

Deep oceans can mask global warming for decade-long periods

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The planet's deep oceans at times may absorb enough heat to flatten the rate of global warming for periods of as long as a decade even in the midst of longer-term warming, according to a new analysis led by the National Center for Atmospheric Research (NCAR).

The study, based on [computer simulations](#) of [global climate](#), points to ocean layers deeper than 1,000 feet (300 meters) as the main location of the "missing heat" during periods such as the past decade when global [air temperatures](#) showed little trend. The findings also suggest that several more intervals like this can be expected over the next century, even as the trend toward overall warming continues.

"We will see global warming go through hiatus periods in the future," says NCAR's Gerald Meehl, lead author of the study. "However, these periods would likely last only about a decade or so, and warming would then resume. This study illustrates one reason why global temperatures do not simply rise in a straight line."

The research, by scientists at NCAR and the Bureau of Meteorology in Australia, will be published online on September 18 in *Nature* [Climate Change](#). Funding for the study came from the National Science Foundation, NCAR's sponsor, and the Department of Energy.

Where the missing heat goes

The 2000s were Earth's warmest decade in more than a century of weather records. However, the single-year mark for warmest global temperature, which had been set in 1998, remained unmatched until 2010.

Yet emissions of [greenhouse gases](#) continued to climb during the 2000s, and [satellite measurements](#) showed that the discrepancy between incoming sunshine and outgoing radiation from Earth actually increased. This implied that heat was building up somewhere on Earth, according to a 2010 study published in *Science* by NCAR researchers Kevin Trenberth and John Fasullo.

The two scientists, who are coauthors on the new study, suggested that the oceans might be storing some of the heat that would otherwise go toward other processes, such as warming the atmosphere or land, or melting more ice and snow. Observations from a global network of buoys showed some warming in the upper ocean, but not enough to account for the global build-up of heat. Although scientists suspected the deep oceans were playing a role, few measurements were available to confirm that hypothesis.

To track where the heat was going, Meehl and colleagues used a powerful software tool known as the Community Climate System Model, which was developed by scientists at NCAR and the Department of Energy with colleagues at other organizations. Using the model's ability to portray complex interactions between the atmosphere, land, oceans, and sea ice, they performed five simulations of global temperatures.

The simulations, which were based on projections of future greenhouse gas emissions from human activities, indicated that temperatures would rise by several degrees during this century. But each simulation also showed periods in which temperatures would stabilize for about a decade

before climbing again. For example, one simulation showed the global average rising by about 2.5 degrees Fahrenheit (1.4 degrees Celsius) between 2000 and 2100, but with two decade-long hiatus periods during the century.

During these hiatus periods, simulations showed that extra energy entered the oceans, with deeper layers absorbing a disproportionate amount of heat due to changes in oceanic circulation. The vast area of ocean below about 1,000 feet (300 meters) warmed by 18% to 19% more during hiatus periods than at other times. In contrast, the shallower global ocean above 1,000 feet warmed by 60% less than during non-hiatus periods in the simulation.

"This study suggests the missing energy has indeed been buried in the ocean," Trenberth says. "The heat has not disappeared, and so it cannot be ignored. It must have consequences."

A pattern like La Nina

The simulations also indicated that the oceanic warming during hiatus periods has a regional signature. During a hiatus, average sea-surface temperatures decrease across the tropical Pacific, while they tend to increase at higher latitudes, especially around 30°S and 30°N in the Pacific and between 35°N and 40°N in the Atlantic, where surface waters converge to push heat into deeper oceanic layers.

These patterns are similar to those observed during a La Niña event, according to Meehl. He adds that El Niño and La Niña events can be overlaid on top of a hiatus-related pattern. [Global temperatures](#) tend to drop slightly during La Niña, as cooler waters reach the surface of the tropical Pacific, and they rise slightly during El Niño, when those waters are warmer.

"The main hiatus in observed warming has corresponded with La Niña conditions, which is consistent with the simulations," Trenberth says.

The simulations were part of NCAR's contribution to the Coupled Model Intercomparison Project Phase 5 (CMIP5). They were run on supercomputers at NCAR's National Science Foundation-supported Climate Simulation Laboratory, and on supercomputers at Oak Ridge Leadership Computing Facility and the National Energy Research Scientific Computing Center, both supported by the Office of Science of the U.S. Department of Energy.

Provided by National Center for Atmospheric Research

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