

Global Climate Change

With the recent bombardment of messages in the popular media on global climate change, many people are confused about what it is and what it can mean for the future of our world. How is Earth's climate changing? What will global climate change do? What is science doing about global climate change?



Ecological Society of America

How is Our Atmosphere Different?

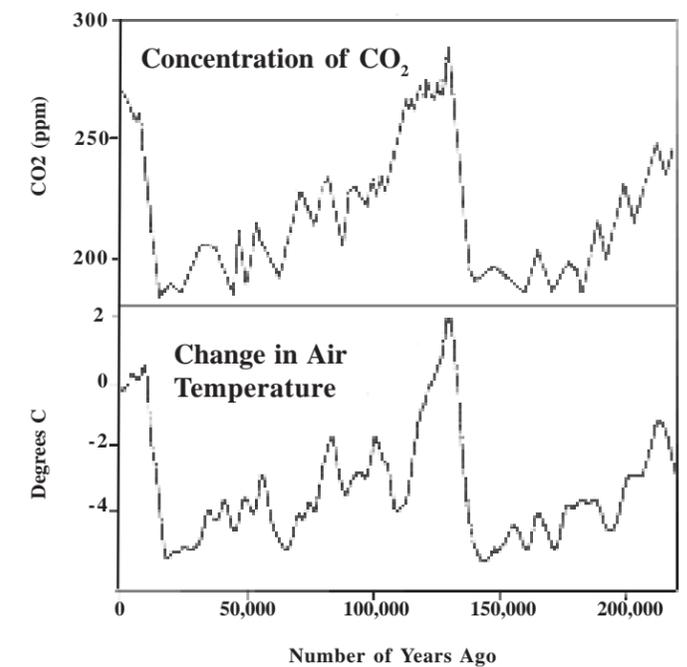
The Earth's atmosphere is a natural greenhouse that keeps the average global temperature around 60 degrees Fahrenheit. Water vapor, carbon dioxide, methane, nitrous oxide, and other trace gases in our atmosphere trap the sun's heat as it is reradiated from the Earth back into space. The natural composition of Earth's atmosphere is appropriate to maintain temperatures conducive to the development and maintenance of life. In the absence of atmospheric carbon dioxide, and other greenhouse gases that trap the incoming heat of the sun, the average global temperature would hover around freezing. Too much carbon dioxide would give us a much warmer atmosphere. For example, with its atmosphere of carbon dioxide, the temperature of the planet Venus is 885 degrees Fahrenheit, compared to 129 degrees Fahrenheit if its carbon dioxide atmosphere were to be removed.



What is Global Climate Change?

Over the past 220,000 years (for which we have records from ice cores of the polar ice caps), glacial and interglacial periods have come and gone as the concentration of atmospheric carbon dioxide has risen and fallen. Changes in the average air temperature have been in direct response to the heat-trapping influence of carbon dioxide (see figure at right).

Why is there concern now for increases in atmospheric carbon dioxide and temperature that have been observed on Earth before? There are two reasons. The first is that the current rise in atmospheric carbon dioxide is due to human activities, mostly the burning of fossil fuels. The second is the rapid rate of carbon dioxide increase, 30% since the beginning of the Industrial Revolution less than 200 years ago. Such an increase has not been experienced before on Earth in all of human history or during the evolution of our current ecosystems. If the past is any indication of the future, we are in for significant global warming.



Variations in atmospheric CO₂ and air temperature at the South Pole. Note that the graph of change in air temperature tracks that of CO₂ concentration. Modified from: J. Jouzel, N. I. Barkov, J. M. Barnola, M. Bender, J. Chappellaz, C. Genthon, V. M. Kotlyakov, V. Lipenkov, C. Lorius, J. R. Petit, D. Raynaud, G. Raisbeck, C. Ritz, T. Sowers, M. Stievenard, F. You and P. You, Extending the Vostok ice-core record of paleoclimate to the penultimate glacial period, *Nature*, 364, 1993, 407-412.

How Much Warming and When?

This is a topic open for some debate as there are still scientific unknowns. Many diverse sciences are involved including meteorology, chemistry, physics, oceanography, and ecology. The focus is on complex systems that do not respond in a straight-forward fashion. Possible outcomes are based on empirical research (conducting experiments), past data, sophisticated models, and an understanding of interactions between systems.

Global models used by scientists project temperature increases of three to eleven degrees Fahrenheit with carbon dioxide increases up to twice the level that existed before industrialization. Due to the number of factors involved, general circulation models are better at modeling changes at a global level rather than locally or regionally. As scientific understanding of climate increases (better understanding of the role of clouds, topography, or the oceans, for example), models will improve and their projections of future climate scenarios will become more accurate.

Many human activities may counteract the warming caused by greater greenhouse gas emissions. Irrigation of agricultural lands, for example, cools local environments. Air pollutants, such as sulfur dioxide from the burning of coal and oil, put aerosol particles in the atmosphere that increase cloudiness, also leading to local and regional cooling. Cities create their own urban heat islands generating climates quite different from surrounding areas that have more trees and grass and less concrete and asphalt.

These effects make it difficult to sort out global from regional influences, how much change has occurred already, and what future changes we can expect. It is indisputable, however, that past changes in temperature correspond with changes in atmospheric carbon dioxide concentrations. Rising temperatures corresponding to increasing atmospheric carbon dioxide concentrations are consistent with the laws of physics.

Despite the uncertainties associated with the timing and extent of global climate change, there is scientific consensus that it is happening. Over 2,500 scientists support the key findings of the United Nation's 1996 Intergovernmental Panel on Climate Change report. Members of professional, scientific societies, such as the Ecological Society of America, have signed a statement supporting as solid science the fact that human-generated greenhouse gas emissions, mainly carbon dioxide, are trapping the Earth's heat like a greenhouse.



What Are Greenhouse Gases?

Greenhouse gases trap the heat of the sun, impacting the temperature on Earth. The four major greenhouse gases are carbon dioxide, methane, nitrous oxide, and fluorocarbons. Carbon dioxide (CO₂) is the largest contributor to global warming. Its primary source is the burning of fossil fuels (such as gas, coal, and oil) for energy and transportation. Changing land-use patterns through agriculture and deforestation also contribute to emissions of CO₂. Sources of methane (CH₄) emissions include rice farming, domestic animals, natural gas and coal production, and landfills. The use of nitrogenous fertilizers, the production of nylon, and sewage treatment plants are all sources of nitrous oxide (N₂O). Fluorocarbon emissions result from human-made chemicals used primarily for refrigeration and insulation.

Increased greenhouse gases may or may not increase local land temperatures, depending on the degree to which local and regional climate is modified by other human actions. But a warmer atmosphere will influence other Earth properties.



Sea levels are expected to rise as global temperatures increase. This could result from melting ice caps and glaciers, as well as from expansion of the oceans as they warm. Rising sea levels could have many impacts including flooding of low-lying islands and coastal areas, beach erosion, and the intrusion of salt water into estuary and wetland ecosystems.

Because oceans play a role in climate regulation, higher ocean temperatures may lead to a number of potential impacts. Warming seas could change the type and abundance of ocean populations--California fishing vessels may catch tropical fish, zooplankton and krill populations may decline, or coral reefs may be damaged.

A warmer atmosphere generally means a more energetic atmosphere. Because more energy means a faster water cycle of rain and snow to evaporation and transpiration, there might be more variability in weather patterns, with an increase in floods and droughts. This could impact agriculture, human health, and property.

An increase in the emission of greenhouse gases could shift the carbon and nitrogen cycles essential to interactions between plants, the atmosphere, and soil. This could have consequences for agriculture, forestry, and the healthy

What Will Global Climate Change Do?

functioning of ecosystems. For example, photosynthetic rates of many plants may be enhanced by increased atmospheric carbon dioxide. Trees and crops could grow faster, especially if other resources are not limiting. Warmer climates may allow agricultural crops to be grown in areas that do not currently support them. Not all plants react the same way to increased carbon dioxide levels. Therefore, some species could gain a relative advantage over others, potentially changing the make-up of natural and agricultural systems.

As temperature and precipitation patterns change, some habitat types may move or change, as would the plants and animals that depend on them. New populations of species may move into some areas and existing populations might move out or be lost. The predicted rate of climate change may cause some populations to become stranded and unable to adapt to changing conditions. Or they may shift ranges as the climate to which they are adapted effectively moves northward or to higher elevations. Other populations may be able to adapt to climatic and habitat changes. Changes in habitats based on climate change have the potential to expand the range of pest species such as weeds and mosquitoes.



If plant and animal populations are lost or redistributed, we may experience a disruption of ecosystem services upon which we depend. These include the production of goods for our consumption (agricultural products, timber, seafood, fish, etc.), as well as services such as the purification of air and water, the creation and maintenance of fertile soils, and the mitigation of floods and drought.

The consequences of all these changes on natural and human-dominated environments will be many and varied. Rarely will the effects of climate change operate alone to influence ecosystems. Instead, climate change will be in addition to current environmental stresses. The world's climate controls many natural functions, from the distribution of species to the production of forests. Changing the climate is essentially an uncontrolled global experiment.



What Is Science Doing?

Scientists of diverse disciplines are investigating the many aspects of global climate change to improve our understanding of the factors associated with this phenomenon. Research is focusing on future greenhouse gas emissions and cycling. Ecologists are investigating how plants, animals, and entire ecosystems respond to increased temperatures and alterations in water and gas cycles. They are also looking at how changes in ecosystems may have feedback impacts on the climate, particularly the rates and regional patterns of climate change. Scientists are exploring how oceans, clouds, pollution, and topography affect both global and regional climate and how to improve the accuracy of climate models.

Technologies and strategies are needed for coping with climate change and its impacts. These can be identified for a number of "intensively managed" systems (agriculture, water resources, developed coastlines), but most are very costly. Fewer options can be identified for natural systems (wetlands, wilderness areas, coral reefs, etc.).

Ecologists have much to contribute to the analysis of the global change problem. They study the effects of climate on a number of ecological processes including plant growth, photosynthesis, and nutrient quality; species distribution and interactions; and decomposition and nutrient cycling.

While scientists continue to improve our knowledge of the potential impacts of climate change, it is not necessary for us to have complete and perfect knowledge to make sound decisions on how to respond to the issue. Changing Earth's climate is unpredictable, and while research is still being conducted to see what the impacts may be, we need to begin moving forward with actions to minimize the rate and extent of global climate change, mitigate existing changes, and adapt to changes as they happen.

Where Can I Get More Information?

- The Ecological Society of America, 1707 H Street, NW, Washington, DC 20006. 202-833-8773. esahq@esa.org; <http://www.esa.org>.
- U.S. Global Change Research Information Office, GCRI User Services, PO Box 1000
61 Route 9W, Palisades, New York 10964. 845-365-8930. help@gcrio.org; <http://www.gcrio.org>.
- U.S. Environmental Protection Agency, Office of Policy, Planning, and Evaluation, Global Warming Program.
<http://www.epa.gov/globalwarming.nsf>
- National Oceanic and Atmospheric Agency, Office of Global Programs, 1100 Wayne Avenue, Suite 1210, Silver Spring, MD 20910. 301-427-2089. <http://www.ogp.noaa.gov>.
- Intergovernmental Panel on Climate Change (IPCC). United Nations Environment Programme and World Meteorological Organization. IPCC Secretariat c/o World Meteorological Organization, 7bis Avenue de la Paix, C.P. 2300, CH- 1211 Geneva 2, Switzerland. +41-22-730-8208. ipcc_sec@gateway.wmo.ch; <http://www.ipcc.ch/>
- United Nations Environment Programme, United Nations Framework Convention on Climate Change, P.O. Box 260124, D-53153, Bonn, Germany. +49-228-815-1000. secretariat@unfccc.int; <http://www.unfccc.int>.