

Depths of the Weddell Sea are warming five times faster than elsewhere

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Southern Ocean. Credit: Thomas Steuer

Over the past three decades, the depths of the Antarctic Weddell Sea have warmed five times faster than the rest of the ocean at depths exceeding 2,000 meters. This was the main finding of an article just

published by oceanographers from the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI). In the article, they analyze an unprecedented oceanographic time series from the Weddell Sea and show that the warming of the polar depths is chiefly due to changed winds and currents above and in the Southern Ocean. In addition, the experts warn that the warming of the Weddell Sea could permanently weaken the overturning of tremendous water masses that takes place there—with far-reaching consequences for global ocean circulation. Their study was just released on the online portal of the *Journal of Climate*.

Over the past several decades, the world's oceans have absorbed more than 90 percent of the heat trapped in the atmosphere by greenhouse-gas emissions, effectively slowing the rise in [air temperatures](#) around the globe. In this regard, the Southern Ocean is pivotal. Though it only accounts for 15 percent of the world's oceans in terms of area, because of the overturning that takes place there, it absorbs roughly three-fourths of the heat.

Until recently, very little was known about what happens to this heat in the depths of the Southern Ocean, due to the lack of sufficiently long time series. In order to trace the development down to the seafloor, researchers relied on regularly repeated ship-based measurements taken with 'CTD' probes (Conductivity, Temperature and Depth). These probes have now become so precise that they can measure changes in [water temperature](#) down to the nearest ten-thousandth of a degree Celsius. The data they gather can also be used to determine the water masses' density and salinity.

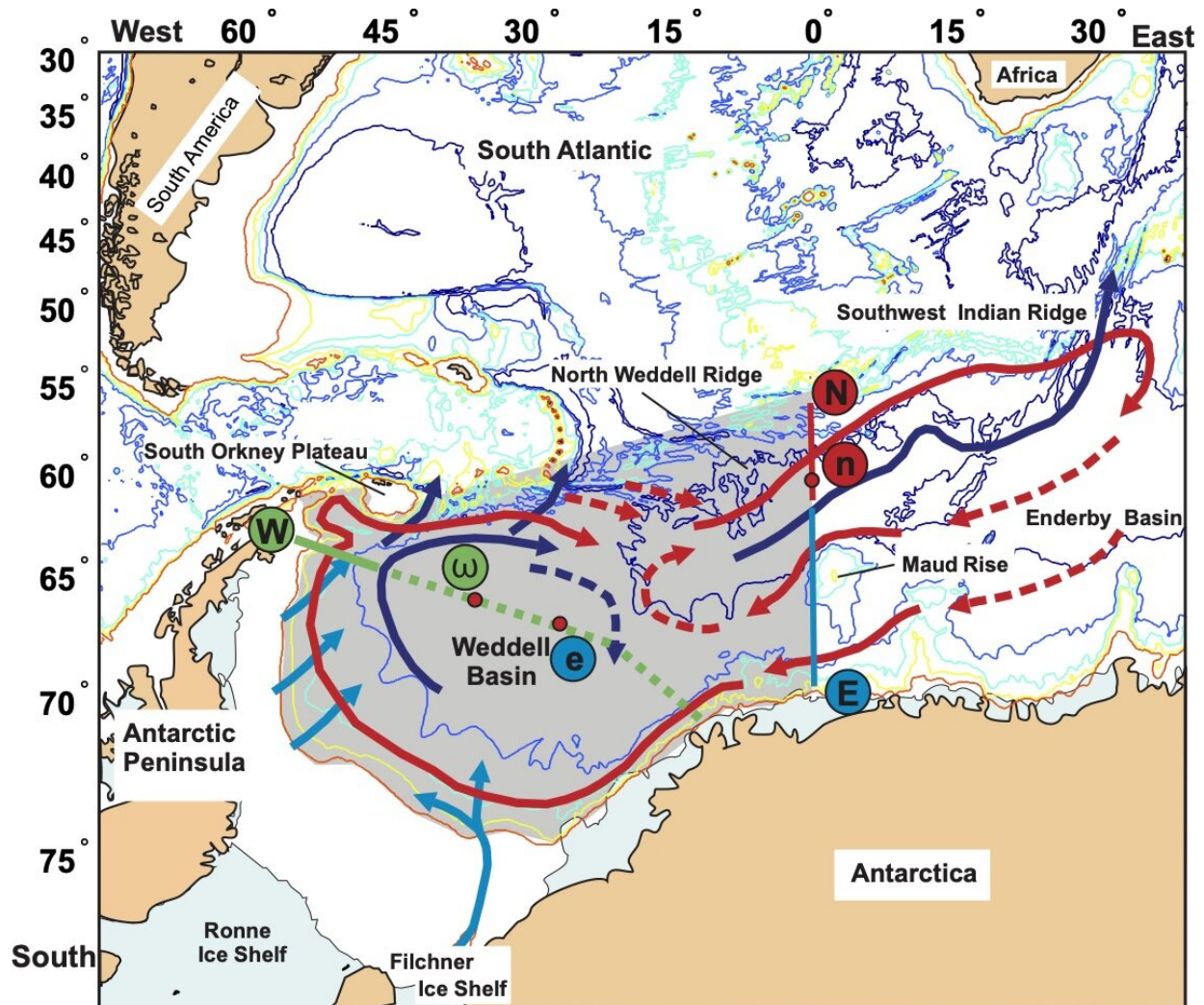
For the past 30 years, AWI oceanographers have been taking these temperature and salinity readings during expeditions to the Weddell Sea on board the German research icebreaker Polarstern—always at the same sites, always from the surface to the seafloor, and always with

extremely high accuracy. By doing so, the researchers have produced the only time series of its kind on the South Atlantic and the Weddell Sea, which has now allowed them to precisely reconstruct the warming of the Weddell Sea and identify potential causes.

Only the water below 700 meters is growing warmer

Their findings are surprising. "Our data shows a clear division in the water column of the Weddell Sea. While the water in the upper 700 meters has hardly warmed at all, in the deeper regions we're seeing a consistent temperature rise of 0.0021 to 0.0024 degrees Celsius per year," says Dr. Volker Strass, an AWI oceanographer and the study's first author.

These values may seem minuscule at first glance. But, as Strass explains, "Since the [ocean](#) has roughly 1,000 times the heat capacity of the atmosphere, these numbers represent an enormous scale of heat absorption. By using the temperature rise to calculate the warming rate in watts per square meter, you can see that over the past 30 years, at depths of over 2,000 meters the Weddell Sea has absorbed five times as much heat as the rest of the ocean on average." Through the formation of bottom water in the Weddell Sea, this heat is then distributed to the deep basins of the world's oceans.



Credit: Alfred Wegener Institute

Potential effects on global circulation

In the Weddell Sea, which represents the southern extension of the Atlantic Ocean and is roughly ten times the size of the North Sea, tremendous water masses cool down. In the course of sea-ice formation they take on salt, sink to deeper water layers as cold and heavy Antarctic Bottom Water, and then spread to the great ocean basins as a deep-sea

current. This overturning is considered to be an important motor for the global ocean circulation. The warming of the depths of the Weddell Sea could weaken that motor, since warmer water has a lower density. Consequently, it is lighter and could fill higher layers of the water column.

"Our [field data](#) already shows a temperature-related loss in density in the deeper water masses of the Weddell Sea. This change is most pronounced in the Bottom Water," says co-author and AWI oceanographer Gerd Rohardt. Whether or not the Antarctic Bottom Water will continue to fulfill its function as the deepest limb of the global ocean overturning circulation chiefly depends on how the density of the water masses above it changes. "In order to monitor these developments, we'll need to continue our regular ship-based readings in the Weddell Sea," says the researcher.

Tracking down the cause: Winds and currents are transporting more heat farther south

As the cause of the increased heat input in the depths of the Weddell Sea, the researchers have identified a change in the wind and current systems over and in the Southern Ocean. "Over the past three decades, the westerlies and with them the Antarctic Circumpolar Current have not only shifted one to two degrees to the south; they have also intensified. As a result, the diameter of the Weddell Gyre has decreased, and the flow speed of the water masses has increased. Because of these two factors, more heat from the Circumpolar Current is transported to the Weddell Sea today than when we first began our measurements," explains Prof Torsten Kanzow, Head of the AWI's Climate Sciences Division and another co-author of the study.

Once the heat reaches the depths of the Weddell Sea, the major bottom

[water](#) currents distribute it to all ocean basins. "Our time series confirms the pivotal role of the Southern Ocean and especially the Weddell Sea in terms of storing [heat](#) in the depths of the world's oceans," says Volker Strass. If the warming of the Weddell Sea continues unchecked, he explains, it will have far-reaching consequences not only for the massive ice shelves on the southern coast of the Weddell Sea, which extend far out into the ocean, and as such, for sea-level rise in the long term, but also for the conveyor belt of ocean circulation as a whole.

More information: Volker H. Strass et al, Multidecadal Warming and Density Loss in the Deep Weddell Sea, Antarctica, *Journal of Climate* (2020). [DOI: 10.1175/JCLI-D-20-0271.1](https://doi.org/10.1175/JCLI-D-20-0271.1)

Provided by Alfred Wegener Institute

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