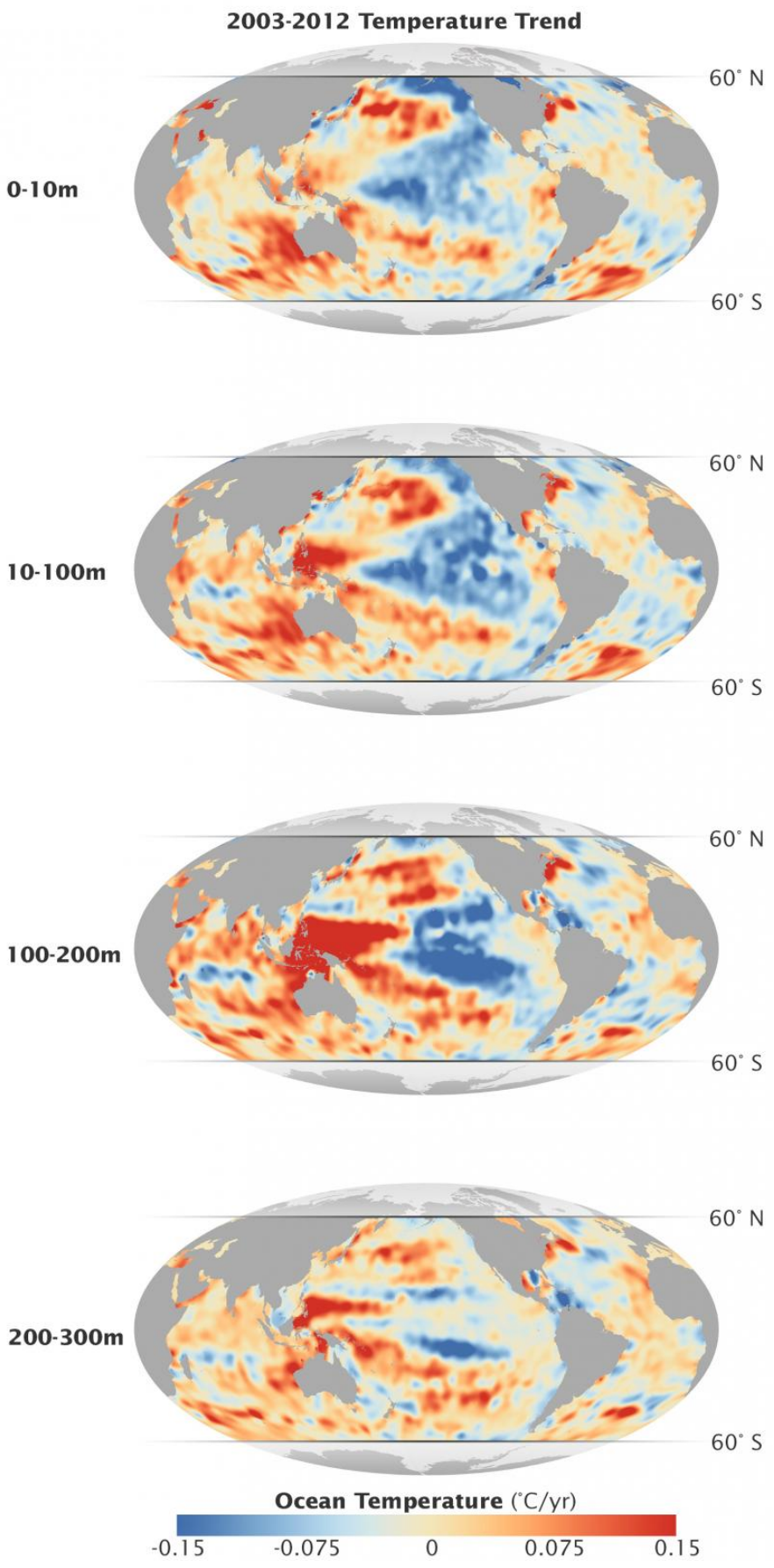
New study finds heat is being stored beneath the ocean surface

July 10 2015


2003-2012 Temperature Trend
0-10m
10-100m
100-200m
200-300m
60° N
60° S
Ocean Temperature (°C/yr)
-0.15
-0.075
0
0.075
0.15

acquired 2003 - 2012

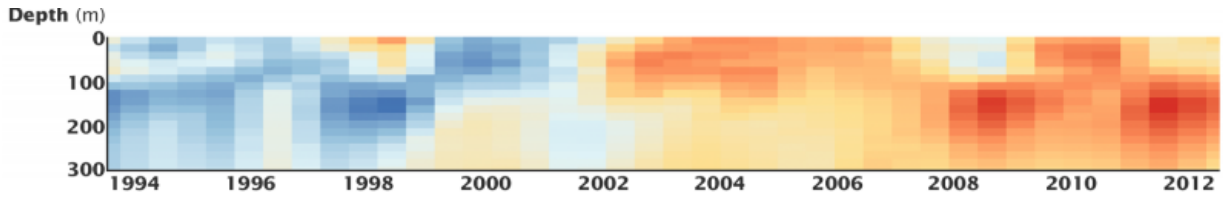
For much of the past decade, a puzzle has been confounding the climate science community. Nearly all of the measurable indicators of global climate change—such as sea level, ice cover on land and sea, atmospheric carbon dioxide concentrations—show a world changing on short, medium, and long time scales. But for the better part of a decade, global surface temperatures appeared to level off. The overall, long-term trend was upward, but the climb was less steep from 2003–2012. Some scientists, the media, and climate contrarians began referring to it as "the hiatus."

If greenhouse gases are still increasing and all other indicators show warming-related change, why wouldn't surface temperatures keep climbing steadily, year after year? One of the leading explanations offered by scientists was that extra heat was being stored in the ocean.

Now a new analysis by three ocean scientists at NASA's Jet Propulsion Laboratory not only confirms that the extra heat has been going into the ocean, but it shows where. According to research by Veronica Nieves, Josh Willis, and Bill Patzert, the waters of the Western Pacific and the Indian Ocean warmed significantly from 2003 to 2012. But the warming did not occur at the surface; it showed up below 10 meters (32 feet) in depth, and mostly between 100 to 300 meters (300 to 1,000 feet) below the sea surface. They published their results on July 9, 2015, in the journal *Science*.

"Overall, the ocean is still absorbing extra heat," said Willis, an oceanographer at JPL. "But the top couple of layers of the ocean

exchange heat easily and can keep it away from the surface for ten years or so because of natural cycles. In the long run, the planet is still warming."



acquired 1993 - 2012

To understand the slowdown in global surface warming, Nieves and colleagues dove into two decades of ocean temperature records; specifically, they examined data sets compiled from underwater floats and other instruments by the Argo team at the Scripps Institution of Oceanography, by the World Ocean Atlas (WOA), and by Japanese scientist Masao Ishii and colleagues. The JPL team found that for most of the decade from 2003–2012, waters near the surface (0–10 meters) of the Pacific Ocean cooled across much of the basin. However, the water in lower layers—10–100 meters, 100–200 meters, and 200–300 meters—warmed.

The animated map at the top of this page shows the trends in water temperatures in various depth layers of the ocean as measured between 2003 and 2012. Areas in red depict warming trends in degrees Celsius per year, while blues depict cooling trends. Warming is most acute between 100–200 meters in the western Pacific and the eastern Indian Ocean. Some areas of the Pacific appear to cool—particularly near the surface and in the eastern half, which correlates well with the cool phase

of the Pacific Decadal Oscillation (PDO), which has been underway for much of the past 15 to 20 years.

Note that the Atlantic Ocean does not show significant trends at any depth, with warming temperatures in one place counter-balanced by cooling in others. The Atlantic basin is also relatively small compared to the Pacific and does not have as much impact on global temperatures. The JPL team also noted that the temperature signal was neutral or inconclusive at depths below 300 meters, where measurements are relatively sparse.

The figure below depicts the trends in a different way. It represents a cross-section of the top 300 meters of the global ocean and how temperatures changed from 1993 to 2012. Note how there are cooler waters near the surface in several years in the 2000s, but that waters at depth grow much warmer. Note, too, how the overall trend in 20 years goes from a cooling ocean to a significantly warmer ocean.

Nieves, Willis, and Patzert were provoked to launch the study because they wanted a more detailed, nuanced picture of ocean temperatures than is possible with most models. On a broad scale, models can replicate broad and long-term trends in the sea; but on smaller scales of space and time, a lot of the models cannot match real-world conditions. The new findings should help improve models of ocean heat storage and climate impacts on regional scales.

The Pacific Ocean covers nearly one-third of Earth's surface, so it has an outsized impact on the global thermostat. "As the top 100 meters of the Pacific goes, so goes the surface temperatures of the planet," said Patzert, a climatologist at JPL. With the surface layer of the ocean being cooler for much of the study period, those waters had a moderating effect on air masses and weather systems on the continents. However, ocean and air temperatures have started to rise swiftly in the past two to

three years, which suggests that the cool phase of the PDO and the warming hiatus is over.

"Natural, decadal variability has been with us for centuries, and it continues to have big regional impacts on society," said Nieves, a JPL scientist with a joint appointment at the University of California, Los Angeles. "We can expect to have more hiatuses in the future, but unless future hiatuses are stronger than usual, they will be less visible due to fast rising greenhouse gases. Right now, the combined effect of the human-caused warming and the Pacific changing to a warm phase can play together and produce warming acceleration."

More information: "Recent hiatus caused by decadal shift in Indo-Pacific heating." *Science* DOI: 10.1126/science.aaa4521

Provided by NASA