Determining the Future of CO2 Using an Earth System Model

Research Highlight

Carbon dioxide is the dominant human-made greenhouse gas in Earth's atmosphere, increasing by roughly 43% since the Industrial Revolution. Some scientists believe that changes in CO_2 levels in the atmosphere will be the primary factor that determines future climate change. Yet how do we know that predictions are accurate?

A team of researchers from numerous U.S. scientific institutions set out to determine how the varying structure of CO_2 might impact climate predictions. The study, recently reported in a special issue of the *Journal of Climate*, used historically observed CO_2 data to determine how well the Community Earth System Model (CESM)-Biogeochemistry would predict future concentrations of the gas. Funded by the National Science Foundation and the U.S. Department of Energy (DOE), CESM is a global climate model that provides state-of-the-art computer simulations of the Earth's past, present, and future climate states. It models CO_2 in a variety of ways.

How models, such as the Community Earth System Model, simulate the amount of CO_2 in the atmosphere will likely hold the key to monitoring climate change.

"Atmospheric CO_2 integrates processes involving land, ocean, and air," said Dr. Gretchen Keppel-Aleks of the University of Michigan, who lead the team. "Its variations on seasonal and longer-time scales indicate how climate and carbon cycle processes interact."

Applying global historical data (1850 to 2005), including data from the DOE's Atmospheric Radiation Measurement Climate Research Facility, the team used CESM to examine seasonal cycles of CO_2 and how they varied vertically and horizontally. Researchers also looked at trends across years and decades. With this understanding, they developed two scenarios. The first assumed stabilization of CO_2 emissions by the middle of the twenty-first century through support from the international community and a common global price for emissions of CO_2 and other greenhouse gases. The second assumed steady population growth with continuing high energy demand and little investment in energy technology, leading to a reliance on local and high-carbon-content fuels. Scientists then modeled these scenarios in the CESM from 2005 to 2100.

They found that CESM results largely matched observations in the historical data, with a few exceptions. For example, the model predicted that atmospheric CO_2 would be higher than what was actually observed, perhaps indicating that the uptake portions of the model for land and ocean need to be strengthened. Ongoing model development in the representation of photosynthesis and ocean biogeochemistry is likely to further improve the simulation of seasonal CO_2 dynamics and spatial gradients in CESM.

Reference(s)

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Aerosol Life Cycle