

What is Causing Climate Change?

Executive Summary¹

This module provides an overview of the basic concepts of climate science, such as the role of greenhouse gases in Earth's climate system and their impact on recent warming. Such information is central for understanding the cause of climate change and possible solutions to its impacts, which may come to bear on issues that arise in court cases.

The sun supplies the Earth with energy that heats its surface and atmosphere. That heat is then reradiated from the Earth's surface into the atmosphere. Some of the reradiated heat passes through the atmosphere into space, but most of it is absorbed by the atmosphere and radiates again to warm the Earth (and eventually also to pass into space). That absorption of heat is due to greenhouse gases in the atmosphere, such as carbon dioxide, which capture infrared radiation just as a greenhouse holds heat. Indeed, without any greenhouse gases in the atmosphere, Earth would be much colder and life as it is known would not exist.

Beginning in the mid-1800s, the widespread use of fossil fuels (coal, oil, and gas) for energy resulted in an accelerated growth relative to preindustrial levels of atmospheric carbon dioxide, a byproduct of fossil fuel combustion. Various lines of evidence indicate that the climate has warmed over this time: mean global surface temperature and upper-ocean heat content have increased, Arctic sea-ice cover has declined, northern-hemisphere snow cover has decreased, and global sea level has risen.

By reconstructing past levels of carbon dioxide from air preserved in ice cores, scientists have found that the atmospheric levels ranged from below 200 parts per million (ppm) to approximately 300 ppm over the last 800,000 years. Such shifts took place over thousands of years and were partially responsible for triggering changes in global cold periods (ice ages) and warm periods (interglacial periods). Since the mid-1800s, human emissions have raised atmospheric carbon dioxide levels in very short geologic time by about half to approximately 420 ppm. Carbon dioxide levels had approached that high in the past, approximately three to five million years ago, and in that period average global surface temperature was 4 to 6°F higher than the preindustrial baseline. Carbon dioxide levels perhaps even exceeded 1000 ppm around 50 million years ago, during which average global surface temperature was 18°F higher than the preindustrial baseline.

Atmospheric greenhouse gas levels are one of many variables that can influence Earth's climate. Suspended particulate and liquid matter known as aerosols are examples of other contributors to climate change. These can reflect sunlight and cool the planet or absorb solar energy and warm the atmosphere. Total solar output can also affect the temperature of the planet, as can changes in ocean circulation patterns. Scientists have calculated the

contribution of each of these and have found consistently that human-caused greenhouse gas emissions are the only plausible explanation for postindustrial warming. These calculations are documented in reports by authoritative national and international organizations created to review the full body of the scientific literature such as the U.S. National Climate Assessment and the U.N. Intergovernmental Panel on Climate Change.

Models, which are mathematical representations of Earth's climate system, can be used to forecast future climate change based on different scenarios of greenhouse gas emissions. Under a "business-as-usual" scenario, or one in which emissions are not curbed, such models indicate that average temperature by the end of the century could be about 5 to 9°F higher than today. The "Paris Agreement" adopted at COP21 calls for limiting temperature increase to 2°C or about 3°F above preindustrial levels at most, and pursuing efforts to keep temperature increase below 1.5°C. In aggressive emissions-reduction scenarios, it is possible to limit the end-of-century temperature to as low as 1.5°C. Such reductions will require transforming many sectors of the economy, such as transportation (29% of U.S. emissions), electricity (25% of U.S. emissions), industry (23% of U.S. emissions), commercial and residential (13% of U.S. emissions), and agriculture (10% of U.S. emissions).

¹This is a summary of *What is Causing Climate Change?* by Inez Y. Fung.