Ocean Circulation Doesn't Work As Expected

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This model of North Atlantic currents has been called into question by new data from Duke University and the Woods Hole Oceanographic Institution. Image: Archana Gowda, Duke

(PhysOrg.com) -- The familiar model of Atlantic ocean currents that shows a discrete "conveyor belt" of deep, cold water flowing southward from the Labrador Sea is probably all wet.

New research led by Duke University and the Woods Hole Oceanographic Institution relied on an armada of sophisticated floats to show that much of this water, originating in the sea between Newfoundland and Greenland, is diverted generally eastward by the time it flows as far south as Massachusetts. From there it disburses to the depths in complex ways that are difficult to follow.

A 50-year-old model of ocean currents had shown this southbound subsurface flow of cold water forming a continuous loop with the familiar northbound flow of warm water on the surface, called the Gulf Stream.

"Everybody always thought this deep flow operated like a conveyor belt, but what we are saying is that concept doesn't hold anymore," said Duke oceanographer Susan Lozier. "So it's going to be more difficult to measure these climate change signals in the deep ocean."

And since cold Labrador seawater is thought to influence and perhaps moderate human-caused climate change, this finding may affect the work of global warming forecasters.

"To learn more about how the cold deep waters spread, we will need to make more measurements in the deep ocean interior, not just close to the coast where we previously thought the cold water was confined," said Woods Hole's Amy Bower.

Lozier, a professor of physical oceanography at Duke's Nicholas School of the Environment and Bower, a senior scientist in the department of physical oceanography at the Woods Hole Institution, are co-principal authors of a report on the findings to be published in the May 14 issue of the research journal *Nature*.

Their research was supported by the National Science Foundation.

Climatologists pay attention to the Labrador Sea because it is one of the starting points of a global circulation pattern that transports cold northern water south to make the tropics a little cooler and then returns warm water at the surface, via the Gulf Stream, to moderate temperatures of northern Europe.

Since forecasters say effects of global warming are magnified at higher latitudes, that makes the Labrador Sea an added focus of attention. Surface waters there absorb heat-trapping carbon dioxide from the atmosphere. And a substantial amount of that CO_2 then gets pulled underwater where it is no longer available to warm Earth's climate.

"We know that a good fraction of the human caused carbon dioxide released since the Industrial revolution is now in the deep North Atlantic" Lozier said. And going along for the ride are also climate-caused water temperature variations originating in the same Labrador Sea location.

The question is how do these climate change signals get spread further south? Oceanographers long thought all this Labrador seawater moved south along what is called the Deep Western Boundary Current (DWBC), which hugs the eastern North American continental shelf all the way to near Florida and then continues further south.

But studies in the 1990s using submersible floats that followed underwater currents "showed little evidence of southbound export of Labrador sea water within the Deep Western Boundary Current (DWBC)," said the new Nature report.

Scientists challenged those earlier studies, however, in part because the floats had to return to the surface to report their positions and observations to satellite receivers. That meant the floats' data could have been "biased by upper ocean currents when they periodically ascended," the report added.

To address those criticisms, Lozier and Bower launched 76 special Range and Fixing of Sound floats into the current south of the Labrador Sea between 2003 and 2006. Those "RAFOS" floats could stay submerged at 700 or 1,500 meters depth and still communicate their data for a range of about 1,000 kilometers using a network of special low frequency and amplitude seismic signals.

But only 8 percent of the RAFOS floats' followed the conveyor belt of the Deep Western Boundary Current, according to the Nature report. About 75 percent of them "escaped" that coast-hugging deep underwater pathway and instead drifted into the open ocean by the time they rounded the southern tail of the Grand Banks.

Eight percent "is a remarkably low number in light of the expectation that the DWBC is the dominant pathway for Labrador Sea Water," the researchers wrote.

Studies led by Lozier and other researchers had previously suggested cold northern waters might follow such "interior pathways" rather than the conveyor belt in route to subtropical regions of the North Atlantic. But "these float tracks offer the first evidence of the dominance of this pathway compared to the DWBC."

Since the RAFOS float paths could only be tracked for two years, Lozier, her graduate student Stefan Gary, and German oceanographer Claus Boning also used a modeling program to simulate the launch and dispersal of more than 7,000 virtual "efloats" from the same starting point.

"That way we could send out many more floats than we can in real life, for a longer period of time," Lozier said.

Subjecting those efloats to the same underwater dynamics as the real ones, the researchers then traced where they moved. "The spread of the model and the RAFOS float trajectories after two years is very similar," they reported.

"The new float observations and simulated float trajectories provide evidence that the southward interior pathway is more important for the transport of Labrador Sea Water through the subtropics than the DWBC, contrary to previous thinking," their report concluded.

"That means it is going to be more difficult to measure climate signals in the deep ocean," Lozier said. "We thought we could just measure them in the Deep Western Boundary Current, but we really can't."

Source: Duke University (news : web)