Scientists find deep-ocean evidence for Atlantic overturning decline

February 17 2015, by Mark Floyd

A new study has found evidence from the deep ocean that the Atlantic meridional overturning circulation – a system of currents that brings warm water from the tropics to the North Atlantic region and keeps its climate more moderate – declined at the end of the last ice age.

Some scientists have long suspected that was the case because the North Atlantic cooled at a time the rest of the planet was warming, but evidence to support the theory has been sparse or indirect. However, the new study, which utilized 25 deep ocean sediment cores and a corresponding computer model, determined that the AMOC not only declined – the process may have pumped more carbon dioxide into the atmosphere.

Results of the study have just been published in the open access journal

Climate of the Past. It was supported by the National Science Foundation.

"There has long been a feeling that if the deep ocean was changing at the end of the last ice age, there should be evidence from the deep ocean to document it – and that has been lacking," said Andreas Schmittner, a climate modeling scientist at Oregon State University and lead author on the study.

"The Atlantic meridional overturning circulation enhances the biological pump, and if it declined it should have had an impact on primary productivity as well as the overall climate for the region," added Schmittner, an associate professor in Oregon State's College of Earth, Ocean, and Atmospheric Sciences.

Schmittner and his colleague David Lund from the University of Connecticut used evidence from 25 sediment cores taken primarily from the Atlantic Ocean, but also from the Indian and Pacific Ocean, which showed a change in the carbon isotope ratio over a period of 3,000 to 4,000 years that began some 19,000 years ago.

The isotopes show up in the shells of tiny organisms called foraminifera that are found in deep ocean sediment cores. When they were alive, their carbonate shells accumulated two carbon isotopes – C-12, a lighter isotope, and C-13, which is heavier. Scientists can tell by the ratio of the two isotopes how ocean circulation and biological productivity were changing and how that affected atmospheric carbon dioxide levels.

When productivity lessened with the decline of the Atlantic meridional overturning circulation, there was more C-13 in the ocean compared to C-12 – except in the North Atlantic, where C-13 decreased strongly in comparison to C-12. An abundance of C-12, on the other hand, indicates that the current system was strong and plankton blooms were plentiful.

To test the evidence, Schmittner ran a computer model combining equations for the physical processes and the chemical and biological processes and said they matched the sediment core data very closely.

"You can divide the oceans of the world into small boxes and look at the physical processes like water velocity, salinity and nutrients to predict plankton growth, sinking rates after death, and how the carbon cycle is affected," he said.

"What we did next was to plug into the model the influx of fresh water into the North Atlantic that would have come from the melting of ice sheets and glaciers and see how that would have affected both the physics and the biology," he added. "What we found in the ice cores was eerily similar to what the computer model predicted."

Schmittner and Lund's model matched ice core data from Antarctica that show increasing levels of carbon dioxide in the atmosphere right after the end of the last glacial maximum (19,000 years before present) for several thousand years. Schmittner's model suggests that the Atlantic meridional overturning circulation decline pulled carbon dioxide from the deep ocean and gradually released it into the atmosphere.

"The current affects the biological pump and if you turn the current off, you reduce the pump and you have less productivity," Schmittner said. "The system then pulls carbon dioxide from the deep ocean and it winds up in the atmosphere."

The researchers note that future global warming may again slow down the circulation because as surface waters warm, they become more buoyant and are less likely to sink – a key process to maintaining the system of currents in the Atlantic. The addition of fresh water from melting ice sheets may compound the slowdown.

Provided by Oregon State University