Some of the latest climate models provide unrealistically high projections of future warming

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A new study from University of Michigan climate researchers concludes that some of the latest-generation climate models may be overly sensitive

to carbon dioxide increases and therefore project future warming that is unrealistically high.

In a letter scheduled for publication April 30 in the journal *Nature Climate Change*, the researchers say that projections from one of the leading models, known as CESM2, are not supported by geological evidence from a previous warming period roughly 50 million years ago.

The researchers used the CESM2 model to simulate temperatures during the Early Eocene, a time when rainforests thrived in the tropics of the New World, according to fossil evidence.

But the CESM2 model projected Early Eocene land temperatures exceeding 55 degrees Celsius (131 F) in the tropics, which is much higher than the temperature tolerance of plant photosynthesis—conflicting with the fossil evidence. On average across the globe, the model projected surface temperatures at least 6 C (11 F) warmer than estimates based on geological evidence.

"Some of the newest models used to make future predictions may be too sensitive to increases in atmospheric carbon dioxide and thus predict too much warming," said U-M's Chris Poulsen, a professor in the U-M Department of Earth and Environmental Sciences and one of the study's three authors.

The other authors are U-M postdoctoral researcher Jiang Zhu and Bette Otto-Bliesner of the National Center for Atmospheric Research. They say their study shows how geological evidence can be used to benchmark climate models and predictions of future warming.

The new study focuses on a key climate parameter called equilibrium climate sensitivity, or ECS. ECS refers to the long-term change in global temperature that would result from a sustained doubling—lasting

hundreds to thousands of years—of heat-trapping carbon dioxide above the preindustrial baseline level of 285 parts per million.

The present-day CO2 level is about 410 ppm, and climate scientists say atmospheric concentrations could hit 1,000 ppm by the year 2100 if nothing is done to limit carbon emissions from the burning of fossil fuels.

For decades, most of the top climate models predicted an equilibrium climate sensitivity of around 3 degrees Celsius (5.4 F), with a range of 1.5 to 4.5 C (2.7 to 8.1 F).

But that changed recently with some of the newest climate models participating in CMIP6. The Coupled Model Intercomparison Project (CMIP) is an internationally coordinated effort between climate-science institutions, and it is now in its sixth phase. The next assessment report from the authoritative Intergovernmental Panel on Climate Change, which is due next year, will rely on CMIP6 models.

Ten of the 27 CMIP6 models have an equilibrium climate sensitivity higher than 4.5 C (8.1 F), meaning that they are more sensitive to CO2 increases than most previous-generation models. The CESM2 model (Community Earth System Model, version 2) tested by the U-M-led research team is one of those CMIP6 models and has an equilibrium climate sensitivity of 5.3 C (9.5 F).

The predecessor to CESM2, the CESM1.2 model, did a remarkably good job of simulating temperatures during the Early Eocene, according to the researchers. It has an equilibrium climate sensitivity of 4.2 C (7.6 F).

"Our study implies that CESM2's climate sensitivity of 5.3 C is likely too high. This means that its prediction of future warming under a high-CO2 scenario would be too high as well," said Zhu, first author of the

Nature Climate Change letter.

"Figuring out whether the high climate sensitivity in CMIP6 models is realistic is of tremendous importance for us to anticipate future warming and to make adaptation plans," said NCAR's Otto-Bliesner.

The team's simulations of the Early Eocene incorporated the latest paleoclimate reconstructions and included data about paleogeography, vegetation cover and land surface properties. Reconstructions of atmospheric carbon dioxide levels from that time predate ice-core records and rely on geochemical and paleobotanical proxies.

The Intergovernmental Panel on Climate Change's Fifth Assessment Report, finalized in 2014, said the global surface temperature increase by the end of the 21st century is likely to exceed 1.5 C relative to the 1850 to 1900 period for most emissions scenarios, and is likely to exceed 2.0 C for some emissions scenarios.

The projections in that assessment were based on the previous generation of CMIP models, known as CMIP5 models. The newer CMIP6 models will likely lead to projections of even greater warming.The Paris climate accord's long-term temperature goal is to keep the increase in global average temperature to well below 2 C above preindustrial levels and to pursue efforts to limit the increase to 1.5 C.

More information: High climate sensitivity in CMIP6 model not supported by paleoclimate, *Nature Climate Change* (2020).

Provided by University of Michigan

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