

Scientists are starting to clear up one of the biggest controversies in climate science



People walk through a flooded street that was caused by the combination of the lunar orbit that caused seasonal high tides and what many believe is the rising sea levels due to climate change on Sept. 30, 2015, in Fort Lauderdale, Fla. Some scientists have suggested that climate models may be predicting too much future warming, but new research is helping to lay these suspicions to rest. (Joe Raedle / Getty Images)

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Washington Post

JULY 5, 2017, 5:15 PM

How much Earth will warm in response to future greenhouse gas emissions may be one of the most fundamental questions in climate science — but it's also one of the most difficult to answer. And it's growing more controversial: In recent years, some scientists have suggested that our climate models may actually be predicting too much future warming, and that climate change will be less severe than the projections suggest.

But new research is helping to lay these suspicions to rest. A study, out Wednesday in the journal *Science Advances*, joins a growing body of literature that suggests the models are on track after all. And while that may be worrisome for the planet, it's good news for the scientists working to understand its future.

The new study addresses a basic conflict between what the models suggest about future climate change and what we can infer from historical observations alone. Some scientists have suggested that the models may be too sensitive, pointing out that the warming they predict for the future is greater than what we would expect based only on the warming patterns we've observed since humans first began emitting greenhouse gases.

The models, for instance, suggest that if the carbon dioxide concentration in the atmosphere were to reach double its preindustrial level, the planet would warm by anywhere from about 2.7 to 8.1 degrees Fahrenheit. But the warming patterns we've actually observed over the past 200 years or so would suggest that a doubling in carbon dioxide should only lead to about 5.4 degrees Fahrenheit of warming at the most.

The discrepancy has become a major cause for concern among climate scientists in recent years, according to the new study's lead author Cristian Proistosescu, a research associate at the University of Washington who conducted the research while completing a Ph.D. at Harvard. Even the United Nations' Intergovernmental Panel on Climate Change acknowledged the issue in its most recent report, he said, stating that it could no longer provide a best estimate for the climate's sensitivity.

"It worried a lot of us," Proistosescu told *The Washington Post*. "We needed to understand why our different estimates didn't work."

The new study helps to reconcile the models with the historical record. It suggests that global warming occurs in different phases or "modes" throughout the planet, some of which happen more quickly than others. Scientists now increasingly believe that certain slow-developing climate processes will amplify warming to a greater extent in the future, putting the models in the right after all. But these processes take time, even up to several hundred years, to really take effect — and because not enough time has passed since the industrial revolution for their signal to really develop, the historical record is what's actually misleading at the moment.

This conclusion is supported by a growing body of research, which suggests that warming estimates made from the historical record alone are "potentially biased low, for reasons we are now just beginning to understand," said Timothy Andrews, a climate scientist with the Met Office, the United Kingdom's national weather service, in an email to *The Washington Post*. While Andrews was not involved with the new study, he's one of multiple scientists whose recent research has tackled the same issue.

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The new study uses a statistical method to separate "fast" and "slow" climate modes in the models. According to Proistosescu, when greenhouse gases are emitted into the atmosphere, a "fast" warming effect begins to take place almost immediately in certain parts of the planet, mainly over the land masses in the Northern Hemisphere. Indeed, these are the parts of Earth where the most rapid warming has been observed since the industrial revolution.

On the other hand, he said, other parts of the planet — namely, the Southern Ocean and the eastern Pacific — respond much more slowly, in part because they're just so deep and cold to

begin with. But as they absorb more heat and finally start to warm up, they may produce a variety of climate feedback effects that actually enhance the global warming that's already occurring. For instance, changes in ocean temperatures can alter atmospheric patterns around the world. The models suggest that these warming ocean regions may lead to a decrease in reflective cloud cover in the future, allowing more solar radiation to make it through the atmosphere to Earth's surface.

While the impact of these processes may be profound, they can also take long periods of time to unfold, Proistosescu said — potentially up to 300 years or so. Through their statistical parsing, the researchers found that the models suggest the effects of this slow climate mode only account for about 3 percent of the human-caused warming we've seen so far. But in the future, under a scenario in which atmospheric carbon dioxide concentrations double, it could account for up to half of all warming that occurs.

Since they were able to separate the fast and slow climate modes, the researchers also conducted a test to see what would happen if they only applied fast climate warming in the models. When they did so, the model predictions suddenly fell in line with the historical record — suggesting that the still-developing slow mode is the reason the two have failed to match so far.

That said, the study does beg the question of how we can be so sure the slow climate mode will actually develop as it does in the model, since humans have yet to really observe it in nature. According to Piers Forster, a University of Leeds climate scientist who has also studied climate sensitivity, the models tend to rely on certain assumptions that have not yet unfolded in real life — for instance, that the eastern Pacific will eventually warm to a greater extent than the western Pacific.

"This doesn't necessarily mean the models are wrong," he added in an emailed comment to *The Washington Post*. But, he said, it does suggest that "we do not yet fully understand these long term changes in the Pacific and therefore these climate change amplification effects."

According to Proistosescu, some studies of Earth's ancient climate — which scientists can conduct using information from sources like ice cores and preserved sediments — do suggest that a slow climate mode does exist and has occurred in the past. And he added that the climate models rely on basic physical processes to a great extent, and "we trust that they do the basic physics correctly."

But he agreed that some caution — or at least a great deal more research on how these slow climate responses will continue to develop — is called for. In fact, identifying the uncertainties that remain about Earth's climate sensitivity is another significant outcome of the study, he suggested.

The research indicates that the models and the historical record are not so different after all, and that there are certain large-scale climate feedback processes still unfolding. How exactly those develop may still be uncertain — no one's arguing that the models are currently perfect, Proistosescu said.

"But they're close enough that you trust that there is an effect there, you just need to better quantify what that is," he added. "And that's where a lot of the work is going."

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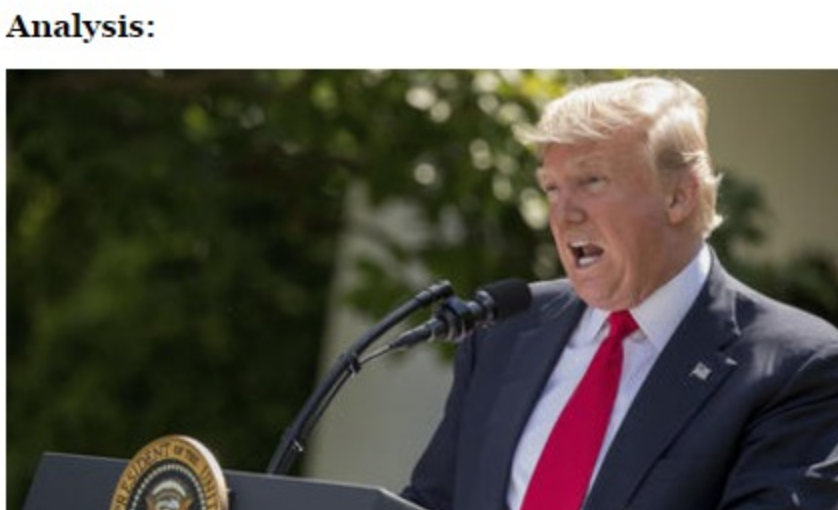
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