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## Amazon drought: Much damage still to come (commentary)

Commentary by Philip M. Fearnside, Rosimeire Araújo Silva on 1 November 2023



- *The Amazon Rainforest is being hit by three kinds of drought at once: an “eastern El Niño,” a “central El Niño” and an “Atlantic dipole.”*
- *Together, these drought conditions extend to almost the entire Amazon, and they are expected to last until at least mid-2024.*
- *These phenomena are all aggravated by global warming.*
- *This is a commentary and does not necessarily reflect the views of Mongabay. It is an updated translation of a text by the authors that is available in Portuguese on Amazônia Real.*

### The drought of 2023

The 2023 drought in the Amazon is part of the climate crisis, and the tendency is for this to worsen, both over the course of the current event and in the frequency and intensity of events of this type in the future. Water in an area in the eastern part of the equatorial Pacific Ocean is already very warm (an “eastern El Niño”), and it is even hotter than it was during the 2015-2016 “Godzilla” El Niño.

This patch is widening, reaching the central Pacific region, which is the region that causes El Niños of the type that occurred in 1982-1983 (a “central El Niño”). Both types of El Niño affect the northern part of the Amazon, and the eastern El Niño also affects areas in the southwestern Amazon, as happened in 2015 and as is happening this year with very low flows in the Madeira and Purus Rivers.

At the same time, we have a patch of warm water in the tropical North Atlantic Ocean together with cooler water in the South Atlantic, which implies drought in the

southwestern part of the Amazon, as happened in 2005 and 2010. The forecast is for the onset of rain to be delayed in relation to normal and for a drier-than-normal rainy season. This could result not only in extremely low water levels in rivers this year, but also low levels in 2024.

The 2023 drought, which is far from over, has already caused dramatic damage: 154 [dolphins died](#) in Lake Tefé, where the water temperature reached [39 °C](#), or two degrees above human body temperature. Many [fish have died](#) due to the increase in water temperature, which kills both through the direct effect of temperature and by reducing the oxygen content of the water. There are [dramatic impacts](#) on human populations due to the isolation of communities, the impossibility of river transport in many places, and the loss of livelihoods that depend on fishing and agriculture.

## Forecast for the Amazon in 2023-2024

### Pacific Ocean – Eastern El Niño followed by Central El Niño.

A succession of notable climate events has occurred in the Pacific Ocean, beginning with an eastern El Niño followed by the addition of a central El Niño. The eastern El Niño warming of surface water in the areas known as “Niño 1+2” and “Niño 3” in the eastern part of the tropical Pacific Ocean (Figure 1). This type of El Niño affects the southern of the Amazon, in addition to the northern part. The eastern Pacific was already hot in June 2023 (Figure 2). This influence persisted even during the dry season prior to contributions from the central El Niño, with warming in the region known as “Niño 3.4” in the central part of the tropical Pacific Ocean.

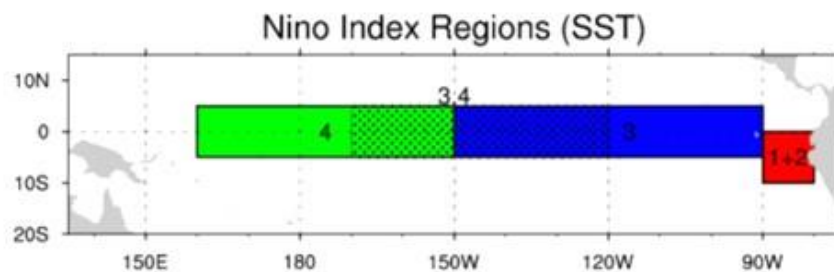
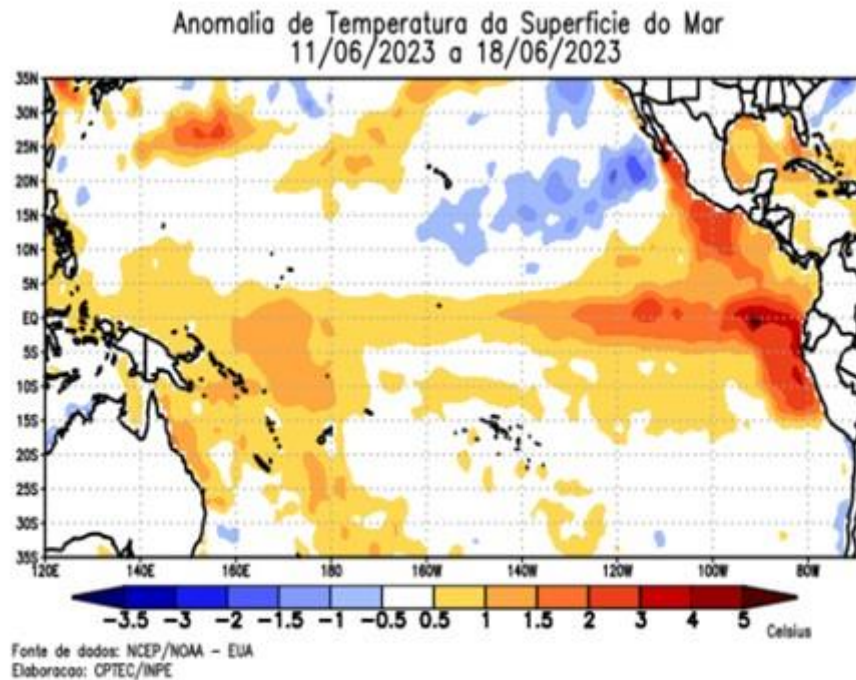


Figure 1. Location of El Niño index regions in the equatorial Pacific Ocean. In an “eastern El Niño,” surface water warms in regions 1+2 and 3. A “central El Niño” has warming in region 3.4, which covers parts of regions 3 and 4. Image courtesy of the National Center for Atmospheric Research (NCAR).



**Figura 1:** Anomalia da temperatura da superfície do mar na região do Pacífico durante o período de 10 a 17 de junho de 2023.

Figure 2. Anomalies (departures from the average) and sea surface temperature in the Pacific Ocean from June 10 to 17, 2023. Image courtesy of the National Institute of Meteorology (INMET).

Since June 2023, warming has been moving towards the central part of the Pacific, contributing to the formation of the central El Niño, which is expected to reach maturity in December 2023 and weaken by June-July 2024. Warm water in the central and western Pacific already configures a central El Niño (Figure 3). The central El Niño of 1982 led to the [mortality of standing trees](#) in the Amazon due to lack of water and due to forest fires. The central El Niño of 1997 resulted in the “great Roraima fire,” which burned [12.5 ± 1.5 thousand km<sup>2</sup>](#) (3,089 million acres ± 370 thousand acres) of forests and which, despite the help of firefighters from Argentina, was only extinguished with the arrival of the rains in March 1998.

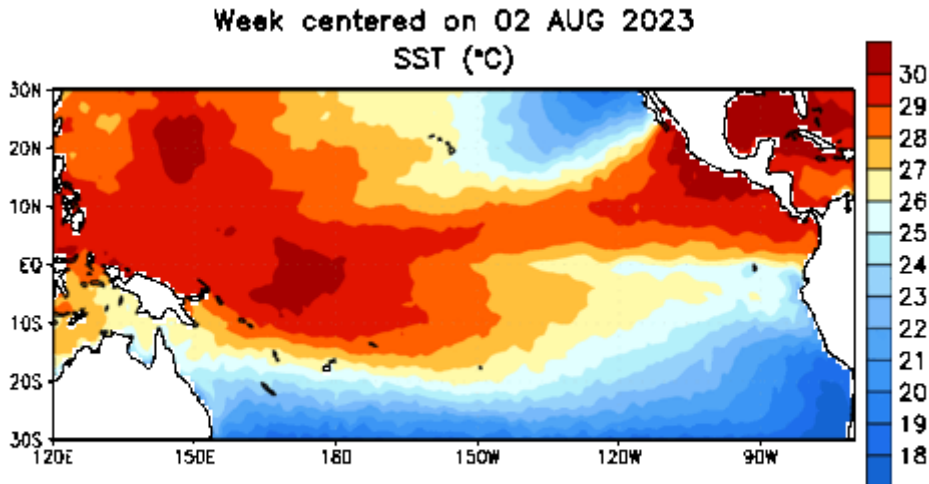


Figure 3. Sea surface temperature (SST) for the weeks of August 2 to October 18, 2023. Image courtesy of the Climate Prediction Center (CPC).

A phenomenon in the western Pacific Ocean that precedes major El Niño events is the lowering of the thermocline (the division between warm surface water and the cold water of the deep ocean), increasing the volume of warm water and, therefore, the heat content stored in this part of the ocean. The heat content in the western Pacific Ocean reached a [record high](#) in the last quarter of 2022 — [even higher](#) than in the years before the super-El Niños of 1982 and 1997. The warning that there would be an El Niño in 2023 came in [December 2022](#), and in [early June 2023](#) the El Niño officially arrived.

This meteorological pattern suggests delays in the rainy season in the Amazon, with a reduction in precipitation in the central, northern, and eastern parts of the region. The likelihood of warm temperatures in the central Pacific Ocean returning to “normal” levels is minimal until the April-May-June quarter of 2024 (Figure 4).

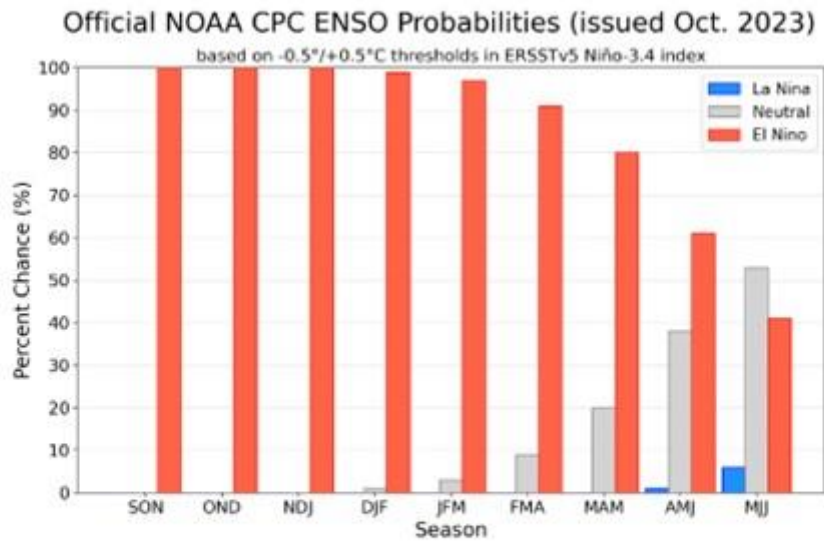


Figure 7. Official ENSO probabilities for the Niño 3.4 sea surface temperature index ( $5^{\circ}\text{N}$ - $5^{\circ}\text{S}$ ,  $120^{\circ}\text{W}$ - $170^{\circ}\text{W}$ ). Figure updated 12 October 2023.

Figure 4. Probability of having an El Niño with warm water in the center of the Pacific Ocean, per quarter from September 2023 to July 2024. Image courtesy of the Climate Prediction Center (CPC).

With the reduction in rainfall in the 2023-2024 rainy season and with reservoirs still below their normal levels due to the significant drought in 2023, water levels in hydroelectric reservoirs are expected to be below average during the 2024 dry season. This implies significant challenges for 2025 as well.

### Atlantic Ocean – Warming of the tropical North Atlantic

In addition to the influence of El Niño, the Amazon drought is also worsened by anomalous warming in the tropical North Atlantic. There is a [complex relationship](#) between Pacific El Niños and warming in the North Atlantic, and between these phenomena and droughts in different parts of the Amazon. In the Atlantic Ocean, warming in the tropical North Atlantic and cold or neutrality in the tropical South Atlantic occurred in October 2023, indicating that a dipole has already formed in the Atlantic (Figure 5). A dipole leads to droughts in Brazil's state of Acre and other parts of southwestern Amazonia, as happened in [2005](#) and [2010](#).

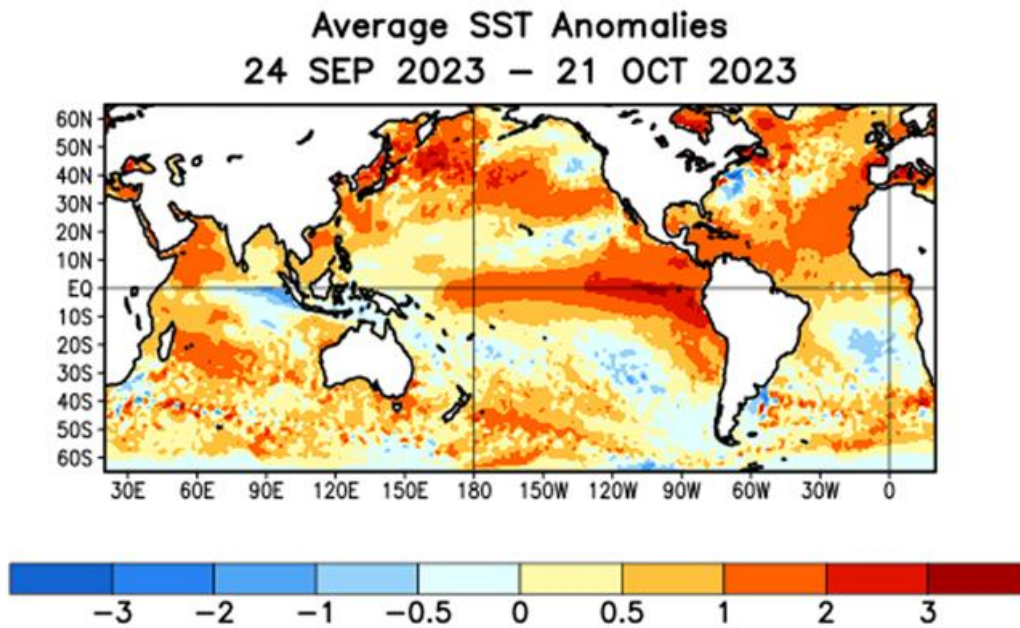


Figure 5. Average sea surface temperature (SST) anomalies in the world's oceans for September 24 to October 21, 2023. The formation of an Atlantic dipole is apparent. Image courtesy of the Climate Prediction Center (CPC).

This pattern of warming of the tropical North Atlantic is projected to persist during the Amazon rainy season, resulting in the confinement of the Intertropical Convergence Zone at latitudes further north than usual. This causes delays and compromises the rainy season in northern and northeastern South America. In June, July and August 2024 the influence of El Niño is expected to weaken but the dipole in the tropical Atlantic would continue.

Rainfall is expected to be reduced during the transition to the dry season in the southern and southwestern portions of the Amazon. The forecast until June 2024 (Figure 6) indicates the presence of a dipole throughout this time, which is bad news for Acre and neighboring areas.

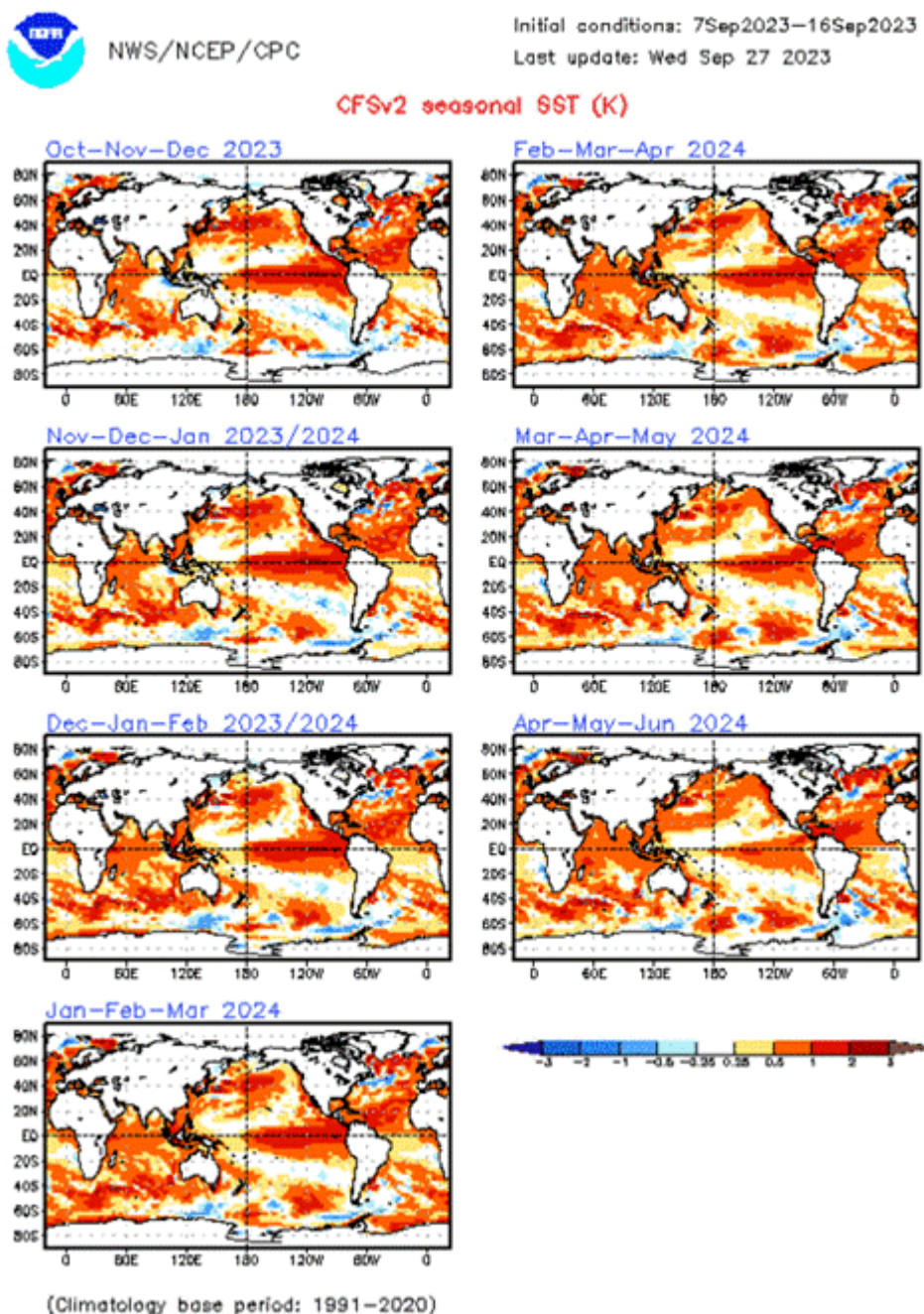


Figure 6. Sea surface temperature (SST) forecast in the world's oceans through June 2024. Image courtesy of the Climate Prediction Center (CPC).

Given that the effects of the two oceans occur in different parts of the Amazon, moderate to intense drought is expected in most of the Amazon, with more pronounced impacts in the south and southwest during the transition to the 2024 dry season and in the central and eastern portion during the 2024 dry season. The drought forecast for November 2023 to January 2024 (Figure 7) shows almost the entire Amazon in severe drought, including both in the northern and southern parts of the region. Some increased rain in northern Peru and in the Purus River drainage in Brazil may help with flows in the Amazon River, but not with the extended drought's impacts on the forest.

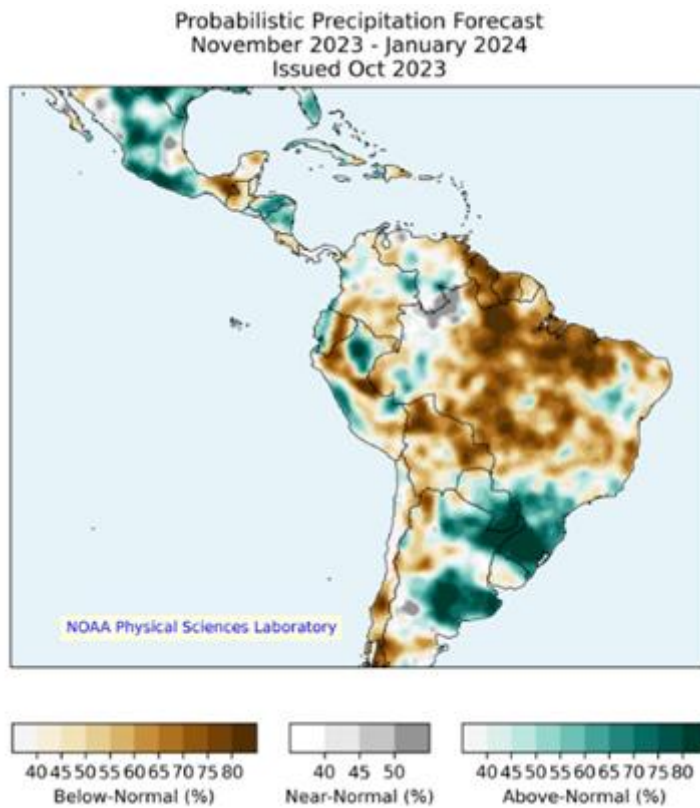


Figure 7. Rainfall forecast for November 2023 to January 2024. Image courtesy of the National Oceanic and Aeronautic Administration (NOAA).

*This article is an updated translation of a text by the authors that is available in Portuguese on [Amazônia Real](#).*

*Banner image: Municipalities such as Manacapuru are depending on food aid deliveries due to the historic drought in the state of Amazonas. Rivers like the Amazonas (pictured) have reached record lows since data collection began. Image courtesy of Alex Pazuello/Secom/Agência Amazonas.*