts to measure the ocean’s ability to continue to absorb excess greenhouse gases and help offset global warming.

Iron fertilization and the ocean’s “twilight zone”
WHOI biogeochemist Ken Bursneler has shed light on the “twilight zone,” a dim ocean layer that acts as a critical gateway allowing some carbon-filled particles to sink to the depths. The research is key for assessing strategies to mitigate climate change by fertilizing the oceans with iron—to promote blooms of photosynthetic marine plants and transfer more CO₂ from the air to the deep ocean.

Do jelly-like animals help shunt CO₂ to the deep sea?
WHOI biologist Larry Madin and colleagues are investigating salps, small transparent ocean creatures that swarm by the billions. Salps may transport tons of carbon per day from the ocean surface to the deep sea and keep it from re-entering the atmosphere.

Precipitation patterns have changed
Whois physical oceanographer Joe Alford is investigating how rainfall patterns over the ocean are changing. He is using a complex computer model that simulates weather systems, climate, and precipitation over the ocean.

Oceans are warming; salinity is changing
• CO₂ levels have risen 35 percent since the industrial revolu­tion began in the mid-18th century and are likely at their highest levels in the past 20 million years. The main source is the burning of fossil fuels, such as oil, natural gas, and coal.
• Earth’s average temperature has been increasing over the past century (albeit not uniformly), with warming accelerating over the past 50 years. The rate of increase in temperatures began to be measured in the 1850s, 11 have occurred in the past 12 years.
• No known natural forcing can account for the recent severe warming.

How much excess carbon dioxide can the oceans hold?
The WHOI Upper Ocean Processes Group has developed technology to measure the ocean’s response to climate change.

Sea levels are rising
• As ocean temperatures increase, water expands, causing sea levels to rise. Once sea level begins to rise because of thermal expansion, it will continue to do so for centuries regardless of mitigative actions.
• Sea levels have risen 7 inches over the 20th century, and nearly 1.5 inches between 1993 and 2003.

How fast can sea level rise?
WHOI geologist Bill Thompson is examining links between past changes in sea level and climate. Corals are excellent indica­tors of sea level because they must grow in sunlight near the sea surface. Developing new methods to precisely date corals, he is finding that sea level has risen more frequently and abruptly in the past than previously suspected.

Oceans are warming; salinity is changing
• Increased evaporation leaves some areas of the ocean more salty, while increased rainfall adds fresh water to other areas.
• Oceans in the mid- and high latitudes show evidence of fresh­ening, while those in tropical regions have increased in salinity.
• Global mean sea surface temperature increased 0.9°F in the 20th century, and the IPCC stated that “global ocean heat content has increased significantly since the late 1950s.”

Tracking ocean changes over the past half-century
WHOI physical oceanographer Ruth Curry and colleagues are analyzing temperature and salinity data collected throughout the oceans to investigate whether climate change is affecting ocean circulation and the global water cycle, and vice versa.

Monitoring the global water cycle
WHOI physical oceanographer Ray Schmitt and engineer Bob Pettit are designing a self-cleaning sensor to solve the hurdle of fouling. Used on drifters, the sensor will be able to obtain ex­tensive salinity measurements that reveal patterns of evaporation and precipitation over the ocean.

Rising temperatures, rising disease?
WHOI biologist Rebecca Gast is exploring whether warming ocean temperatures, among other factors, may make it easier for human pathogens to survive in coastal waters.

WHOI scientists Don Anderson and Dennis McGillicuddy are investigating links between climate changes and harmful algal blooms.

Extreme weather events are more frequent
• Since 1950, cold days and nights and frost days have become less frequent, while hot days and nights and heat waves have be­come more frequent.
• Warmer air also holds more water vapor, leading to heavy rains, when this higher water-content atmosphere drops its moisture.

Air-sea interactions that drive weather and climate
WHOI physical oceanographers Lisan Yu and Bob Weller are integrating observations from satellites, moorings, ships, and models to advance understanding of critical air-sea exchanges of heat, fresh water, and momentum that affect evaporation and rainfall patterns.

Sensitive but tough sensors to get precise, essential data
The WHOI Upper Ocean Processes Group has developed in­tegrated systems for moorings that can measure heat, sunlight, wind speed and direction, precipitation, barometric pressure, humidity, air temperature, sea surface temperature, and salini­ty—key data computer models needed to calculate climate.

Ice and snow cover are disappearing
• Glaciers are retreating and ice and snow cover are disappearing in many regions around the world.
• Melting ice exposing land or water, both of which reflect less solar radiation than ice. That reinforces rising temperatures, which melt more ice. Once such loops begin, their endpoint is hard to predict.
• Increased melting of the vast Greenland Ice Sheet may make it vulnerable to sudden, catastrophic breakup.

What’s causing the Greenland Ice Sheet to surge?
WHOI geologist Sarah Das has established ice camps on Greenland to investigate a theory that warmer temperatures are creating more and larger lakes atop the ice sheet, which cause fractures in the ice that leak water to the glacial base and lubricate slippage into the sea. Once started, the phenomenon could be hard to reverse.

The Arctic region is vulnerable
• Glaciers are melting, permafrost is thawing, land is subsid­ing, the snow season has shortened, and sea ice is thinning and shrinking.
• Little to no sea ice is expected in the Arctic’s summers by 2100.

Under-ice instruments to reveal Arctic Ocean circulation
WHOI physical oceanographer Al Plueddeman is tracking waters from the Arctic’s icy bottom to the ocean surface. He is using the Arctic Winch, a device that can get sensors in and out of ice-infested surface waters from below.

WHOI physical oceanographer John Toole and Rick Krishak are using temperature-profile data to determine the source of the cold, salty water that shields sea ice from deeper, warmer water that could melt it. Changing climate potentially could cause the halocline to weaken or disappear.

WHOI physical oceanographer Bob Pickart is tracking waters over the Alaskan continental shelf and into the Arctic Ocean in­terior, using the Arctic Winch, a device that can get sensors in and out of ice-infested surface waters from below.

WHOI physical oceanographer Andrey Proshutinsky estab­lished a long-term observing network for the Beaufort Gyre, the “flywheel of Arctic climate,” which alternately holds and releases large amounts of cold, relatively fresh water.

WHOI physical oceanographers John Toole and Rick Krishak are deploying Ice-Tethered Profilers, long-term moorings installed on drifting ice floes that measure water properties be­low and send data back daily.

Will climate change upset the Arctic’s fertile ecosystem?
WHOI biologist Carin Ashjian is investigating the oceanogra­phy and biological conditions that sustain the Arctic’s delic­i­ately balanced food web—from phytoplankton to whales and benthic societies.

Abrupt climate change is a wild card
• For many years it was believed that climate changes have been gradual—that the Earth gradually cycles between glacial periods and warm interglacial periods. We now know this is not always the case.
• Such abrupt climate changes could make future adaptation ex­ tremely difficult, even for the most developed countries.

Past and future ocean and climate changes
WHOI paleoceanographers Jerry McManus and Delia Oppo’s studies of seal floor sediments—and geochemist Laura Robinson’s analyses of deep-sea corals—provide clues to past ocean circula­tion and climate changes, and their potential in the future.

Monitoring the ocean’s response to climate change
WHOI established and maintains Line W, a long-term ocean observatory located in the warm northbound and southbound North Atlantic currents that play a major role in regulating climate.