# North Atlantic temperature helps forecast extreme events in Northeast Brazil up to three months in advance

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The dried-up Sobradinho dam in Bahia state in December 2015. The finding comes from a study reported by scientists from Brazil, China, Australia and Germany in the journal *Geophysical Research Letters*. The group used a novel methodology focusing on low rainfall and severe drought. Credit: Marcello Casal Jr./Agência Brasil

The sea surface temperature in the North Atlantic Ocean can be a

predictor up to three months in advance of extreme climate events involving reduced rainfall and intense drought in the Northeast region of Brazil. This is one of the main findings of a study by researchers in Brazil, China, Australia and Germany, according to an article published in *Geophysical Research Letters*.

Using a novel methodology based on the concept of precipitation deficit, the study showed that in recent years the influence of the North Atlantic has become more persistent than that of the tropical Pacific, hitherto considered one of the main factors in the intensity of the droughts suffered by the Northeast. At the same time, atmospheric connections between the Pacific and North Atlantic have become more frequent, suggesting that interactions between tropical ocean basins have reinforced the droughts occurring in the region in recent decades.

"The study was motivated by the severe drought that lasted from 2012 until 2015. This long period led us to think, from the meteorological standpoint, about how tropical ocean temperatures influence the climate. The difference now is the innovative methodology exploring the contrasts between the Pacific and Atlantic, and the pattern of drought in the Northeast of Brazil. The findings can be used as a management tool for weather forecasts in advance of events with this potential," Lincoln Muniz Alves, a scientist at Brazil's National Space Research Institute (INPE) and a co-author of the article, told Agência FAPESP.

The 2012–15 drought in a part of the Northeast already classified as semi-arid was so intense that it destroyed crops and left cities and villages without water. Other studies had already identified changes in atmospheric circulation as the main cause, suggesting that an active role was played by the Atlantic Ocean's surface temperature, which was warmer than usual, and by El Niño, a climate phenomenon involving abnormally warm temperatures in the Pacific.

This El Niño was considered one of the most impactful (after those recorded in 1982-83 and 1997-98) and caused losses in different parts of the world. In Brazil, the adverse effects included intense drought in the Northeast and the Amazon, a far longer dry season than usual in the North and several parts of central Brazil (northern areas of Minas Gerais and Goiás states as well as the Federal District), and floods in the South.

"This type of El Niño, known as 'canonical' because the anomalous warming occurs in the same specific area of the Pacific Ocean, has changed in terms of both location and intensity. In parallel, we've seen anomalous warming in the tropical Atlantic in recent decades. Based on our multifaceted analysis, the article provides ample evidence for forecasters to monitor the signs coming from the tropical Atlantic several months in advance. The Pacific's influence is undeniable, but the Atlantic has more," Alves said.

## New parameters

As explained by the authors, the study used methods such as non-linear phase coherence and generalized event synchronization analysis to understand the cause-and-effect mechanisms underlying the climate phenomena investigated. To this end, the relationships between sea surface temperature variability and the standard precipitation index were interpreted as direct interactions, while those between the oceans were interpreted as indirect effects on rainfall levels.

The researchers used precipitation data from the Climate Prediction Center (CPC), a branch of the US National Oceanic & Atmospheric Administration's National Weather Service (NOAA-NWS). They selected four regions: the Northeast of Brazil, the center of the drought for decades; an area called Niño 3, where there was intense activity of the El Niño Southern Oscillation (ENSO); and the North and South Atlantic, areas analyzed in previous studies.

To verify consistency, they compared the results with Niño 4, an area that includes the central equatorial Pacific and part of the South Atlantic. For each domain, they calculated the spatial mean of the variable of interest and daily anomalies relative to a baseline for the period 1981-2010. The rainy season was defined as January-April, and the dry season as May-August.

They concluded that the North Atlantic was the main influence on precipitation shortfalls and the occurrence of droughts during the period analyzed. Precipitation and sea surface temperature frequencies changed after very strong El Niño and La Niña events, increasing the likelihood of phase coherence.

"A normal or linear pattern like the one seen three decades ago no longer exists," Alves said. "Several other studies have corroborated our results. Our methodology shows that no linear pattern exists as a basis for forecasting and that conventional approaches should be abandoned. We highlighted the importance of looking at other oceans rather than focusing on the Pacific alone."

The article also concludes that other factors such as land-use changes can lead to alterations in the hydrologic cycle, as already demonstrated by modeling studies, especially regarding the Amazon basin. For this reason, the scientists suggest that further research using the methodology they have developed should investigate how land-use changes alter climate characteristics and interactions.

"When we discuss climate change, we're also talking about socio-economic impacts and the effect on biodiversity. Meteorological centers can use the model to work on prevention as a contribution to public policy and decision making on mitigation of extreme events," Alves said.

**More information:** Y. Mao et al, Phase Coherence Between

Surrounding Oceans Enhances Precipitation Shortages in Northeast Brazil, *Geophysical Research Letters* (2022). DOI: 10.1029/2021GL097647