What Is Climate and How Is It Changing?

Photo by Jesse Stanley

Student Reading 1

You have probably seen or heard the term **climate change** in numerous places, from magazines to movies, at school, and at home. Everyone is talking about it. But what exactly is climate change, and how does it relate to our lives?

Climate change refers to any change in climate over time, whether due to natural factors (such as

Exit Glacier in Alaska has receded significantly in the last century. *Photo by Jesse Stanley*

> Eating foods that are grown closer to home can reduce greenhouse gas emissions from transporting food long distances.

volcanic eruptions) or human activities. Climate is average weather (including temperature, precipitation, and wind) over a period of time (from months to millions of years).[1] When we examine weather over many years, climate patterns emerge. Weather events not only make up climate, but they can also be affected by changes to the climate.

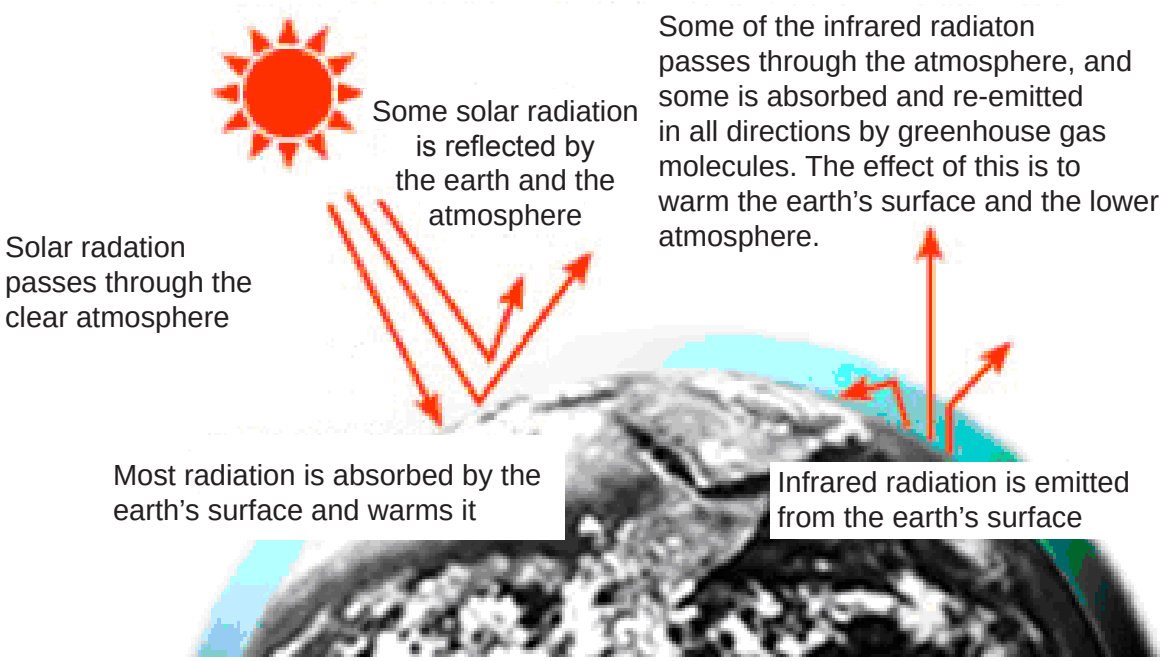
Earth's Greenhouse Effect

To study climate change, we need to understand Earth's **greenhouse effect**. The greenhouse effect is an important phenomenon that makes conditions on Earth suitable for life; without it Earth would be a much colder planet. Some of the sun's radiation that reaches Earth's surface is absorbed by the earth, but some of it is reflected back into space by clouds, air particles, snow, ice, and deserts. When reflected back, the radiation changes into infrared radiation (or heat). Certain gases in Earth's **atmosphere** act like a blanket to retain (and reflect back down to the earth) much of this infrared radiation, making surface temperatures on Earth about 34°C (61°F) warmer than they would be otherwise.[2]

Some **greenhouse gases** occur naturally, and some are man-made. Water vapor is a greenhouse gas that occurs naturally, as a result of Earth's water cycle. Other greenhouse gases such as chlorofluorocarbons (CFCs) are manufactured entirely by humans.

Many greenhouse gases that occur naturally are also released through human activities. For example, carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) are all cycled through Earth's atmosphere during processes that occur in nature. Carbon dioxide is released by all living things, nitrous oxide is released by organisms in the soil, and methane is a natural byproduct of decomposition. Human activities such as burning **fossil fuels** (when we drive gasoline-powered cars, for example) in-

The Greenhouse Effect



Source: United States Environmental Protection Agency

crease the amounts of these gases in Earth's atmosphere, affecting the balance of natural cycles.

Scientists who study climate change often focus on carbon dioxide because the concentration of CO_2 in the atmosphere is greater than any other greenhouse gas, excluding water vapor. CO_2 accounts for 74% of global greenhouse gas emissions from human activities.[3] CO_2 can remain in the atmosphere for up to 200 years.[4]

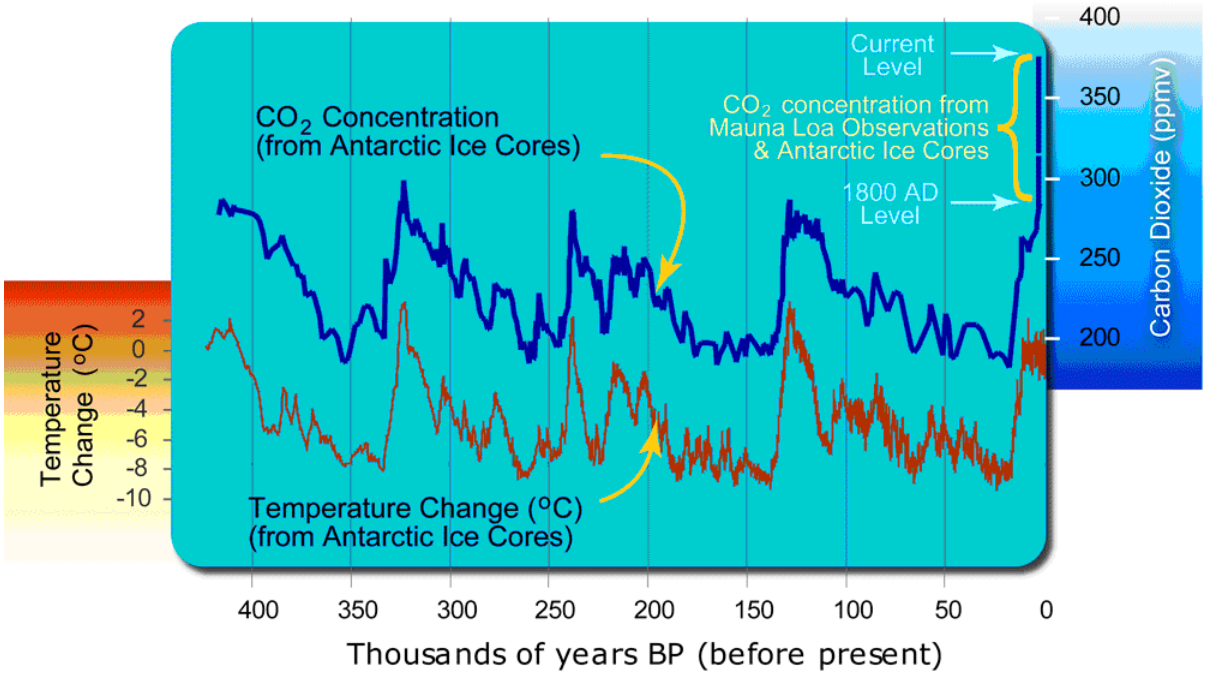
CO_2 levels in the atmosphere have continued to rise since 1750. Because this increase coincides with industrial activities (manufacturing, processing, and transporting goods), many experts attribute the increased CO_2 to humans. The Intergovernmental Panel on Climate Change estimates that CO_2 levels have increased by about 35% during the industrial era, primarily due to deforestation and consumption of fossil fuels.[5]

Carbon Sources and Sinks

Carbon is one of the two elements that make up carbon dioxide (the other is oxygen). Many processes are **carbon sources** that add CO_2 to the atmosphere by emitting more carbon to the atmosphere than they absorb. Carbon sources include burning fossil fuels (coal, petroleum oil, natural gas), deforestation, and agricultural processes, such as tilling soil and raising livestock. Many industrial/manufacturing processes, such as making cement, steel, and agricultural fertilizers, are also carbon sources.[6]

Certain places called **carbon sinks** can retain carbon for a long time, keeping it out of the atmosphere. They tend to absorb more CO_2 than they emit. Forests, oceans, and soil are currently the main carbon sinks on Earth.

We can alter the ability of carbon sinks to retain carbon. For example, when we remove trees from a forest or till soil, the carbon they have been holding is released into



Data Source C02: ftp://cdiac.ornl.gov/pub/trends/co2/vostok.icecore.co2

Data Source Temp: http://cdiac.esd.ornl.gov/ftp/trends/temp/vostok/vostok.1999.temp.dat

Graphic by Michael Ernst, The Woods Hole Research Center

the atmosphere as CO_2. Fossil fuels can also be considered carbon sinks because CO_2 is locked inside them for thousands of years. It is only when we burn them for energy that they release CO_2.

Measuring Carbon Dioxide and Temperature Trends

Historic levels of atmospheric CO_2 can be measured by analyzing ice cores. Tiny gas bubbles trapped deep in the ice provide evidence of many gases present in Earth's atmosphere thousands of years ago. One dataset, from ice cores at the Russian Vostok research station in East Antarctica, has allowed scientists to determine CO_2 levels from over 400,000 years ago.[7]

A much shorter and more recent dataset has been obtained in a different manner, by sampling air from atop a volcano. The world's most complete and continuous CO_2 record has been collected since the 1950s at an observatory near the summit of the Mauna Loa Volcano in the U.S. state of Hawaii.[8] Because this volcano is far from many human activities (a carbon source) and vegetation (a carbon sink), it is an ideal site for accurately measuring CO_2.

Carbon dioxide trends from the Vostok ice cores show that atmospheric CO_2 concentrations have risen faster during the past two centuries than at any time in the preceding 400,000 years.[9] The ice cores reveal a strong link between CO_2 concentrations and temperature changes on Earth. CO2 concentrations measured at Mauna Loa also indicate a steep increase over the past 50 years.

The increasing CO_2 concentrations have numerous documented consequences. Eleven years between 1995 and 2006 are among the twelve hottest years recorded since 1850, when global surface temperatures were first recorded by instruments. Warming air and ocean temperatures have caused snow and ice to melt. Melting glaciers and

The Spirit Lake Community School District in Iowa powers it buildings by using wind turbines. *Photo from Spirit Lake Community School District*

snow have led to sea level rise, resulting in decreased salinity of oceans. Oceans have become more acidic due to increased CO_2 levels. Wind and precipitation patterns have changed in many regions during the past century, resulting in increased rainfall in some places and droughts in others.[10]

Where Do We Fit In?

The exact amount of climate change that can be attributed to human actions is not clear. However, it is clear that increasing greenhouse gas emissions result in warmer global temperatures and that human activities emit greenhouse gases. While climate change may not be due solely to human activities, it is very likely that the changes observed during the past 50 years are not due to natural causes alone.[11]

Is it too late to become part of the solution? No--we already have the knowledge and technology to start making positive changes. For example, a change in lifestyle (consuming fewer resources, conserving energy, reducing travel, etc.) can help mitigate climate change.[12] Switching from fossil fuels to sources of clean, renewable energy sources like wind and solar can reduce greenhouse gas emissions. Even how we eat can make a difference. Eating foods that are grown closer to home can reduce greenhouse gas emissions from transporting food long distances.[13]

Schools, organizations, businesses, cities, and governments around the world are taking steps to respond to the challenges of climate change. These groups are all made up of individuals like you. For better or worse, your actions can have an impact far beyond your own life. You can start making positive changes today to reduce your impact on our climate.

Vocabulary

atmosphere—a layer of gases, including nitrogen, oxygen, and carbon dioxide, surrounding the Earth

carbon sink—a place (ecosystem) or organism that can store carbon for long periods of time; examples include oceans, plants, and other organisms that use carbon dioxide from the atmosphere during photosynthesis

carbon source—anything that adds carbon to the atmosphere by emitting more carbon than it absorbs

climate change – any variation in global or regional long-term weather patterns

fossil fuels—energy sources such as petroleum, coal, and natural gas that are produced by the decomposition of ancient plants and animals

greenhouse effect – process by which gases in Earth's atmosphere retain infrared radiation (heat) from the sun to warm the earth's surface

greenhouse gas—any gas in the atmosphere capable of absorbing infrared radiation (or heat) reflected from the earth's surface

Checking for Understanding

1. How is carbon dioxide related to climate change? Include a discussion of the greenhouse effect in your explanation.
2. List three activities that you did today (or things that you used) that emitted greenhouse gases.
3. List three specific ways that you can personally reduce greenhouse gas emissions.
4. Imagine yourself 50 years from now. What do you want the earth to look like in 50 years?
5. What are some steps you can take now to ensure your vision of the future?

[1]H. Le Treut, et al., "Historical Overview of Climate Change Science," in Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, ed. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller (Cambridge, UK: Cambridge University Press, 2007), 93-128. http://ipcc-wg1.ucar.edu/wg1/wg1-report.html.

[2]Ibid.

[3]U.S. Environmental Protection Agency. 2007. "Global Greenhouse Gas Data," http://www.epa.gov/climatechange/emissions/globalghg.html.

[4]IPCC, "Technical Summary," in Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, ed. J. T. Houghton, Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden and D. Xiaosu (Cambridge, UK: Cambridge University Press, 2001), 21-83. http://www.ipcc.ch/pub/wg1TARtechsum.pdf.

[5]H. Le Treut, et al.

[6]U.S. Environmental Protection Agency. 2007. "Human-Related Sources and Sinks of Carbon Dioxide," http://www.epa.gov/climatechange/emissions/co2_human.html.

[7]See Vostok Ice Core Data on the National Oceanic and Atmospheric Administration's website: http://www.ncdc.noaa.gov/paleo/icecore/antarctica/vostok/vostok.html.

[8]See Mauna Loa Observatory data on the National Oceanic and Atmospheric Administration's website: http://www.mlo.noaa.gov/home.html.

[9]Woods Hole Research Center, The Warming of the Earth, http://www.whrc.org/resources/online_publications/warming_earth/index.htm (accessed September 23, 2007).

[10]IPCC, "Summary for Policymakers," in Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, ed. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H. L. Miller (Cambridge, UK: Cambridge University Press, 2007), 1-18. http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_SPM.pdf.

[11]Ibid.

[12]IPCC, "Summary for Policymakers," in Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, ed. B. Metz, O. R. Davidson, P. R. Bosch, R. Dave, and L. A. Meyer (Cambridge, UK: Cambridge University Press, 2007), 1-23. http://www.mnp.nl/ipcc/pages_media/FAR4docs/final_pdfs_ar4/SPM.pdf.

[13]Paul Rauber, "Decoder: Miles to Go Before You Eat," Sierra Magazine, May 31, 2006. www.sierraclub.org/sierra/200605/decoder.asp