Global Climate Change Program

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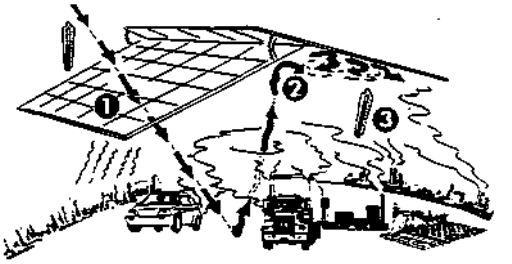
By Degrees

What Is the Greenhouse Effect?

There is a growing consensus among scientists that global temperatures have increased by 0.8°F over the last century and will continue to increase. Climate models predict 4- to 9-degree temperature increases by the year 2050. A temperature change of this magnitude, in a 60-year period, is unprecedented for this planet and could have serious impacts on our climate, agriculture, water resources, and society. The principal mechanism responsible for this change in global climate is the "greenhouse effect"

The term "greenhouse effect" (boxes 1 and 2) describes a natural phenomenon of the earth's solar radiation balance, first postulated by John Tyndall and Svante Arrhenius in the late 1800s. Atmospheric gases, such as water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and other trace gases, are relatively transparent to incoming solar (short-wave) radiation and are more or less opaque to outgoing terrestrial (long-wave) radiation. The gases absorb the terrestrial radiation and radiate this trapped energy back toward the earth, warming its surface and the troposphere (lower atmosphere). Without the "greenhouse effect" temperatures in the troposphere would be about 60

Box 1 - The Greenhouse Analogy. The greenhouse analogy works well in comparing the transparency of the atmosphere and glass panes to incoming solar radiation. The warming of the atmosphere due to the heating of absorbing gas molecules and the radiation of long-wave radiation back to the earth's surface, however, is in contrast to glass panes, which do not radiate long-wave radiation but rather trap heat within the greenhouse. The important factor in keeping a greenhouse warm is preventing the mixing of the warmer inside air with the cooler outside air.



Carbon dioxide and other gases produced by industry and other man-made and natural sources accumulate in the atmosphere. These gases act like the glass panes of a greenhouse, letting in the sun's warming rays (1) and trapping the infrared energy that is radiated from the warming (2). As a result the air is heated <3).

Box 2 - Confusion with Other Climate Change Issues. Statements such as "I definitely think the damage to the ozone layer is having a greenhouse effect" shows the confusion of the many global change issues we find on our plate in the 1990s. The depletion of the ozone layer, due to chlorofluorocarbons (CFCs) and the El Nino impact on weather and global temperatures, due to the warming of water in the eastern Pacific, are phenomena separate from the greenhouse effect. Atmospheric gases do play dual roles. For example CH_4 is a greenhouse gas, but it also reacts with CFCs to reduce the destruction of ozone.

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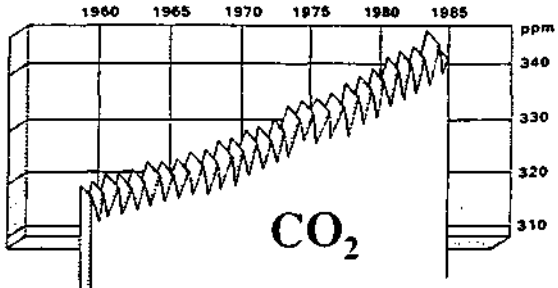

The saw-toothed pattern shows how CO_2 is absorbed by plants in the summer and builds during the winter when plants are dormant.

degrees lower and thus unable to keep the earth's temperature at a "livable" level.

Atmospheric concentrations of greenhouse gases have varied over geologic time scales, leading to warming and cooling effects. But the bad connotation given to the "greenhouse effect" is attributable to human activities, especially in recent decades, when greenhouse gases are being added to the atmosphere at unprecedented rates. Since 1880, CO_2, CH_4, and N_2O concentrations have increased by about 25 , 30, and 6 percent, respectively. For example, 40 years ago 6 trillion tons of CO_2 per year were released into the atmosphere from the energy sector. Today, we emit more than 25 trillion tons.

The increasing burden of gases in the atmosphere skews the balance of the greenhouse effect. Although the atmosphere remains transparent to solar radiation, growing concentrations of greenhouse gases make it increasingly opaque to outgoing terrestrial radiation—producing an *enhanced* warming. Increasing CO_2 accounts for about two-thirds of the enhanced wanning, with CH_4 and N_2O accounting for about 15 percent and 7 percent, respectively (box 3). Industrialized countries contribute about two-thirds of all greenhouse emissions (21 percent from the United States, with 3 to 4 percent from Illinois), mostly from fossil fuels. The remaining one-third is attributed to developing countries, mostly from agriculture and deforestation, the cutting down of forests (box 4).

Box 3 - Warming Influence of Gases. The contribution of greenhouse gases to warming or the global warming potential (GWP) depends on three factors: their atmospheric concentration, their lifetime in the atmosphere, and their effectiveness in absorbing outgoing terrestrial radiation.

Box 4 - Deforestation. The cutting down of forests (biota in general) reduces the uptake of atmospheric carbon by photosynthesis. The burning of this wood releases carbon (stored in the wood) to the atmosphere.

Venus, a planet with a surface temperature of 850 degrees, is described as a planet where the "greenhouse heating has run wild." Its thick atmosphere has about the same amount of carbon as found in the earth's atmosphere, oceans, rocks, and biota combined. The release of more gases into our atmosphere clearly has the potential to raise atmospheric temperatures, causing the global climate to warm.

The "greenhouse effect" is not new to this planet, and it is essentially undisputed. The growing emissions of greenhouse gases into the atmosphere are well documented. What is not well known, however, is the amount of change in atmospheric composition required to cause major climate change, the rate and patterns at which temperatures may increase and their impact on different regions, and the role of positive and negative feedbacks in the atmosphere (i.e., will increased water vapor and clouds warm or cool the atmosphere?). Critics of global warming argue that these unknowns are not adequately addressed and may negate any greenhouse wanning. It is worth noting that as our understanding of these unknowns and the complexity of the atmosphere has grown, earlier projected temperature increases have been revised downward.

Further Reading

Lemonick, Michael D., "The Heat is On," *Time* 130 (October 19, 1987):58-67.

U.S. Congress, Office of Technology Assessment, *Changing by Degrees: Steps to Reduce Greenhouse Gases,* OTA-O-482. Washington DC: U.S. Government Printing Office, 1991, pp. 45-73.