Shutdown of circulation pattern could be disastrous, researchers say

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If global warming shuts down the thermohaline circulation in the North Atlantic Ocean, the result could be catastrophic climate change. The environmental effects, models indicate, depend upon whether the shutdown is reversible or irreversible.

"If the thermohaline shutdown is irreversible, we would have to work much harder to get it to restart," said Michael Schlesinger, a professor of atmospheric sciences at the University of Illinois at Urbana-Champaign and a co-author of a report to be presented at the American Geophysical Union meeting in San Francisco, Dec. 13-17. "Not only would we have the very difficult task of removing carbon dioxide from the atmosphere, we also would have the virtually impossible task of removing fresh water from the North Atlantic Ocean."

The thermohaline circulation is driven by differences in seawater density, caused by temperature and salinity. Like a great conveyor belt, the circulation pattern moves warm surface water from the southern hemisphere toward the North Pole. Between Greenland and Norway, the water cools, sinks into the deep ocean, and begins flowing back to the south.

"This movement carries a tremendous amount of heat northward, and plays a vital role in maintaining the current climate," Schlesinger said. "While shutting it down due to global warming would not cause an ice age, as was depicted in a recent blockbuster movie, 'The Day After Tomorrow,' eastern North America and western Europe would nevertheless experience a shift in climate."

Paleoclimate records constructed from Greenland ice cores have revealed that the thermohaline circulation has, indeed, shut down in the past and caused regional climate change. As the vast ice sheet that covered much of North America during the last ice age finally receded, the meltwater flowed out the St. Lawrence and into the North Atlantic.

"The additional fresh water made the ocean surface less dense and it stopped sinking, effectively shutting down the thermohaline circulation," Schlesinger said. "As a result, Greenland cooled by about 7 degrees Celsius within several decades. When the meltwater stopped, the circulation pattern restarted, and Greenland warmed."

Since the system has previously shut down by itself, "it is not unlikely that it will do so again, especially with our help in pouring greenhouse gases into the atmosphere," Schlesinger said. "Higher temperatures due to global warming could add fresh water to the northern North Atlantic by increasing the precipitation and by melting nearby sea ice, mountain glaciers and the Greenland ice sheet. This influx of fresh water could reduce the surface salinity and density, leading to a shutdown of the thermohaline circulation.

Schlesinger and his team simulated the potential effects with an uncoupled ocean general circulation model and with it coupled to an atmosphere general circulation model. They found that the thermohaline circulation shut down irreversibly in the uncoupled model simulation, but reversibly in the coupled model simulation.

"The different results occurred because of a crucial feedback mechanism that appeared only in the coupled model simulation," Schlesinger said. "Enhanced evaporation increased the salinity and density of the ocean surface, offsetting the effects of additional fresh water."

"The irreversible shutdown of the thermohaline circulation thus appears to be an artifact of the model, rather than a likely outcome of global warming," Schlesinger said. "But, because the possibility of an irreversible shutdown cannot be excluded, suitable policy options should continue to be explored. Doing nothing to abate global warming would be foolhardy if the thermohaline circulation shutdown is irreversible."

Coauthors are U. of I. graduate student Jianjun Yin, research specialist Natasha Andronova, research programmer Bin Li, and Princeton University researcher Sergey Malyshev. The National Science Foundation funded the work.

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