

Past, Present and Future Temperatures — The “Hockey Stick”

To clear up some misconceptions about global temperature trends, and especially about the significance of the well-known “hockey stick” graph, UCS answers some frequently asked questions.

How do we calculate Earth’s temperature over time?

Over the past 150 years, surface air and water temperatures have been measured regularly at stations around the world. Looking back earlier in time, however, it is difficult to accurately reconstruct global average temperatures because written records are not available. To understand climate trends when Henry VIII ruled England, for example, climate experts must rely on biological or physical archives—known as “proxies”—that preserve past temperature. Tree rings, coral skeletons, and glacial ice cores are proxies for annual temperature records, while boreholes (holes drilled deep into Earth’s crust) can show temperature shifts over longer periods of time.

What is the “hockey stick” graph?

This graph, created by a group of climate researchers in the late 1990s, reflects average Northern Hemisphere temperature changes over the past several centuries. It was the first comprehensive study combining data from many different archives of temperature including tree rings, ice cores, and coral reefs. It demonstrated that Northern Hemisphere temperatures rose sharply during the late 20th century, in marked contrast to the relatively small temperature fluctuations during the previous six centuries. The graph got its name because its shape resembles a hockey stick, with the blade end representing the sharp temperature rise over recent years.

Is there legitimate scientific debate about the accuracy of the hockey stick graph?

Yes, but mainly about the details, not the essential point. Temperature fluctuations that predate written records are preserved in natural archives (e.g., tree rings, ice cores, boreholes) with various time periods (e.g., seasonal, annual, decadal). The scientific discussion has focused on the best statistical method for combining these various records to accurately capture temperature fluctuations for the Northern Hemisphere. As is typical of the scientific process, independent teams of researchers have worked to reproduce the results of the “hockey stick” by using their own approaches and even by using slightly different data. These studies sometimes produce slightly higher temperature fluctuations in the past compared with the initial study. But despite their differences, they still yield the same essential conclusion: the past 10- to 20-year period was likely the warmest of the past millennium.

How much does our understanding of global warming depend on the hockey stick graph?

The short answer is “very little.” The hockey stick graph constitutes only one among literally thousands of pieces of evidence that have contributed to the present scientific consensus on the human influence on global warming. In 2001, the Intergovernmental Panel on Climate Change (IPCC) concluded in its authoritative third assessment report, *Climate Change 2001: The Scientific Basis*, that “there is new and stronger evidence that most of the warming observed over the last 50 years



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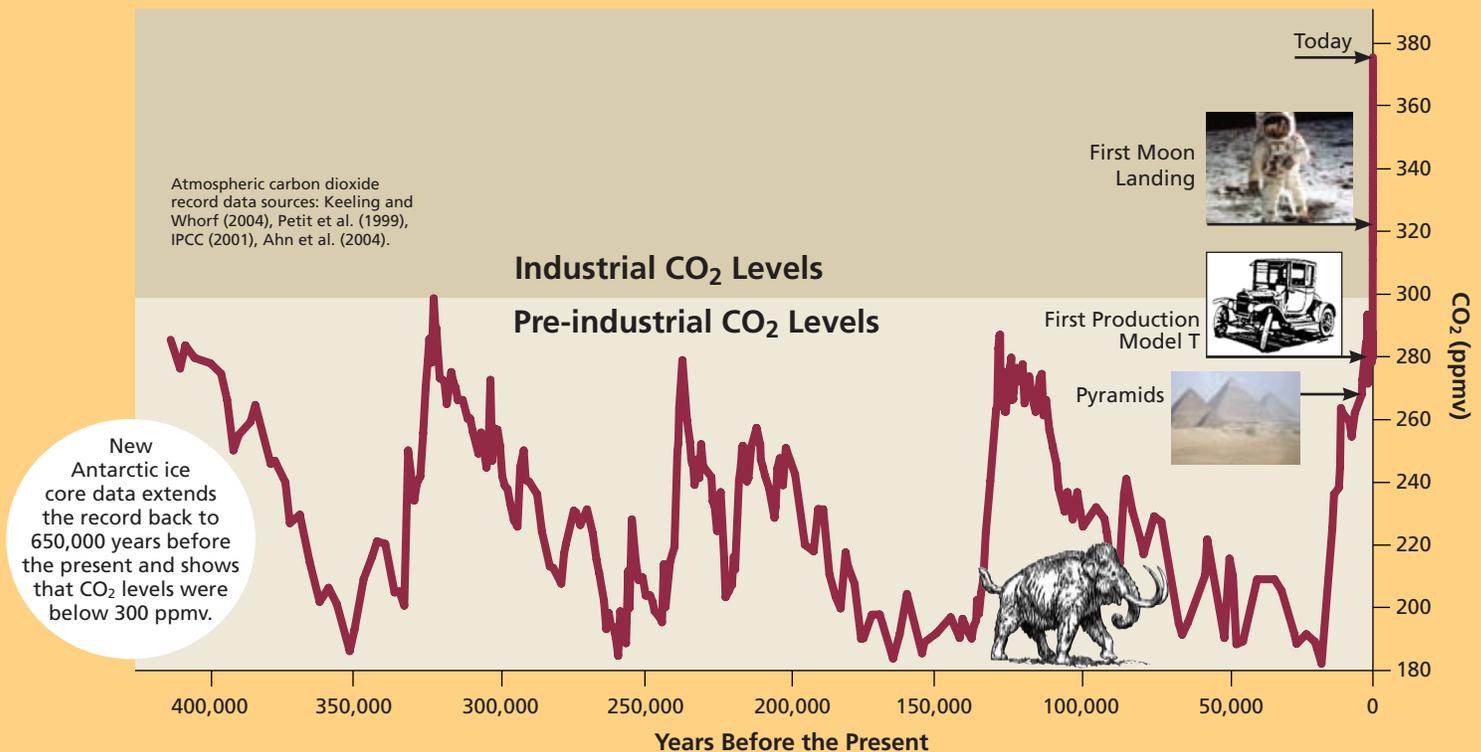


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Carbon Dioxide Levels Today are Higher than over the Past 650,000 Years



is attributable to human activities.” As one climate expert observed: “The IPCC Report... is 881 pages in length. It weighs 5.5 pounds and contains over 200 figures and 80 tables. It would be absurd to think that the weight of its conclusions rests on any one figure or table; rather it paints a convincing picture in the totality of its science, as noted succinctly in its title.”¹

We are now observing real changes due to higher temperatures. Here are some examples:

- The Mt. Kilimanjaro glacier, which has survived the past 11,000 years, is currently at risk of disappearing by 2020 if present rates of melting continue;
- Enormous tracts of Siberian peatlands, with vast stores of carbon, are beginning to thaw and release carbon dioxide and methane into the atmosphere;
- The Larsen B ice shelf in Antarctica has lost volume as large chunks (some as large as the state of Rhode Island) have recently broken free and melted;
- The annual surface area of Arctic sea ice has declined eight percent over the past several decades;
- Large-scale increases in ocean temperatures have been detected over the past 45 years; and
- Plants and animals are changing their habitation ranges, sometimes drama-

tically, such as robins and mosquitoes in the Arctic that were previously unknown there.

Antarctic ice core records vividly illustrate that atmospheric carbon dioxide (CO₂) levels today are higher than levels recorded over the past 650,000 years (see figure above). Atmospheric CO₂ levels have risen 30 percent in the last 150 years, with half of that rise occurring only in the last three decades. It is a well-established scientific fact that CO₂ (and other gases emitted from industrial and agricultural sources) traps heat in the atmosphere, so it is no surprise that we are now witnessing a dramatic increase in temperature.

Compared with other factors that influence climate (including solar variation, volcanic eruptions, and pollutant emissions such as sulfur dioxide), human activities—primarily burning fossil fuels and deforestation—have been a major contributor to climate change over the last 50 years.

How do past climate trends help us understand future temperature?

Reconstructions of past climates help us build accurate projections of how future climates will be affected by global warming. Much as the Air Force builds

computer programs to simulate aircraft flight under different conditions, climate scientists build computer programs to help simulate global climate under different conditions. These computer programs, called General Circulation Models (GCMs), use various assumptions about physical, chemical, and biological processes that occur within Earth’s atmosphere and oceans and on its land surfaces. To ensure accuracy, each model is checked to see if it generates results that correctly reproduce the past and current climate. Once accuracy is established, the computer program can then be used to explore the likely future climate if, for example, we double the atmospheric concentration of carbon dioxide.

1 Bradley, R.S. 2005. Letter to Representative Joseph Barton (R-TX), July 13. Dr. Raymond Bradley is a University Distinguished Professor at the University of Massachusetts at Amherst.



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