

## Overview of the Science

A greenhouse heats up because its glass lets in the sun's rays but blocks some heat from escaping. Likewise, scientists have known since the nineteenth century that carbon dioxide and other greenhouse gases let the sun's rays into the atmosphere but block some of the heat from escaping.

Human activities have released a huge amount of carbon dioxide in the atmosphere. The two largest sources are:

- **Fossil Fuels:** Carbon is stored in coal, gasoline, and natural gas. These are called fossil fuels because they were formed from organisms that died millions of years ago, which removed carbon dioxide from the atmosphere as they grew. When we burn fossil fuels, that carbon is released into the atmosphere again as carbon dioxide.
- **Deforestation:** Carbon is stored in trees, which removed carbon dioxide from the air as they grew. When we clear forests for agriculture, the trees rot or burn, and that carbon is released into the atmosphere again as carbon dioxide.

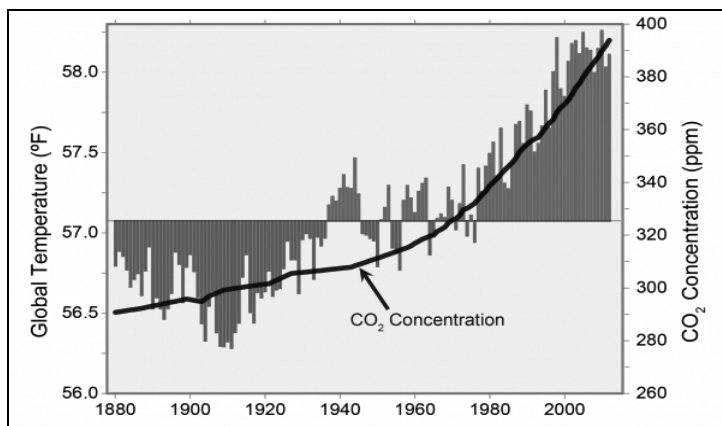
For 800,000 years, the Earth's climate has gone through a natural cycle alternating ice ages and warmer interglacial periods. During ice ages, the concentration of carbon dioxide in the atmosphere went down as low as 180 parts per million (ppm); during the warmer periods the concentration of carbon dioxide went up as high as 290 ppm. Notice that the difference between the coldest and warmest points in this cycle is 110 ppm. The percentage increase determines the amount of warming, and there was an increase of a bit over 60%.

At the beginning of the industrial revolution, in 1750, the concentration of carbon dioxide was 280 ppm; now it is over 410 ppm—an increase of just over 45%—and it is still rising. Emissions have been increasing so quickly that we have added about as much carbon dioxide in the last 40 years as we added in the first 230 years of the industrial revolution. And human activity has also added other greenhouse gases besides carbon dioxide.

As expected, the increase in carbon dioxide and other greenhouse gases has increased global temperatures. Surface temperatures have risen by just over 1° Celsius (1.8° Fahrenheit)

and ocean temperatures by just under 1° Celsius since the beginning of the industrial revolution.

Figure 1 shows that temperatures increased as carbon dioxide concentrations in the atmosphere increased. From 1880 to the 1930s, the average annual temperature was always below the average for the entire period from 1880 to the 2000s. From the 1930s through the 1970s, annual temperature was sometimes below and sometimes above the average. Since 1980, it has always been above the average. T but the long-term trend is very clear, though there are fluctuations from year to year because of events such as volcanoes (which lower temperatures by reflecting sunlight into space), La Niña (which lowers surface temperature as cool water wells up from the ocean depths off the coast of South America), and El Niño (which raises temperature as warm water wells up off he coast of South America).



**Figure 1: Carbon Dioxide and Global Temperature<sup>1</sup>**

Global warming has already caused more destructive tropical storms, worse flooding, and worse wildfires. These effects are noticeable now, with a temperature increase of about 1°C. If we do not limit global warming, there will be much worse damage in the future.

In the Paris agreement of 2015, the nations of the world reached consensus that we should limit warming to well below 2°C in order to avoid the most catastrophic effects of global warming.

This overview should make the basic facts about global warming clear. You can understand it by remembering that:

- Scientists have known since the nineteenth century that carbon dioxide traps some of the sun's heat.
- Human activity has released vast amounts of carbon dioxide and other greenhouse gases.
- Since the beginning of the industrial revolution, the concentration of carbon dioxide in the atmosphere has increased from 280 ppm to 410 ppm.
- The Earth has become warmer.

Keeping those basic facts in mind can immunize us against attempts to deny or obfuscate the science of global warming. Now, let's look at the science in more detail.