Climatologists offer explanation for widening of tropical belt

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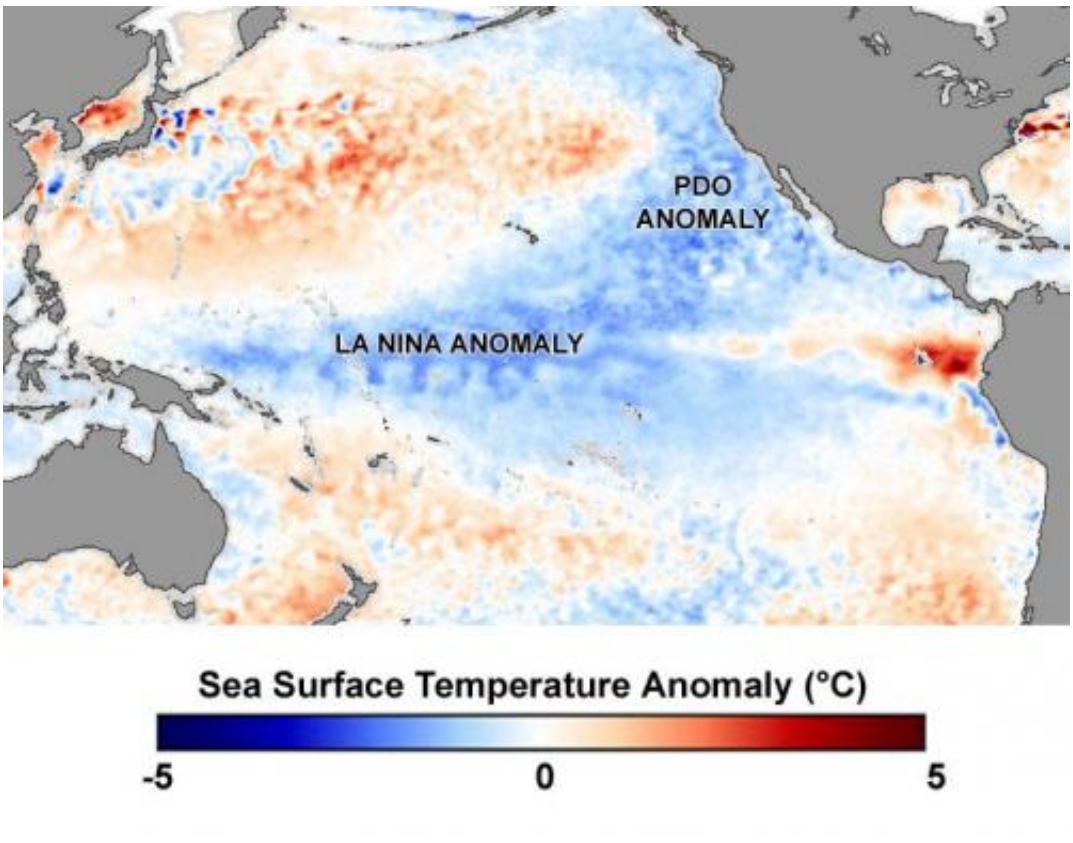

A cool-water anomaly known as La Niña occupied the tropical Pacific Ocean throughout 2007 and early 2008. In April 2008, scientists at NASA's Jet Propulsion Laboratory announced that while the La Niña was weakening, the Pacific Decadal Oscillation (PDO)—a larger-scale, slower-cycling ocean pattern—had shifted to its cool phase. This image shows the sea surface temperature anomaly in the Pacific Ocean from April 14–21, 2008. Places where the Pacific was cooler than normal are blue, places where temperatures were average are white, and places where the ocean was warmer than normal are red. The broad area of cooler-than-average water off the coast of North America

from Alaska (top center) to the equator is a classic feature of the cool phase of the PDO. The cool waters wrap in a horseshoe shape around a core of warmer-than-average water. (In the warm phase, the pattern is reversed). Unlike El Niño and La Niña, which may occur every 3 to 7 years and last from 6 to 18 months, the PDO can remain in the same phase for 20 to 30 years. The shift in the PDO can have significant implications for global climate. Credit: NASA/Jesse Allen, AMSR-E/Chelle Gentemann And Frank Wentz/Remote Sensing Systems.

(Phys.org) —Recent studies have shown that the Earth's tropical belt—demarcated, roughly, by the Tropics of Cancer and Capricorn—has progressively expanded since at least the late 1970s. Several explanations for this widening have been proposed, such as radiative forcing due to greenhouse gas increase and stratospheric ozone depletion.

Now, a team of climatologists, led by researchers at the University of California, Riverside, posits that the recent widening of the tropical belt is primarily caused by multi-decadal sea surface temperature variability in the Pacific Ocean. This variability includes the Pacific Decadal Oscillation (PDO), a long-lived El Niño-like pattern of Pacific climate variability that works like a switch every 30 years or so between two different circulation patterns in the North Pacific Ocean. It also includes, the researchers say, anthropogenic pollutants, which act to modify the PDO.

Study results appear March 16 in *Nature Geoscience*.

"Prior analyses have found that climate models underestimate the observed rate of tropical widening, leading to questions on possible model deficiencies, possible errors in the observations, and lack of confidence in future projections," said Robert J. Allen, an assistant professor of climatology in UC Riverside's Department of Earth

Sciences, who led the study. "Furthermore, there has been no clear explanation for what is driving the widening."

Now Allen's team has found that the recent tropical widening is largely driven by the PDO.

"Although this widening is considered a 'natural' mode of climate variability, implying tropical widening is primarily driven by internal dynamics of the climate system, we also show that anthropogenic pollutants have driven trends in the PDO," Allen said. "Thus, tropical widening is related to both the PDO and anthropogenic pollutants."

Widening concerns

Tropical widening is associated with several significant changes in our climate, including shifts in large-scale atmospheric circulation, like storm tracks, and major climate zones. For example, in Southern California, tropical widening may be associated with less precipitation.

Of particular concern are the semi-arid regions poleward of the subtropical dry belts, including the Mediterranean, the southwestern United States and northern Mexico, southern Australia, southern Africa, and parts of South America. A poleward expansion of the tropics is likely to bring even drier conditions to these heavily populated regions, but may bring increased moisture to other areas.

Widening of the tropics would also probably be associated with poleward movement of major extratropical climate zones due to changes in the position of jet streams, storm tracks, mean position of high and low pressure systems, and associated precipitation regimes. An increase in the width of the tropics could increase the area affected by tropical storms (hurricanes), or could change climatological tropical cyclone development regions and tracks.

Belt contraction

Allen's research team also showed that prior to the recent (since ~1980 onwards) tropical widening, the tropical belt actually contracted for several decades, consistent with the reversal of the PDO during this earlier time period.

"The reversal of the PDO, in turn, may be related to the global increase in anthropogenic pollutant emissions prior to the ~ early 1980s," Allen said.

Analysis

Allen's team analyzed IPCC AR5 (5th Assessment Report) climate models, several observational and reanalysis data sets, and conducted their own climate model experiments to quantify tropical widening, and to isolate the main cause.

"When we analyzed IPCC climate model experiments driven with the time-evolution of observed sea surface temperatures, we found much larger rates of tropical widening, in better agreement to the observed rate–particularly in the Northern Hemisphere," Allen said. "This immediately pointed to the importance of sea surface temperatures, and also suggested that models are capable of reproducing the observed rate of tropical widening, that is, they were not 'deficient' in some way."

Encouraged by their findings, the researchers then asked the question, "What aspect of the SSTs is driving the expansion?" They found the answer in the leading pattern of sea surface temperature variability in the North Pacific: the PDO.

They supported their argument by re-analyzing the models with PDO-

variability statistically removed.

"In this case, we found tropical widening—particularly in the Northern Hemisphere—is completely eliminated," Allen said. "This is true for both types of models–those driven with observed sea surface temperatures, and the coupled climate models that simulate evolution of both the atmosphere and ocean and are thus not expected to yield the real-world evolution of the PDO.

"If we stratify the rate of tropical widening in the coupled models by their respective PDO evolution," Allen added, "we find a statistically significant relationship: coupled models that simulate a larger PDO trend have larger tropical widening, and vice versa. Thus, even coupled models can simulate the observed rate of tropical widening, but only if they simulate the real-world evolution of the PDO."

Future work

Next, the researchers will be looking at how anthropogenic pollutants, by modifying the PDO and large scale weather systems, have affected precipitation in the Southwest United States, including Southern California.

"Future emissions pathways show decreased pollutant emissions through the 21st century, implying pollutants may continue to drive a positive PDO and tropical widening," Allen said.

Provided by University of California - Riverside