GLOBAL CLIMATE CHANGE

Dr. Tamara Shapiro Ledley
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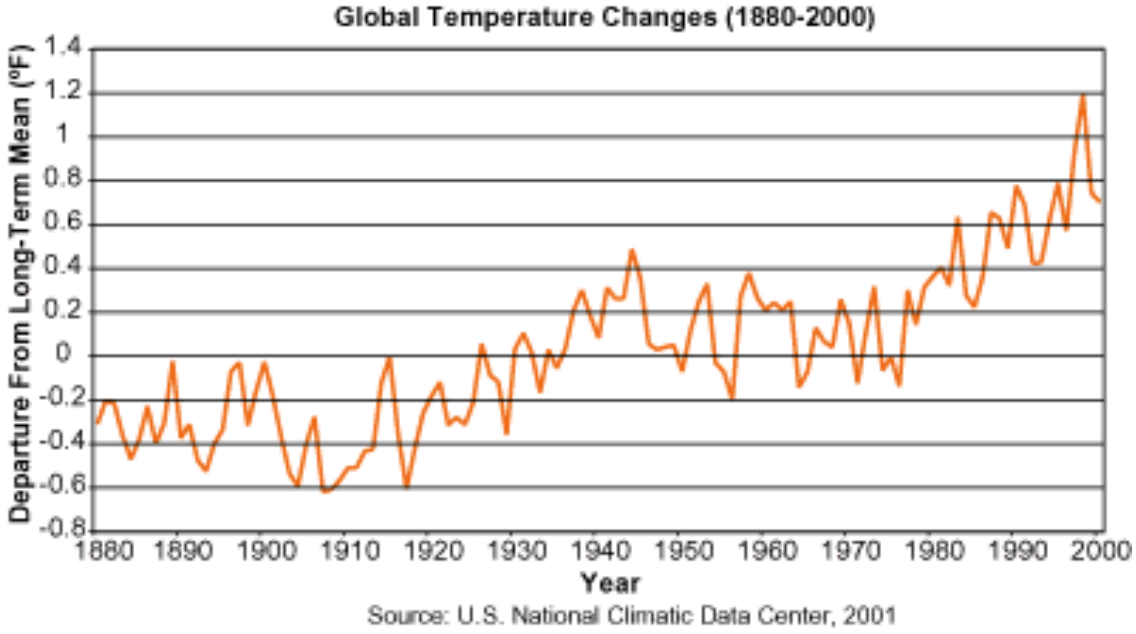
As you read, think about...
What is the greenhouse effect? Why is the greenhouse effect important for life on Earth?

The surface of the Earth and its lower atmosphere are kept warm by certain gases that occur naturally in the atmosphere. These gases, mainly water vapor (H_2O), carbon dioxide (CO_2), and ozone (O_3), absorb infrared radiation emitted by the Earth's surface, keeping the energy near the surface and keeping temperatures about 30°C warmer than they would be otherwise. This natural phenomenon, popularly known as the "greenhouse effect," is responsible for the existence of life on Earth.

Since the start of the Industrial Revolution, greenhouse gases have increased tremendously. These greenhouse gases include carbon dioxide, methane, nitrous oxide, and primarily two chlorofluorocarbons. Of these gases, CO_2 has increased the most, rising from a pre-industrial level of about 280 parts per million (ppm) to 369.4 ppm in 2000. There is growing concern in the scientific community that the addition of these gases to the atmosphere will increase the greenhouse effect, warming the Earth more than would occur through natural variations.



Global means surface temperature increased by about 1.0°F between 1880 and 2000, however, that increase has not been smooth. The ten warmest years all occurred in the last 15 years of the 20th century with the warmest year being 1998.

There is little disagreement among scientists that the increase in greenhouse gases has increased the amount of energy absorbed and retained by the Earth system; i.e. that Earth's surface air temperatures have risen beyond the range of natural fluctuation. Among the questions that remain are these: How will this increase in available energy and surface air temperature affect each component of the Earth's system? How large will the effects of these changes be?

Computer Modeling

As you read, think about...
Why do scientists use computer models to study climate change?
Why are scientists concerned about the increase in greenhouse gas levels?

Some scientists use computer models to answer questions like these. Computer models use mathematical formulas to take into account the physical and chemical processes of the Earth system and are used to simulate the climate of the Earth over time. By adding more greenhouse gases into the model, scientists can examine how the simulated Earth system responds.

Many of these computer models predict that further increases in greenhouse gases will result in (a) warmer temperatures, and (b) more precipitation and evaporation worldwide. One series of experiments using several different computer models predicted "a rise in average global temperature" of between 1.5 and 4.5°C when the current level of atmospheric CO_2 was doubled from its current value. Model results also suggest that increasing greenhouse gases will have the biggest impact in the Arctic and the Antarctic, and that there will be more extreme weather events such as droughts, floods, and extremes in temperatures worldwide.

Recently, researchers have tried to determine how best to control global warming. Most scientists feel that cutting CO_2 emissions is critical because CO_2 is the most abundant greenhouse gas and because it has increased more than any other. Other scientists argue that other greenhouse gases have a much bigger impact molecule for molecule than does CO_2. For example, Dr. James E. Hansen and his colleagues conclude from their studies that recent warming trends are due largely to increases in methane and chlorofluorocarbons, along with increases in black soot particles and other compounds that create ozone in smog. Dr. Hansen argues that it may easier and cheaper to slow climate change by focusing on these emissions because these gases and particles are easier to control than CO_2. Other scientists fear that targeting these gases and particles will only slow the predicted climate changes. They feel that CO_2 emissions must be reduced, too.

Polar Studies

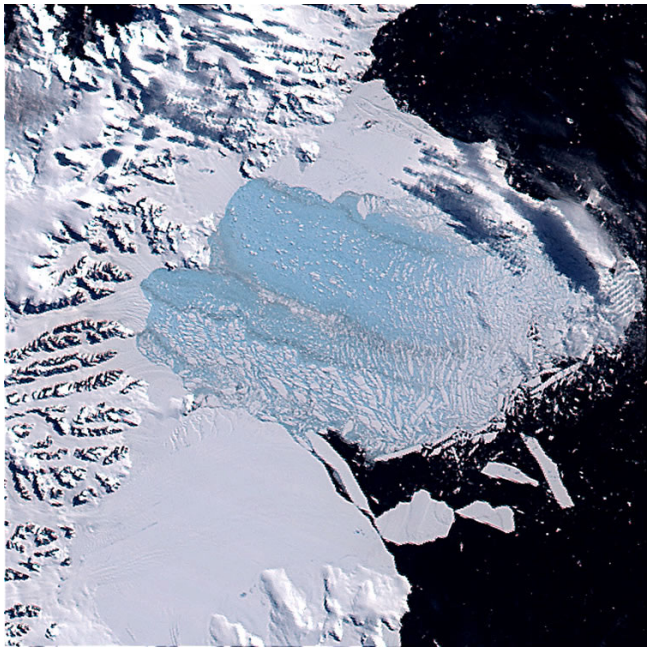
As you read, think about...
Why do scientists study climate change in Antarctica?
What changes in Antarctic sea ice have scientists noticed over the past 150 years?

Another way to answer questions about global warming is to monitor Earth's climate system and check whether observed changes match the changes predicted by the computer mod-

els. Since greenhouse gases are thought to have the greatest impact in the polar regions, many scientists have turned their attention to the Arctic and the Antarctic. Some recent discoveries suggest that the predicted changes are in fact occurring.

The first discovery is about the amount of sea ice at the poles. The thickness of sea ice is most accurately measured from a submarine under the ice. Recent submarine studies suggest that the sea ice in the Arctic has thinned by about 40% since 1960. According to satellite measurements, the expanse of sea ice has decreased by 5% over the same period. Moreover, a recent expedition to the North Pole found open water there. No one has ever found open water at the North Pole before; in fact, scientists think that the last time there was open water at the North Pole was more than 50 million years ago.

A second discovery involves the length of the sea-ice season in Antarctica. An analysis of historical records indicates that between 1846 and 1996, the date of fall freeze has moved 9.8 days later, and the date of spring thaw has moved 8.7 days earlier. Over that same period, the average global temperature increased by 1.6°C.



Larsen B ice shelf, March 2002
Image courtesy Ted Scambos, NSIDC/NASA

In addition, during February-March of 2002 (summer in the Southern hemisphere) along the Antarctic Peninsula, a piece of the Larsen B ice shelf disintegrated. This piece of the ice shelf, the size of the state of Rhode Island, is from an area that scientists believe has been covered by an ice shelf for the last 12,000 years.

These changes are certainly the result of increased temperatures, but what has caused the rise in temperature? The sea ice and ice shelf studies cannot tell us that. Temperature changes are caused by many things. However, the evidence from the computer simulation studies strongly suggests that the changes in polar ice are the result of increases in greenhouse gases—at least in part.