Unstable Atlantic deep ocean circulation under future climate conditions

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Eirik Vinje Galaasen is preparing foraminifera shells from the last interglacial period for stable isotope analyses in the massspectrometer. Credit: Photo: Gudrun Sylte

Today, deep waters formed in the northern North Atlantic fill approximately half of the deep ocean globally. In the process, this impacts on the circum-Atlantic climate, regional sea level, and soak up much of the excess atmospheric carbon dioxide from industrialisation—helping to moderate the effects of global warming.

Changes in this circulation mode are considered a potential tipping point in future climate change that could have widespread and long-lasting impacts including on regional sea level, the intensity and pacing of Sahel droughts, and the pattern and rate of ocean acidification and CO2 sequestration.

Until now, this pattern of circulation has been considered relatively stable during warm climate states such as those projected for the end of the century. A new study led by researchers from the Bjerknes Centre of Climate Research at the University of Bergen (UiB) and Uni Research in Norway, suggests that Atlantic deep water formation may be much more fragile than previously realised.

The researchers Eirik Vinje Galaasen (UiB), Ulysses Ninnemann (UiB), Nil Irvali (Uni Research), and Helga (Kikki) Kleiven (UiB) and their colleagues from Rutgers University, USA (Professor Yair Rosenthal), Laboratoire des Sciences du Climat et de l'Environnement, France (Research Scientist Catherine Kissel) and the University of Cambridge, UK (Professor David Hodell) used the shells of tiny single-celled, bottom-dwelling foraminifera found in marine sediment in the North Atlantic Ocean to reconstruct the surface ocean conditions and concomitant deep ocean circulation of about 125,000 years ago. This is the last interglacial period, when the North Atlantic was warmer, fresher and sea level was higher than it is today and looked a lot like what climate models predict it will look by the end of this century.

"At that time, there were a series of sudden and large reductions in the influence of these North Atlantic waters in the deep ocean. These deep water reductions occurred repeatedly, each lasting for some centuries before bouncing back. The unstable circulation operated as if it was near a threshold and flickered back and forth across it," says Eirik Vinje Galaasen, a PhD student and now researcher at UiB's Department of Earth Science, who is the lead author of the paper published in the

journal *Science*.

"These types of changes hadn't been noticed before because they are so short-lived. Geologists hadn't focused on century scale ocean changes because they are difficult to detect," adds Professor Ulysses Ninnemann, from UiB's Department of Earth Science and Galaasen's PhD adviser.

"Our study demonstrates that deep water formation can be disrupted by the freshening of the regional surface water, which might happen due to enhanced precipitation and glacier melting under future climate change scenarios," says Yair Rosenthal, a co-author on the paper.

The international team studied traces of deep ocean properties imprinted in the sediments on the seafloor. Coring into the seafloor mud they could look back in time to reconstruct changes in the abyssal ocean at a location South of Greenland that is sensitive to North Atlantic Deep Water. The mud at this location builds up 10

More information: "Rapid Reductions in North Atlantic Deep Water During the Peak of the Last Interglacial Period," by E.V. Galaasen et al. *Science*, 2014.

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