Scientists say the global ocean circulation may be more vulnerable to shutdown than we thought

Chelsea Harvey, The Washington Post, 1-4-17

Intense future climate change could have a far different impact on the world than current models predict, suggests a thought-provoking new study just out in the journal Science Advances. If atmospheric carbon dioxide concentrations were to double in the future, it finds, a major ocean current — one that helps regulate climate and weather patterns all over the world — could collapse. And that could paint a very different picture of the future than what we've assumed so far.

The Atlantic meridional overturning circulation, or AMOC, is often described as a large oceanic conveyor belt. It's a system of water currents that transports warm water northward from the Atlantic toward the Arctic, contributing to the mild climate conditions found in places like Western Europe. In the Northern Atlantic, the northward flowing surface water eventually cools and sinks down toward the bottom of the ocean, and another current brings that cooler water back down south again. The whole process is part of a much larger system of overturning currents that circulates all over the world, from pole to pole.

But some scientists have begun to worry that the AMOC isn't accurately represented in current climate models. They say that many models portray the current as being more stable than real-life observations suggest it actually is. Recent studies have suggested that the AMOC is weakening, although there's some scientific debate about how much of this has been caused by human activities and how much by natural variations.

Nevertheless, the authors of the new study point out, many climate models assume a fairly stable AMOC — and that could be affecting the predictions they make for how the ocean will change under future climate change. And because overturning circulation patterns have such a significant effect on climate and weather all over the world, this could have big implications for all kinds of other climate-related projections as well.

"This is a very common and well-known issue in climate models," said the new study's lead author, Wei Liu, a postdoctoral associate at Yale University, who conducted the work while at the University of California at San Diego. "I wanted to see, if I use a corrected model, how this will affect the future climate change."

Liu and colleagues from the UC-San Diego and the University of Wisconsin at Madison took a commonly used climate model and corrected for what they considered to be the AMOC stability bias. Then they ran an experiment to see how the correction would affect the model's projections under future climate change. They instantaneously doubled the atmospheric carbon dioxide concentration from present-day levels in both the corrected and uncorrected models, and then they let both models run for hundreds of simulated years.

The differences were striking. In the uncorrected climate model, the AMOC weakens for a while, but eventually recovers. In the corrected model, however, the AMOC continues to weaken and after 300 years, it collapses altogether.

In a commentary also published today in RealClimate, Stefan Rahmstorf, an oceans physics expert at the Potsdam Institute for Climate Impact Research, explained how such a collapse could occur when the AMOC gets too weak.

“Freshwater continually flows into the northern Atlantic through precipitation, rivers and ice-melting,” he wrote. “But supply of salty waters from the south, through the Gulf Stream System, balances this. If however the current slows, there is less salt supply, and the surface ocean gets less salty.”

Because freshwater is less dense than salty water, this process can lead to a kind of stratification, in which the lighter freshwater gets stuck on the surface of the ocean and can’t sink to the bottom when it reaches the cooler north. When this happens, the overturning process that drives the current back down south again can’t occur.

“There is a critical point when this becomes an unstoppable vicious circle,” Rahmstorf wrote. “This is one of the classic tipping points in the climate system.”

The resulting climate consequences, compared to the uncorrected model, are also dramatic. Without the usual transport of warm water into the north, the corrected model predicts a marked cooling over the northern Atlantic, including in the United Kingdom, Iceland and northwestern Europe, as well as in the Arctic, where sea ice begins to expand.

Because the AMOC is part of a larger global conveyor system, which ferries warm and cold currents between the equator and both poles, the model predicts disruptions in other parts of the world as well. Without cold water moving back down south again, the corrected model indicates a stronger warming pattern south of the equator than what’s predicted by the uncorrected model, causing a polarization in precipitation patterns over the Americas — more rain for places like northeastern Brazil and less rain for Central America. The model also predicts a greater reduction in sea ice for the Antarctic.

All this doesn’t necessarily mean that everything we thought we knew about the future climate is wrong. For one thing, most modern climate projections focus on the next few decades or so, noted Thomas Haine, an expert on ocean circulation at Johns Hopkins University. And within 50 years or so, both the uncorrected and corrected models in the new study produce similar results. It is only after that, under extreme warming, that the current shifts.

Liu also cautioned that certain aspects of the experiment can’t exactly be considered realistic — for instance, instantaneously doubling the atmospheric carbon dioxide concentration. Current climate efforts are aimed at keeping us from ever getting to such a point — but even if we did, the process would happen gradually, not overnight. So the model’s outcome might have been different if the researchers had adopted a more realistic scenario.

Haine also suggested that the correction in the new study may have actually been a bit too strong, compared to actual observations — in other words, the modeled AMOC is “probably more unstable than the real system,” he said.

Rahmstorf also pointed out this issue in his commentary — but he added that the climate model used also did not account for an influx of meltwater from Greenland under future climate change, an event that recent research suggests could substantially speed the AMOC’s weakening.

“With unmitigated emissions . . . the Gulf Stream System weakens on average by 37 percent by the year 2300 without Greenland melt,” he notes. “With Greenland meltwater this doubles to 74 percent. And a few months ago, a study with a high-resolution ocean model appeared, suggesting that the meltwater from Greenland is likely to weaken the AMOC considerably within a few decades.”

The fact that current models don’t take this melting into account is further support for the idea that scientists have been underestimating the risk of a future AMOC collapse, he suggested.

According to Liu, the new study serves to make a point about the dramatic effects that can occur when corrections are made in climate models, as well as the AMOC’s major role in the global climate. By tweaking a climate model to make it more consistent with real-life observations, very different outcomes may be observed, Liu noted.

“I would say that it is reasonably well-accepted that a current generation of climate models [is] missing the essential physics in representing the AMOC,” said Haine. And he added that the new study “points to the need to fix these biases in the climate models.”