Why the Earth's past has scientists so worried about the Atlantic Ocean's circulation

Chris Mooney, Washington Post, 10-13-15

In the last month, there's been much attention to a cool patch in the North Atlantic Ocean, where record cold temperatures over the past eight months present a stark contrast to a globe that is experiencing record warmth. And although there is certainly no consensus on the matter yet, some scientists think this pattern may be a sign of one long-feared consequence of climate change — a slowing of North Atlantic Ocean circulation, due to a freshening of surface waters.

The cause, goes the thinking, would be the rapidly melting Greenland ice sheet, whose large freshwater flows may weaken ocean "overturning" by reducing the density of cold surface waters (colder, salty water is denser). If cold, salty waters don't sink in the North Atlantic and flow back southward toward Antarctica at depth, then warm surface waters won't flow northward to take their place. The result could be a significant change to northern hemisphere climate, as less ocean-borne heat reaches higher latitudes.

Now, two new studies just out in Nature Geoscience help to underscore why scientists have a good reason to think this sort of thing can happen — namely, because it appears to have happened in the Earth's distant past. And not just once but on multiple occasions.

For a long time scientists have been trying to figure out a funny thing about glacial periods of Earth's history. These periods are not, you see, uniformly cold. Rather, they show an alternation between so-called stadials — long periods featuring quite cold temperatures — and interstadials, which are relatively rapidly occurring warmer periods during glacials.

So what causes this oscillation in glacial temperatures?

A leading theory is that this all has something to do with changes in the circulation of the oceans. The idea is that large flows of ice into the ocean in the North Atlantic cause freshening at the surface. This could then weaken Atlantic Ocean circulation, lessen northward heat transport, and ultimately cause a cold period — another stadial.

The first study in Nature Geoscience seems to confirm as much by looking at a deep sea core from the middle of the South Atlantic Ocean, off the coast of South America in waters that aren't far from the beginning of the Southern Ocean and, then, Antarctica. The research, led by Julia Gottschalk of the University of Cambridge in collaboration with other researchers from Cambridge, the United States, Australia and France, finds "a very tight link between abrupt changes in the ocean circulation, and these events, these transitions between cold climate states and warm climate states during the last glacial period," as Gottschalk puts it.

But how could the researchers know this from a single cylinder of mud extracted from more than two miles beneath the ocean?

The trick, Gottschalk says, is that the core was taken from a region where very different water masses, characteristic of the North and South Atlantic, meet. "The waters formed in the north are preserving, so they're less corrosive," Gottschalk says. "And the waters from the south are more corrosive because they have more CO_2, more acid basically."

And these water characteristics have an effect on the dissolution of the shells of tiny microorganisms called foraminifera, which fall to the seafloor and become part of the core sample that the scientists examined.

Thus, by examining these shells, the researchers were able to tell when the area was bathing in waters that had traveled southward from the North Atlantic — so-called North Atlantic Deep Water, a key part of the overturning circulation — and when that circulation was weaker and South Atlantic waters occupied the area instead. The results, Gottschalk says, are something that scientists studying glacial changes and their causes have lacked — namely, “a clear deep ocean record that really shows these abrupt changes in ocean circulation.”

Indeed, the record showed that during “nearly every” warm or interstadial period, deep water from the North Atlantic made its way southward toward Antarctica — precisely what you would expect if overturning ocean circulation increased in the North Atlantic, snapping back from a more slowed-down state. “Our core site is really very sensitive to these ocean circulation changes, and we could really draw this conclusion that abrupt climate change in the past is really closely coupled to changes in the overturning, or to deepwater mass formation,” Gottschalk says.

More specifically, Gottschalk says, the last 115,000 years featured some 25 abrupt cold-to-warm shifts in the North Atlantic. And “at least during the last 70,000 years these climate shifts were in some way or the other tightly linked with significant changes of the deep Atlantic Ocean circulation, in particular with deep water circulating from the North to the South Atlantic.”

The second study, meanwhile, seeks to explain the Younger Dryas, a cold period that began abruptly 12,900 years ago, as the planet was actually coming out of a glacial period and entering the present interglacial. Suddenly, though, temperatures swung back and became quite cold again for more than a thousand years, leading glaciers and ice sheets to rebuild. And once again, a change in Atlantic Ocean circulation has long been a leading suspect in causing this dramatic, sudden event.

“The start of the Younger Dryas was in a couple of years, really five years or so,” says Hans Renssen of VU University Amsterdam in the Netherlands, who led the research, along with scientists from Belgium, France, the United Kingdom, Norway and Switzerland.

Using climate change models, the researchers tried to reproduce the cooling of the Younger Dryas period. And they found that simulating a full shutdown of the Atlantic’s overturning circulation actually made things too cold — but combining together a more moderate ocean circulation slowdown (losing about half of its force) with a concurrent reduction in solar radiation reaching the Earth’s surface and a change in atmospheric circulation patterns did a very good job of simulating the cool down.

Slowing the Atlantic Ocean’s circulation thus “plays an important role, but it’s not the only mechanism,” Renssen says.

When it comes to modern day implications of the research, however, “it shows that climate is sensitive to changes in the freshwater balance of the ocean,” Renssen says. “So I would not expect a Younger Dryas, or a thousand year-long cold period, but I think there’s still a serious risk of the ocean circulation to weaken, and even abruptly.”

Granted, it’s important to distinguish between past periods, like the Younger Dryas, and where we are today. For the Younger Dryas, the trigger event is thought to be a gigantic freshwater flow from the huge Lake

Agassiz, which had been previously hemmed in by the Laurentide Ice Sheet — a vast ice sheet that covered much of North America during the last glacial period.

But neither Lake Agassiz nor the Laurentide Ice Sheet exists today. So whatever they did in the past could be quite different from the effects of large ice loss from Greenland in the present.

The gist of the new research, then, is that the idea of abrupt climate changes brought on by ocean circulation changes is very much alive and well in climate change research. Whether what we’re currently seeing matches what happened in the past is another matter — but the past certainly gives ample reason for concern.