

Scientists find 20 years of deep water warming leading to sea level rise

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Sea-level rise has the potential to reshape the coastal environment. Credit: NOAA

Scientists analyzing measurements taken in the deep ocean around the globe over the past two decades find a warming trend that contributes to sea level rise, especially around Antarctica.

Greenhouse gases in the atmosphere, such as carbon dioxide, cause heating of the Earth. Over the past few decades, at least 80 percent of this heat energy has gone into the ocean, warming it in the process.

“Previous studies have shown that the upper ocean is warming, but our analysis determines how much additional heat the deep ocean is storing from warming observed all the way to the [ocean floor](#),” said Sarah

Purkey, an oceanographer at the University of Washington and lead author of the study.

This study shows that the deep ocean - below about 3,300 feet - is taking up about 16 percent of what the upper ocean is absorbing. The authors note that there are several possible causes for this deep warming: a shift in Southern Ocean winds, a change in the density of what is called Antarctic Bottom Water, or how quickly that bottom water is formed near the Antarctic, where it sinks to fill the deepest, coldest portions of the ocean around much of the globe.

The scientists found the strongest deep warming around Antarctica, weakening with distance from its source as it spreads around the globe. While the temperature increases are small (about 0.03°C per decade in the deep Southern Ocean, less elsewhere), the large volume of the ocean over which they are found and the high capacity of water to absorb heat means that this warming accounts for a huge amount of [energy storage](#). If this deep ocean heating were going into the atmosphere instead - a physical impossibility - it would be warming at a rate of about 3°C (over 5°F) per decade.

“A warming Earth causes [sea level rise](#) in two ways,” said Gregory Johnson, a NOAA oceanographer at the Pacific Marine Environmental Laboratory in Seattle, and the study’s co-author. “The warming heats the ocean, causing it to expand, and melts continental ice, adding water to the ocean. The expansion and added water both cause the sea to encroach on the land.”

Sea level has been rising at around 3 mm (1/8 of a inch) per year on average since 1993, with about half of that caused by ocean thermal expansion and the other half because of additional water added to the ocean, mostly from melting continental ice. Purkey and Johnson note that deep warming of the Southern Ocean accounts for about 1.2 mm

(about 1/20th of an inch) per year of the sea level rise around Antarctica in the past few decades.

The highly accurate [deep-ocean](#) temperature observations used in this study come from ship-based instruments that measure conductivity through salinity, temperature and depth. These measurements were taken on a series of hydrographic surveys of the global ocean in the 1990s through the World Ocean Circulation Experiment and in the 2000s in support of the Climate Variability program. These surveys are now coordinated by the international Global Ship-based Hydrographic Investigations Program.

More information: The study, “Warming of Global Abyssal and Deep Southern Ocean Waters between the 1990s and 2000s: Contributions to Global Heat and Sea Level Rise Budgets,” authored by Sarah G. Purkey and Gregory C. Johnson, will be published in an upcoming edition of the *Journal of Climate*.

Provided by NOAA

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