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Research shows Persistent El Nino-Like Conditions During Past Global Warming

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During the most recent period in Earth's past with a climate warmer than today, the tropical Pacific was in a stable state of El Nino-like conditions, according to a new study by researchers at the University of California, Santa Cruz.

Whether this represents a likely scenario for the future, given the current rise in global temperatures, is uncertain. Nevertheless, the study has important implications for scientists trying to understand the global climate system and how it might respond to global warming, the researchers said.

El Nino is a temporary disruption of normal circulation patterns in the ocean and atmosphere in the tropical Pacific, with important consequences for weather around the globe.

Because the system always returns to the normal circulation patterns after an El Nino event, many scientists have considered these patterns to be the only state in which the system can remain stable over long periods of time.

The new study, published this week in the journal Science, shows that there is another stable state for the ocean-atmosphere system that is dramatically different from today's.

"The stable configuration that we've gotten used to is not the only stable configuration for the tropical Pacific, and this suggests that the Earth's system for global heat transport functioned in a fundamentally different way the last time the climate was warmer than it is today," said the study's lead author, Michael Wara.

Wara, who earned a Ph.D. in ocean sciences at UCSC, is now studying law and environmental policy at Stanford University. His coauthors are Christina Ravelo, associate professor of ocean sciences at UCSC, and Margaret Delaney, professor of ocean sciences at UCSC.

The researchers based their findings on an analysis of hundreds of samples from sediment cores drilled from the ocean floor on opposite sides of the tropical Pacific Ocean.

The sediment cores were obtained by the international Ocean Drilling Program from a site near Indonesia in the western Pacific and another site near the Galapagos Islands in the eastern Pacific.

The sediments contain the microscopic shells of tiny sea creatures called foraminifera that lived in the surface waters of the ocean. The chemistry of these shells - in particular, the ratio of magnesium to calcium - is highly sensitive to the temperature of the water in which they formed.

By analyzing the composition of the shells, the researchers were to reconstruct a detailed record of sea-surface temperatures in the tropical Pacific during the Pliocene epoch, which lasted from about 5 million years ago to about 1.7 million years ago.

Currently, the normal sea-surface temperatures in the tropical Pacific show a strong gradient from cool temperatures in the eastern Pacific off South America, where upwelling of cold deep water occurs, to much warmer temperatures in the west, where the trade winds pile up warm surface waters.

During an El Nino, the trade winds slacken and warm water spreads eastward across the tropical Pacific, drastically weakening the temperature gradient. The UCSC researchers found that sea-surface temperatures during the Pliocene were much like those seen during an El Nino event.

"It looks like a permanent El Nino," Ravelo said. "We know El Ninos have far-reaching global climate effects today, so that gives us an idea of what the global climate system may have been like during the Pliocene."

The UCSC group's findings contradict a study published earlier this year in Science, which used the same methods but found cooler rather than warmer temperatures in the eastern Pacific.

Ravelo said the difference is probably due to the much smaller number of samples analyzed in the earlier study. The UCSC group obtained more than 400 data points for the same time period covered by six data points in the earlier paper.

"Maybe they were unlucky and got a couple of samples that don't represent that time period well," Ravelo said.

Previous research by Ravelo and others has shown that conditions outside the tropics during the Pliocene were also consistent with a permanent El Nino-like state.

The global consequences of El Nino events include dramatic changes in rainfall patterns, causing serious flooding in some areas while other regions experience droughts. Shifts in ocean temperatures also spread beyond the tropics, affecting fisheries along the California coast, for example.

According to Ravelo, however, the El Nino-like conditions of the

Pliocene should not be regarded as a direct analogy for the future effects of global warming.

Rather, the Pliocene climate should serve as a target for global climate models to test their ability to reproduce the full range of possible climate states.

Climate experts use computer-driven climate models to help them understand how the climate system works and how it is likely to respond to changes such as the increasing concentration of greenhouse gases in the atmosphere.

"The current climate models are very good at reproducing stable conditions in the tropics like we have today, but they should also be able to reproduce this very different tropical climate state that was stable in the past. If they can't, we know there is something missing," Ravelo said.

The new study reinforces the notion that the coupled systems of oceanic and atmospheric circulation that drive the global climate are capable of dramatic shifts from one stable state to another.

"Many aspects of the climate system that appear stable within a certain range of temperatures can shift dramatically when a particular threshold is passed," Wara said. "We can't say where that threshold is, but it is a concern as we continue this ongoing global experiment of adding greenhouse gases to the atmosphere."

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