Tipping points complicate the evaluation of complex climate models

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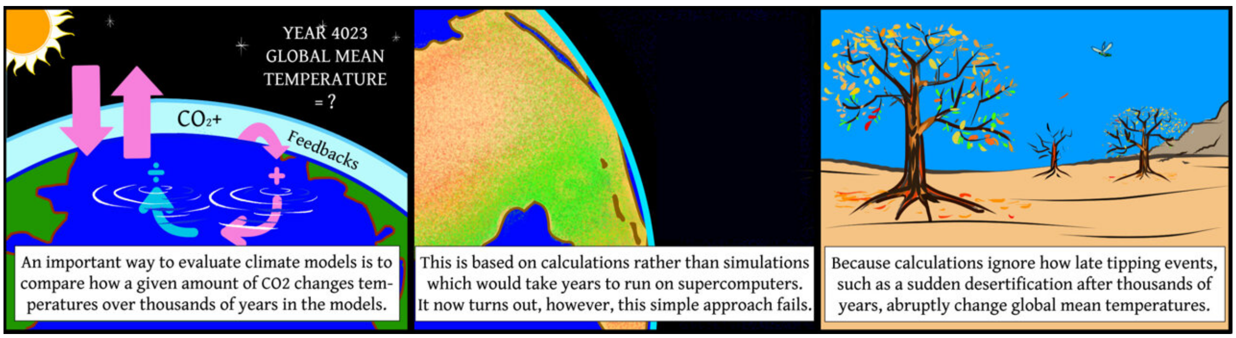

Climate tipping means the common method for comparing climate models is unreliable, a study finds. Credit: TiPES/HP

An analysis by Robbin Bastiaansen and Anna von der Heydt, the University of Utrecht, the Netherlands; and Peter Ashwin, the University of Exeter, UK, indicates that it might remain difficult to accurately find the equilibrium climate sensitivity in complex climate models. The equilibrium climate sensitivity is used to compare and evaluate models and is calculated using a limited set of data from a relatively short simulation. But such results could be heavily underestimating long-term warming as late climate tipping cannot be excluded by the commonly used methods to estimate equilibrium climate sensitivity, conclude the authors. The work is part of the European TiPES project on tipping points in the Earth system.

The equilibrium climate sensitivity is an important number in climate science because it is well suited for the comparison and evaluation of climate models. The number is defined as the total rise in global mean temperature after a doubling of CO_2 in the atmosphere. Because the Earth system is large and complex, reaching a final equilibrium temperature takes thousands of years.

State-of-the-art climate models, however, require months of calculations on supercomputers to simulate even 150 years of climate change. Therefore, it is not feasible to have the models run for years on end to simulate thousands of years of climate change in order to find the model's equilibrium climate sensitivity.

Instead, a simpler method is used: After a model has simulated a couple of hundred years of climate evolution, the data is collected and then used to further estimate how much the mean global temperature goes up if the model was allowed to run until the equilibrium temperature was reached.

However, this commonly used method might be underestimating temperature rise. As Bastiaansen and the team illustrate in the study "Climate Response and Sensitivity: Timescales and Late Tipping Points," published today in *Proceedings of the Royal Society A*, these methods can fail in simple climate models, and therefore also might be inadequate for larger, state-of-the-art climate models.

One problem the group identifies is that climate models, as well as the real climate system, might show a sudden fast temperature increase even after years of a seemingly stable climate. In other words, an abrupt transition in a part of the climate system later than 150 years such as the partial collapse of an ice sheet or sudden desertification of a large part of a continent can greatly influence the global mean temperature and current methods are inapt to estimate the resulting warming.

"So, we show that to be sure of the long-term behavior of a modern global climate model, there are no shortcuts to doing extensive simulations. If you want to know what ultimately is the response/temperature for a given amount of added CO_2, there will be no easy, straightforward and sound way to determine that for sure—even in models," explains Robbin Bastiaansen.

More information: Climate Response and Sensitivity: Timescales and Late Tipping Points, *Proceedings of the Royal Society A Mathematical Physical and Engineering Sciences* (2023). DOI: 10.1098/rspa.2022.0483

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