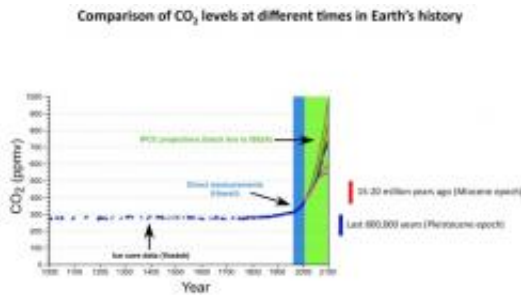


Last time carbon dioxide levels were this high: 15 million years ago, scientists report

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This chart shows carbon dioxide levels for different times in Earth's history. This chart shows carbon dioxide levels for different times in Earth's history, in parts-per-million by volume, with projections for the next 100 years by the Intergovernmental Panel on Climate Change. A new study in *Science* by Aradhna Tripathi and colleagues suggests that the last time carbon dioxide levels were as high as today was between 15-20 million years ago.

You would have to go back at least 15 million years to find carbon dioxide levels on Earth as high as they are today, a UCLA scientist and colleagues report Oct. 8 in the online edition of the journal *Science*.

"The last time [carbon dioxide](#) levels were apparently as high as they are today — and were sustained at those levels — global temperatures were 5 to 10 degrees Fahrenheit higher than they are today, the sea level was

approximately 75 to 120 feet higher than today, there was no permanent sea ice cap in the Arctic and very little ice on Antarctica and Greenland," said the paper's lead author, Aradhna Tripathi, a UCLA assistant professor in the department of Earth and space sciences and the department of atmospheric and oceanic sciences.

"Carbon dioxide is a potent [greenhouse gas](#), and geological observations that we now have for the last 20 million years lend strong support to the idea that carbon dioxide is an important agent for driving climate change throughout Earth's history," she said.

By analyzing the chemistry of bubbles of ancient air trapped in Antarctic ice, scientists have been able to determine the composition of Earth's atmosphere going back as far as 800,000 years, and they have developed a good understanding of how carbon dioxide levels have varied in the atmosphere since that time. But there has been little agreement before this study on how to reconstruct carbon dioxide levels prior to 800,000 years ago.

Tripathi, before joining UCLA's faculty, was part of a research team at England's University of Oxford that developed a new technique to assess carbon dioxide levels in the much more distant past — by studying the ratio of the chemical element [boron](#) to calcium in the shells of ancient single-celled marine [algae](#). Tripathi has now used this method to determine the amount of carbon dioxide in Earth's atmosphere as far back as 20 million years ago.

"We are able, for the first time, to accurately reproduce the ice-core record for the last 800,000 years — the record of atmospheric CO₂ based on measurements of carbon dioxide in gas bubbles in ice," Tripathi said. "This suggests that the technique we are using is valid.

"We then applied this technique to study the history of carbon dioxide

from 800,000 years ago to 20 million years ago," she said. "We report evidence for a very close coupling between carbon dioxide levels and climate. When there is evidence for the growth of a large ice sheet on Antarctica or on Greenland or the growth of sea ice in the Arctic Ocean, we see evidence for a dramatic change in carbon dioxide levels over the last 20 million years.

"A slightly shocking finding," Tripathi said, "is that the only time in the last 20 million years that we find evidence for carbon dioxide levels similar to the modern level of 387 parts per million was 15 to 20 million years ago, when the planet was dramatically different."

Levels of carbon dioxide have varied only between 180 and 300 parts per million over the last 800,000 years — until recent decades, said Tripathi, who is also a member of UCLA's Institute of Geophysics and Planetary Physics. It has been known that modern-day levels of carbon dioxide are unprecedented over the last 800,000 years, but the finding that modern levels have not been reached in the last 15 million years is new.

Prior to the Industrial Revolution of the late 19th and early 20th centuries, the carbon dioxide level was about 280 parts per million, Tripathi said. That figure had changed very little over the previous 1,000 years. But since the Industrial Revolution, the carbon dioxide level has been rising and is likely to soar unless action is taken to reverse the trend, Tripathi said.

"During the Middle Miocene (the time period approximately 14 to 20 million years ago), carbon dioxide levels were sustained at about 400 parts per million, which is about where we are today," Tripathi said.

"Globally, temperatures were 5 to 10 degrees Fahrenheit warmer, a huge amount."

Tripati's new chemical technique has an average uncertainty rate of only 14 parts per million.

"We can now have confidence in making statements about how carbon dioxide has varied throughout history," Tripati said.

In the last 20 million years, key features of the climate record include the sudden appearance of ice on Antarctica about 14 million years ago and a rise in sea level of approximately 75 to 120 feet.

"We have shown that this dramatic rise in sea level is associated with an increase in carbon dioxide levels of about 100 parts per million, a huge change," Tripati said. "This record is the first evidence that carbon dioxide may be linked with environmental changes, such as changes in the terrestrial ecosystem, distribution of ice, sea level and monsoon intensity."

Today, the Arctic Ocean is covered with frozen ice all year long, an ice cap that has been there for about 14 million years.

"Prior to that, there was no permanent [sea ice](#) cap in the Arctic," Tripati said.

Some projections show carbon dioxide levels rising as high as 600 or even 900 parts per million in the next century if no action is taken to reduce carbon dioxide, Tripati said. Such levels may have been reached on Earth 50 million years ago or earlier, said Tripati, who is working to push her data back much farther than 20 million years and to study the last 20 million years in detail.

More than 50 million years ago, there were no ice sheets on Earth, and there were expanded deserts in the subtropics, Tripati noted. The planet was radically different.

Co-authors on the Science paper are Christopher Roberts, a Ph.D. student in the department of Earth sciences at the University of Cambridge, and Robert Eagle, a postdoctoral scholar in the division of geological and planetary sciences at the California Institute of Technology.

The research was funded by UCLA's Division of Physical Sciences and the United Kingdom's National Environmental Research Council.

Tripati's research focuses on the development and application of chemical tools to study climate change throughout history. She studies the evolution of climate and seawater chemistry through time.

"I'm interested in understanding how the carbon cycle and climate have been coupled, and why they have been coupled, over a range of time-scales, from hundreds of years to tens of millions of years," Tripati said.

Source: University of California - Los Angeles

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