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**LIVERMORE SCIENTISTS SUGGEST SOUTHERN HEMISPHERE
OCEAN WARMING UNDERESTIMATED**

LIVERMORE, California -- 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 has likely been underestimated.

"This underestimation is a result of poor sampling of the Southern Hemisphere 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 5th 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 increase 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 between Northern and Southern Hemispheres consistent with highly accurate altimeter observations. However, the partitioning of 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 measuring 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 all show that the ocean has been gradually warming, according to Durack.

“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 upper-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 found in the oceans, this study has important implications for how scientists view the Earth’s overall energy budget and its long-term changes, 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 above 2,000 meters. Using the latest available observations, we’re able to show that this upper-ocean warming and satellite measurements are consistent.”

Other Livermore authors include Peter Gleckler and Karl Taylor. The study was conducted as part of the Climate Research Program at Lawrence Livermore National Laboratory through the Program for Climate Model Diagnosis and Intercomparison, which is funded by the Department of Energy’s Regional and Global Climate Modeling Program under contract DE-AC52-07NA27344. Work at NASA is a contribution from the newly formed NASA Sea Level Change Team (N-SCLT) and is supported by NASA ROSES Physical Oceanography grant NNN13D462T.

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