Cooling of Pacific Waters Tied to Winds from Global Warming

Researchers have identified why most climate models don't match up with an observed cooling trend in the tropics.

By **Rachel Berkowitz**

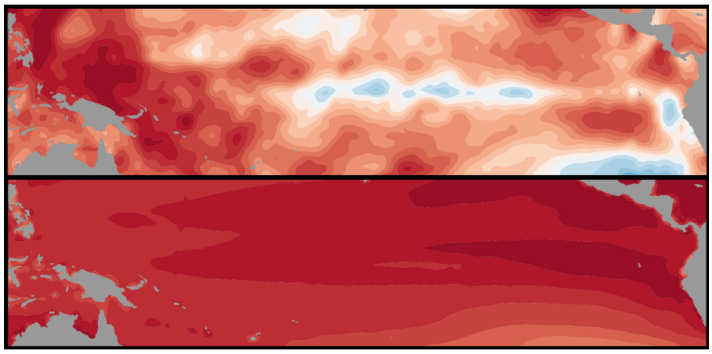
State-of-the-art climate models predict that the Pacific Ocean should be warming in response to rising greenhouse gases. But satellite and *in situ* observations suggest that a large swathe of water behaves otherwise: This region has cooled—or at least resisted warming—over the past several decades. Researchers have now found robust evidence that human-driven global warming is the source of the observed cooling, and they have pinpointed the key wind-driven processes that some climate models miss. They presented the work at this year's annual meeting of the American Meteorology Society in New Orleans.

The region of the tropical Pacific known as the equatorial cold tongue stretches along the equator west from Ecuador for thousands of kilometers, influencing weather patterns worldwide. Oceanographers have been aware of this ocean feature for a century or more, and its origin has been well understood since the 1960s. The cold tongue is caused by trade winds that push surface water away from the equator, making way for colder waters to well upward from below. The problem is that the tongue is getting unexpectedly colder with time. Debate has centered around whether the band's cooling is actually a response to rising CO_2 levels in the atmosphere or to inherent climate variability in the Pacific Ocean—with drastically different implications for future climate.

Changes in wind patterns—driven by global warming—can explain a cooling trend observed in a region of the Pacific Ocean called the equatorial cold tongue.
Credit: John/stock.adobe.com

Feng Jiang, Richard Seager, and Mark Cane at the Lamont Doherty Earth Observatory of Columbia University resolve this debate. They identified an emerging climate-change signal in the tropical Pacific that is distinct from natural long-term variability. Using ocean temperature data and a simple model of wind–ocean interactions, the researchers generated maps of Pacific Ocean temperature evolution over a period from 1958 to present. In these simulated data, they spotted a narrow cooling band that emerged over time since the mid-1950s alongside warming elsewhere in the ocean. Concurrently, long-term "cool" and "warm" oscillations in sea surface temperature—known as the Interdecadal Pacific Oscillation (IPO)—persisted, as expected. The emergent cooling band was associated with patterns in subsurface temperature and sea level height that are distinct from those related to the IPO.

By comparing different climate models, the researchers concluded that the emergent cooling trend is due to changes in wind patterns from anthropogenic (human-caused) global warming. These wind changes, in turn, drive changes in



Historical sea surface temperature data from 1958 to present (top) indicate a generally cooling band of water extending westward into the Pacific Ocean from the coast of Ecuador, while climate models (bottom) indicate warming over that same period.
Credit: F. Jiang/Lamont Doherty Earth Observatory

upper-ocean circulation and mixing. "What excites me the most is that we found strong evidence showing the observed Pacific-cold-tongue cooling is a robust anthropogenic signal—something our climate models have consistently misinterpreted," says Jiang. So why have climate models failed to simulate the cooling behavior, often predicting a warming tongue instead? The short answer, Jiang explains, is that models fail to represent one or both key processes—circulation adjustments or mixing changes—that drive the observed cooling.

In general, climate models do a good job of capturing global and regional climate-change trends, says Jiang. But as might be expected with something as big and complex as climate, there are discrepancies—the Pacific-cold-tongue discrepancy being one of the most striking. Alexey Fedorov, a climatologist at Yale University, points out that only a relatively small subset of climate models reproduces this pattern of cooling, but even in these models "it appears to be weaker than in the observations." Seager adds that the inability of previous models to match the Pacific's temperature behavior "undermines the realism of their simulations and projections of climate change worldwide." The trend's persistence could raise uncertainties about other model predictions, such as forecasts of tropical cyclones or estimates of climate sensitivity, Seager says.

A streak of cooling in a warming ocean may sound like a respite. But it's not that simple. Kristopher Karnauskas, a physical oceanographer at the University of Colorado Boulder, says "it's hard to overstate the consequences of this trend in the eastern equatorial Pacific and what it means for the future." The wind-driven cooling can impact climate worldwide. For example, the cooling trend appears to have a direct effect on drought in southwest North America and East Africa—and will continue to do so regardless of natural variability.

Karnauskas believes the new study is an important step in understanding how to reconcile the stark discrepancy between climate models and observations of emerging changes in the tropical Pacific. "This is a tricky problem," he adds, because human-caused trends might be relatively small compared to the size of the natural swings. Jiang and colleagues are able to pull out the statistical attributes of trends by focusing on the dynamics of the ocean–atmosphere interactions. Over time, that should lead to models that ensure more dependable future climate projections, Karnauskas says.

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