Long-term study reveals: The deep Greenland Sea is warming faster than the world ocean

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Since 1993, oceanographers from the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI), have carried out regularly expeditions to the Greenland Sea on board the research ice breaker Polarstern to investigate the changes in this region. The programme has always included extensive temperature and salinity measurements. For the present study, the AWI scientists have combined these long term data set with historical observations dating back to the year 1950. The result of their analysis: In the last thirty years, the water temperature between 2000 metres depth and the sea floor has risen by 0.3 degrees centigrade.

'This sounds like a small number, but we need to see this in relation to the large mass of water that has been warmed' says the AWI scientist and lead author of the study, Dr. Raquel Somavilla Cabrillo. 'The amount of heat accumulated within the lowest 1.5 kilometres in the abyssal Greenland Sea would warm the atmosphere above Europe by 4 degrees centigrade. The Greenland Sea is just a small part of the global ocean. However, the observed increase of 0.3 degrees in the deep Greenland Sea is ten times higher than the temperature increase in the global ocean on average. For this reason, this area and the remaining less studied polar oceans need to be taken into consideration'.

The cause of the warming is a change in the subtle interplay of two processes in the Greenland Sea: the cooling by deep convection of very

cold surface waters in winter and the warming by the import of relatively warm deep waters from the interior Arctic Ocean. "Until the early 1980s, the central Greenland Sea has been mixed from the top to the bottom by winter cooling at the surface making waters dense enough to reach the sea floor" explains Somavilla. "This transfer of cold water from the top to the bottom has not occurred in the last 30 years. However, relatively warm water continues to flow from the deep Arctic Ocean into the Greenland Sea. Cooling from above and warming through inflow are no longer balanced, and thus the Greenland Sea is progressively becoming warmer and warmer."

These modified conditions provide AWI scientists with unique research opportunities: "We use these changes as a natural experiment. The warming allows us to calculate how much water flows from the deep central Arctic into the Greenland Sea" says Prof. Dr. Ursula Schauer, head of the Observational Oceanography Department at the Alfred Wegener Institute, about this project and adds: "We observe here a distinct restructuring of the Arctic Ocean. This is a very slow process, and its documentation requires long term observations."

To fully understand how the world's oceans react to climate change, scientists need to investigate the Arctic Ocean in more detail. 'Due to its large volume and its thermal inertia the deep ocean is a powerful heat buffer for climate warming. Especially, the polar oceans are scarcely studied. If we want to understand the role of the deep ocean in the climate system, we need to expand the measurements to remote regions like the Arctic," AWI-scientist Schauer says. For that, she has already planned further Polarstern expeditions. In 2015, Ursula Schauer and her group will go back to the Arctic.

Glossary: Why are the deep waters from the interior Arctic Ocean warm?

The mean temperature of the deep water masses from the interior Arcic Ocean is -0.9 degrees centigrade. That is much warmer than the surface waters of the Greenland Sea, which cool down to -1.8 degrees in winter. However, where does the warmth of the deep Arctic waters come from? It is the result of a long chain reaction, happening in the shallow seas on the edge of the Arctic Ocean – right there, where in winter sea ice formation takes place. When the sea ice is formed the salt, which is present in the water, does not get enclosed. It leaves the ice instead and increases the salinity and density of the water layer below the ice. Due to their rising density these waters get heavier and start sinking. One can compare this sinking process of the water masses with a snowball falling down a freshly snow-covered slope. The longer the snowball rolls, the more snow get attached to its body. That means, while rolling down the Arctic shelf, the salty sinking water masses come across a layer of warm Atlantic water. They take part of the heat and salt in this Atlantic layer and transport it to deeper levels in the Arctic Ocean. At the bottom of the Arctic Ocean these sinking water masses form a body of warm deep water that later on streams out of the Arctic Ocean into the Greenland Sea.

More information: R. Somavilla, U. Schauer and G. Budéus: Increasing amount of Arctic Ocean deep waters in the Greenland Sea, *Geophysical Research Letters*, VOL. 40, 4361, DOI: 10.1002/grl.50775, 2013

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