Warming Could Push the Atlantic Past a ‘Tipping Point’ This Century

The system of ocean currents that regulates the climate for a swath of the planet could collapse sooner than expected, a new analysis found.

Sunrise from Miami Beach this month. Atlantic currents that send warm water from the Caribbean toward Europe could be at risk.Credit...Joe Raedle/Getty Images

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The last time there was a major slowdown in the mighty network of ocean currents that shapes the climate around the North Atlantic, it seems to have plunged Europe into a deep cold for over a millennium.

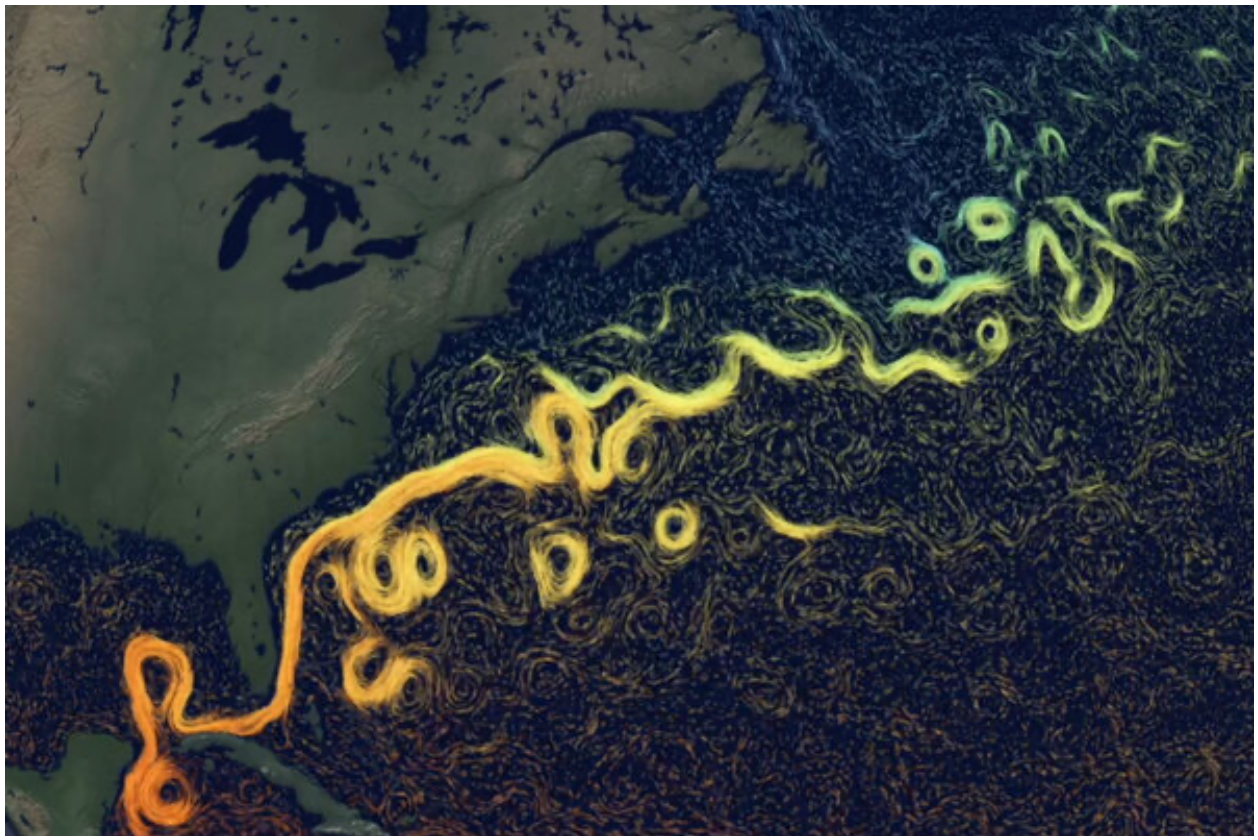
That was roughly 12,800 years ago, when not many people were around to experience it. But in recent decades, human-driven warming could be causing the currents to slow once more, and scientists have been working to determine whether and when they might undergo another great weakening, which would have ripple effects for weather patterns across a swath of the globe.

A pair of researchers in Denmark this week put forth a bold answer: A sharp weakening of the currents, or even a shutdown, could be upon us by century’s end.

It was a surprise even to the researchers that their analysis showed a potential collapse coming so soon, one of them, Susanne Ditlevsen, a professor of statistics at the University of Copenhagen, said in an interview. Climate scientists generally agree that the Atlantic circulation will decline this century, but there's no consensus on whether it will stall out before 2100.

Which is why it was also a surprise, Dr. Ditlevsen said, that she and her co-author were able to pin down the timing of a collapse at all. Scientists are bound to continue studying and debating the issue, but Dr. Ditlevsen said the new findings were reason enough not to regard a shutdown as an abstract, far-off concern. "It's now," she said.

From 2021: The Imperiled Atlantic Currents, Visualized



In the Atlantic Ocean, Subtle Shifts Hint at Dramatic Dangers
A warming atmosphere is causing a branch of the ocean's powerful Gulf Stream to weaken, some scientists fear.

The new research, published on Tuesday in the journal Nature Communications, adds to a growing body of scientific work that describes how humankind's continued emissions of heat-trapping gases could set off climate "tipping points," or rapid and hard-to-reverse changes in the environment.

Abrupt thawing of the Arctic permafrost. Loss of the Amazon rain forest. Collapse of the Greenland and West Antarctic ice sheets. Once the world warms past a certain point, these and

other events could be set into swift motion, scientists warn, though the exact thresholds at which this would occur are still highly uncertain.

In the Atlantic, researchers have been searching for harbingers of tipping-point-like change in a tangle of ocean currents that goes by an unlovely name: the Atlantic Meridional Overturning Circulation, or AMOC (pronounced "EY-mock").

These currents carry warm waters from the tropics through the Gulf Stream, past the southeastern United States, before bending toward northern Europe. When this water releases its heat into the air farther north, it becomes colder and denser, causing it to sink to the deep ocean and move back toward the Equator. This sinking effect, or "overturning," allows the currents to transfer enormous amounts of heat around the planet, making them hugely influential for the climate around the Atlantic and beyond.

As humans warm the atmosphere, however, the melting of the Greenland ice sheet is adding large amounts of fresh water to the North Atlantic, which could be disrupting the balance of heat and salinity that keeps the overturning moving. A patch of the Atlantic south of Greenland has cooled conspicuously in recent years, creating a "cold blob" that some scientists see as a sign that the system is slowing.

Image

Greenland's melting ice sheet is adding large amounts of fresh water to the North Atlantic, which could be disrupting the overturning process. Credit...Lukasz Larsson Warzecha/Getty Images

Were the circulation to tip into a much weaker state, the effects on the climate would be far-reaching, though scientists are still examining their potential magnitude. Much of the Northern Hemisphere could cool. The coastlines of North America and Europe could see faster sea-level rise. Northern Europe could experience stormier winters, while the Sahel in Africa and the monsoon regions of Asia would most likely get less rain.

Evidence from ice and sediment cores indicates that the Atlantic circulation underwent abrupt stops and starts in the deep past. But scientists' most advanced computer models of the global climate have produced a wide range of predictions for how the currents might behave in the coming decades, in part because the mix of factors that shape them is so complex.

Dr. Ditlevsen's new analysis focused on a simple metric, based on sea-surface temperatures, that is similar to ones other scientists have used as proxies for the strength of the Atlantic circulation. She conducted the analysis with Peter Ditlevsen, her brother, who is a climate scientist at the University of Copenhagen's Niels Bohr Institute. They used data on their proxy measure from 1870 to 2020 to calculate statistical indicators that presage changes in the overturning.

"Not only do we see an increase in these indicators," Peter Ditlevsen said, "but we see an increase which is consistent with this approaching a tipping point."

They then used the mathematical properties of a tipping-point-like system to extrapolate from these trends. That led them to predict that the Atlantic circulation could collapse around midcentury, though it could potentially occur as soon as 2025 and as late as 2095.

Their analysis included no specific assumptions about how much greenhouse-gas emissions will rise in this century. It assumed only that the forces bringing about an AMOC collapse would continue at an unchanging pace — essentially, that atmospheric carbon dioxide concentrations would keep rising as they have since the Industrial Revolution.

In interviews, several researchers who study the overturning applauded the new analysis for using a novel approach to predict when we might cross a tipping point, particularly given how hard it has been to do so using computer models of the global climate. But they voiced reservations about some of its methods, and said more work was still needed to nail down the timing with greater certainty.

Susan Lozier, a physical oceanographer at Georgia Tech, said sea-surface temperatures in the North Atlantic near Greenland weren't necessarily influenced by changes in the overturning alone, making them a questionable proxy for inferring those changes. She pointed to a study published last year showing that much of the cold blob's development could be explained by shifts in wind and atmospheric patterns.

Scientists are now using sensors slung across the Atlantic to directly measure the overturning. Dr. Lozier is involved in one of these measurement efforts. The aim is to better understand what's driving the changes beneath the waves, and to improve projections of future changes.

But the projects began collecting data in 2004 at the earliest, which isn't enough time to draw firm long-term conclusions. "It is extremely difficult to look at a short record for the ocean overturning and say what it is going to do over 30, 40 or 50 years," Dr. Lozier said.

Levke Caesar, a postdoctoral researcher studying the overturning at the University of Bremen in Germany, expressed concerns about the older temperature records that Dr. Ditlevsen and Dr. Ditlevsen used to compute their proxy. These records, from the late 19th and early 20th centuries, might not be reliable enough to be used for fine-toothed statistical analysis without careful adjustments, she said.

Still, the new study sent an urgent message about the need to keep collecting data on the changing ocean currents, Dr. Caesar said. "There is something happening, and it's likely out of the ordinary," she said. "Something that wouldn't have happened if it weren't for us humans."

Scientists' uncertainty about the timing of an AMOC collapse shouldn't be taken as an excuse for not reducing greenhouse-gas emissions to try to avoid it, said Hali Kilbourne, an associate research professor at the University of Maryland Center for Environmental Science.

"It is very plausible that we've fallen off a cliff already and don't know it," Dr. Kilbourne said. "I fear, honestly, that by the time any of this is settled science, it's way too late to act."

Raymond Zhong is a climate reporter. He joined The Times in 2017 and was part of the team that won the 2021 Pulitzer Prize in public service for coverage of the coronavirus pandemic.