

# Scientists suggest ocean warming in Southern Hemisphere underestimated

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The Southern Ocean is a remote place where icebergs frequently drift off the Antarctic coast and can be seen during their various stages of melting. This iceberg, sighted off the Amery Ice Shelf, also has bands of translucent blue ice formed by sea or freshwater freezing in bands between layers of more compressed and white glacial ice. Credit: Andrew Meijers/BAS

Using satellite observations and a large suite of climate models, Lawrence Livermore scientists have found that long-term ocean warming in the upper 700 meters of Southern Hemisphere oceans has likely been underestimated.

"This underestimation is a result of poor sampling prior to the last decade and limitations of the analysis methods that conservatively estimated temperature changes in data-sparse regions," said LLNL oceanographer Paul Durack, lead author of a paper appearing in the October 5 issue of the journal *Nature Climate Change*.

Ocean heat storage is important because it accounts for more than 90 percent of the Earth's excess heat that is associated with [global warming](#). The observed ocean and atmosphere warming is a result of continuing greenhouse gas emissions. The Southern Hemisphere oceans make up 60 percent of the world's oceans.

The team found that [climate models](#) simulate the relative increase in sea surface height—a leading indicator of climate change—between Northern and Southern hemispheres is consistent with highly accurate altimeter observations. However, separating the simulated upper-ocean warming in the Northern and Southern hemispheres is inconsistent with observed estimates of ocean heat content change. These sea level and ocean heat content changes should be consistent, and suggest that until recent improvements occurred in the observational system in the early 21st century, Southern Hemisphere ocean heat content changes were likely underestimated.

Since 2004, automated profiling floats (named Argo) have been used to measure global ocean temperatures from the surface down to 2,000 meters. The 3,600 Argo floats currently observing the global ocean provide systematic coverage of the Southern Hemisphere for the first time. Argo float measurements over the last decade, as well as data from

earlier measurements, show that the ocean has been gradually warming, according to Durack.



Akin to having a fleet of miniature research vessels, the global flotilla of more than 3,600 robotic profiling floats provides crucial information on upper layers of the world's ocean currents. Credit: Alicia Navidad/CSIRO.

"Prior to 2004, research has been very limited by the poor measurement coverage," he said. "By using satellite data, along with a large suite of climate model simulations, our results suggest that [global ocean](#) warming has been underestimated by 24 to 58 percent. The conclusion that warming has been underestimated agrees with previous studies, however it's the first time that scientists have tried to estimate how much heat we've missed."

Given that most of the excess [heat](#) associated with global warming is in the oceans, this study has important implications for how scientists view the Earth's overall energy budget, Durack said.

The new results are consistent with another new paper that appears in the same issue of *Nature Climate Change*. Co-author Felix Landerer of NASA's Jet Propulsion Laboratory, who contributed to both studies, says, "Our other new study on deep-ocean warming found that from 2005 to the present, Argo measurements recorded a continuing warming of the upper-ocean. Using the latest available observations, we're able to show that this upper-[ocean warming](#) and satellite measurements are consistent."

**More information:** "Deep-ocean contribution to sea level and energy budget not detectable over the past decade." W. Llovel, J. K. Willis, F. W. Landerer & I. Fukumori *Nature Climate Change* (2014) [DOI: 10.1038/nclimate2387](#)

"Quantifying underestimates of long-term upper-ocean warming." Paul J. Durack, Peter J. Gleckler, Felix W. Landerer & Karl E. Taylor *Nature Climate Change* (2014) [DOI: 10.1038/nclimate2389](#)

Provided by Lawrence Livermore National Laboratory

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