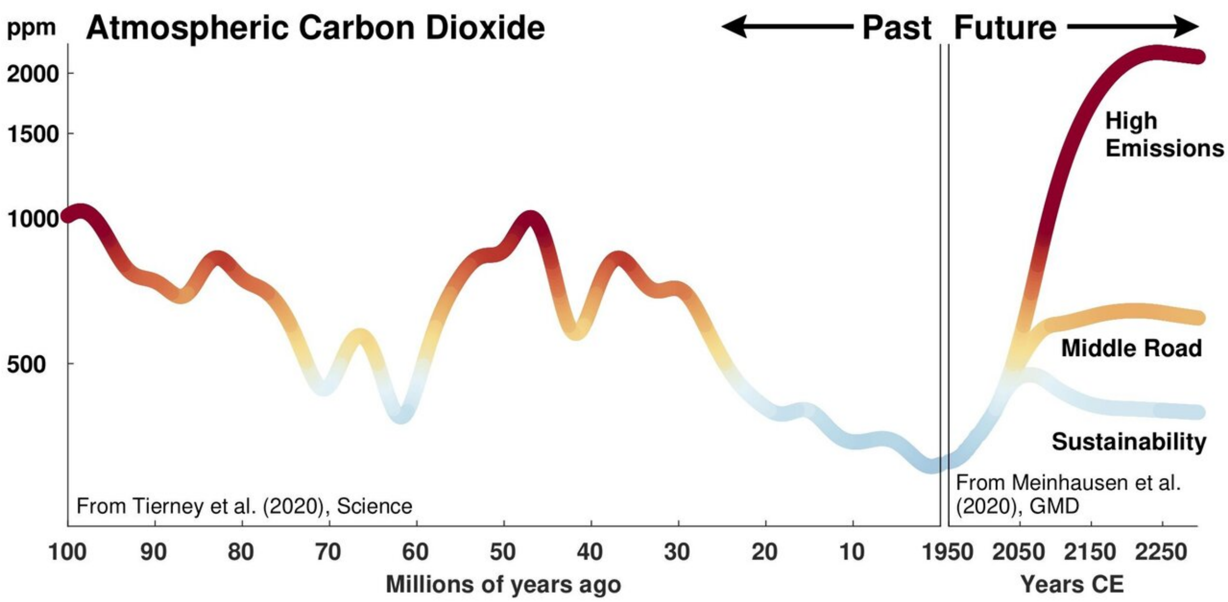
Past is key to predicting future climate, scientists say

November 5 2020



Past carbon dioxide concentrations (at left) compared to possible future emissions scenarios (at right): The rate of current emissions is much faster - occurring over decades - unlike geological changes, which occur over millions of years. If emissions continue unabated, carbon dioxide levels could meet or exceed values associated with past warm climates, such as the Cretaceous period (100 million years ago) or the Eocene epoch (50 million years ago), by the year 2300. Credit: Jessica Tierney/University of Arizona

In a review paper published in the journal *Science*, a group of climate experts make the case for including paleoclimate data in the development of climate models. Such models are used globally to assess the impacts of human-caused greenhouse gas emissions, predict scenarios for future climate and propose strategies for mitigation.

An international team of climate scientists suggests that research centers around the world using numerical models to predict future climate change should include simulations of past climates in their evaluation and statement of their model performance.

"We urge the climate model developer community to pay attention to the past and actively involve it in predicting the future," said Jessica Tierney, the paper's lead author and an associate professor in the University of Arizona's Department of Geosciences. "If your model can simulate past climates accurately, it likely will do a much better job at getting future scenarios right."

As more and better information becomes available about climates in Earth's distant history, reaching back many millions of years before humans existed, past climates become increasingly relevant for improving our understanding of how key elements of the climate system are affected by greenhouse gas levels, according to the study's authors. Unlike historic climate records, which typically only go back a century or two—a mere blink of an eye in the planet's climate history—paleoclimates cover a vastly broader range of climatic conditions that can inform climate models in ways historic data cannot. These periods in Earth's past span a large range of temperatures, precipitation patterns and ice sheet distribution.

"Past climates should be used to evaluate and fine-tune climate models," Tierney said. "Looking to the past to inform the future could help narrow uncertainties surrounding projections of changes in temperature, ice sheets, and the water cycle."

Typically, climate scientists evaluate their models with data from historical weather records, such as satellite measurements, sea surface temperatures, wind speeds, cloud cover and other parameters. The model's algorithms are then adjusted and tuned until their predictions mesh with the observed climate records. Thus, if a computer simulation produces a historically accurate climate based on the observations made during that time, it is considered fit to predict future climate with reasonable accuracy.

"We find that many models perform very well with historic climates, but not so well with climates from the Earth's geological past," Tierney said.

One reason for the discrepancies are differences in how the models compute the effects of clouds, which is one of the great challenges in climate modeling, Tierney said. Such differences cause different models to diverge from each other in terms of what climate scientists refer to as climate sensitivity: a measure of how strongly the Earth's climate responds to a doubling of greenhouse gas emissions.

Several of the latest generation models that are being used for the next report by the Intergovernmental Panel on Climate Change, or IPCC, have a higher climate sensitivity than previous iterations, Tierney explained.

"This means that if you double carbon dioxide emissions, they produce more global warming than their previous counterparts, so the question is: How much confidence do we have in these very sensitive new models?"

In between IPCC reports, which typically are released every eight years, climate models are being updated based on the latest research data.

"Models become more complex, and in theory, they get better, but what does that mean?" Tierney said. "You want to know what happens in the future, so you want to be able to trust the model with regard to what happens in response to higher levels of carbon dioxide."

While there is no debate in the climate science community about human fossil fuel consumption pushing the Earth toward a warmer state for which there is no historical precedent, different models generate varying predictions. Some forecast an increase as large as 6 degrees Celsius by the end of the century.

Tierney said while Earth's atmosphere has experienced carbon dioxide concentrations much higher than today's level of about 400 parts per million, there is no time in the geological record that matches the speed at which humans are contributing to greenhouse gas emissions.

In the paper, the authors applied climate models to several known past climate extremes from the geological record. The most recent warm climate offering a glimpse into the future occurred about 50 million years ago during the Eocene epoch, Tierney said. Global carbon dioxide was at 1,000 parts per million at that time and there were no large ice sheets.

"If we don't cut back emissions, we are headed for Eocene-like CO_2 levels by 2100," Tierney said.

The authors discuss climate changes all the way to the Cretaceous period, about 90 million years ago, when dinosaurs still ruled the Earth. That period shows that the climate can get even warmer, a scenario that Tierney described as "even scarier," with carbon dioxide levels up to 2,000 parts per million and the oceans as warm as a bathtub.

"The key is CO_2," Tierney said. "Whenever we see evidence of warm climate in the geologic record, CO_2 is high as well."

Some models are much better than others at producing the climates seen in the geologic record, which underscores the need to test climate models against paleoclimates, the authors said. In particular, past warm climates such as the Eocene highlight the role that clouds play in contributing to warmer temperatures under increased carbon dioxide levels.

"We urge the climate community to test models on paleoclimates early on, while the models are being developed, rather than afterwards, which tends to be the current practice," Tierney said. "Seemingly small things like clouds affect the Earth's energy balance in major ways and can affect the temperatures your model produces for the year 2100."

More information: "Past climates inform our future" *Science* (2020). science.sciencemag.org/cgi/doi … 1126/science.aay3701

Provided by University of Arizona