ENSO Phenomenon:
A Newsletter for the Amazon

Impacts on the Amazon Region

November, 2023

Introduction

This Newsletter is produced by the Situation Room of the Amazon Regional Observatory (ORA) of the Amazon Cooperation Treaty Organization (ACTO). Its primary objective is to provide comprehensive and up-to-date information on the monitoring of atmospheric-oceanic conditions, known as El Niño-Southern Oscillation (ENSO). During El Niño events, the Equatorial Pacific Ocean experiences higher temperatures compared to the historical average (climatology), whereas the La Niña phase is characterized by colder temperatures. These ocean temperature variations have global impacts on atmospheric circulation patterns, moisture transport, temperature and precipitation (Figure 1).

In general terms, this Newsletter offers a synthesis of timely and valuable overview of ongoing monitoring of the El Niño/La Niña phenomenon and its potential effects in the Amazon Region for the month of **November**. This report is part of a series of reports that began in June 2023.

The target audience for this Newsletter encompasses managers, decision makers, planners, farmers, the media, and the general population of ACTO Member Countries.

Figure 1: The characterization of El Niño Southern Oscillation (ENSO) phenomena. Source: NOAA, OMM.

Introduction

El Niño and La Niña climate phenomena have significant global impacts, especially on climate modulation in the Amazon. During El Niño, the Amazon Region undergoes drier conditions due to increased temperatures in the Pacific Ocean. As a result, water availability decreases, forest fires increase, and local communities face challenges related to food and water shortage (Figures 2 and 3).

Conversely, La Niña is associated with intense rainfall, leading to flooding and disruptions in ecosystems and riparian communities. In the long-term, these climatic variations also impact biodiversity, underscoring the crucial need for monitoring and preparedness to address climate challenges in the Amazon region (Figures 4 and 5).

Global Effects of El Niño

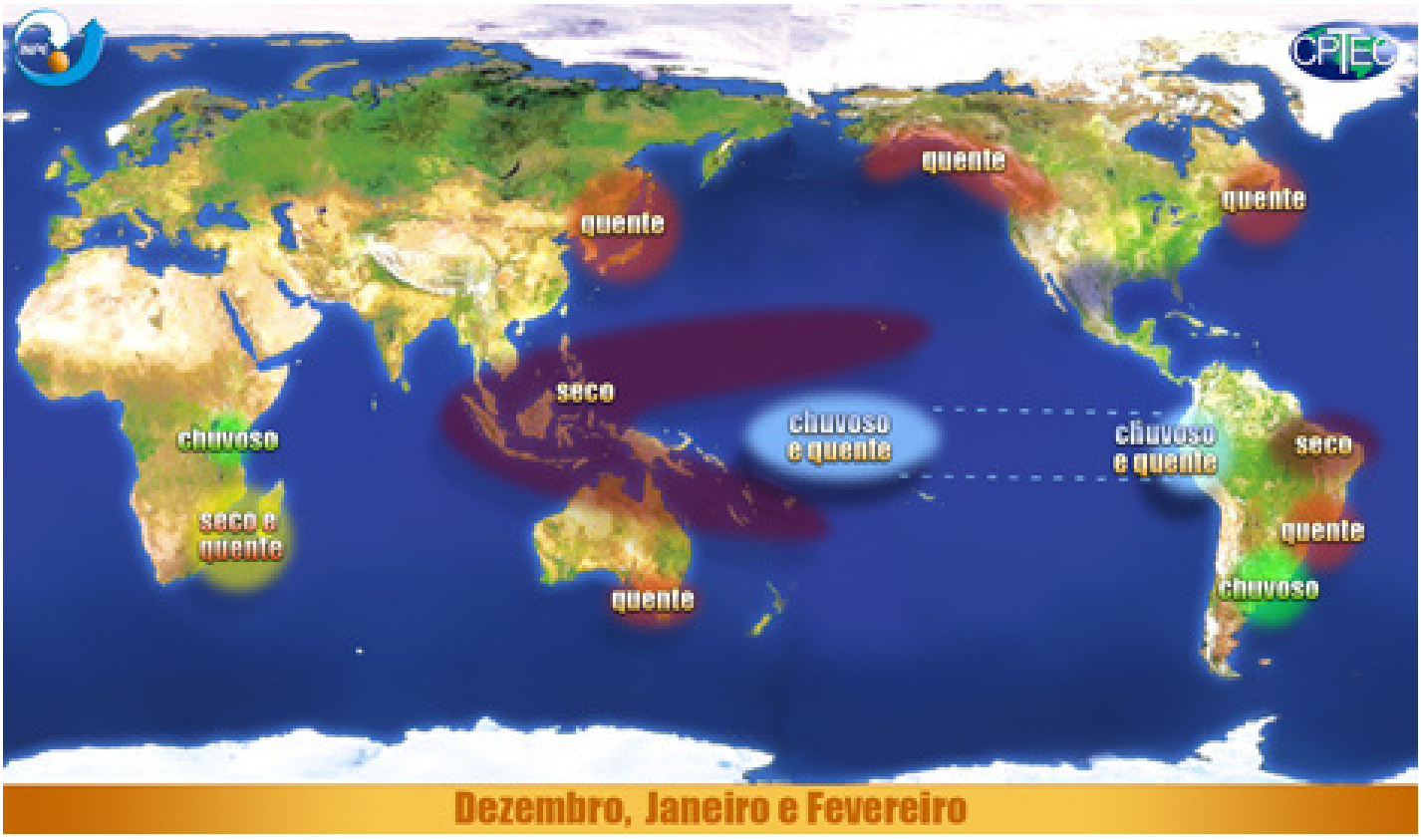


Figure 2: Global El Niño effects in the December-February quarter.
Source: NOAA, Bureu of Meteorology e CPTEC-INPE.

Introduction

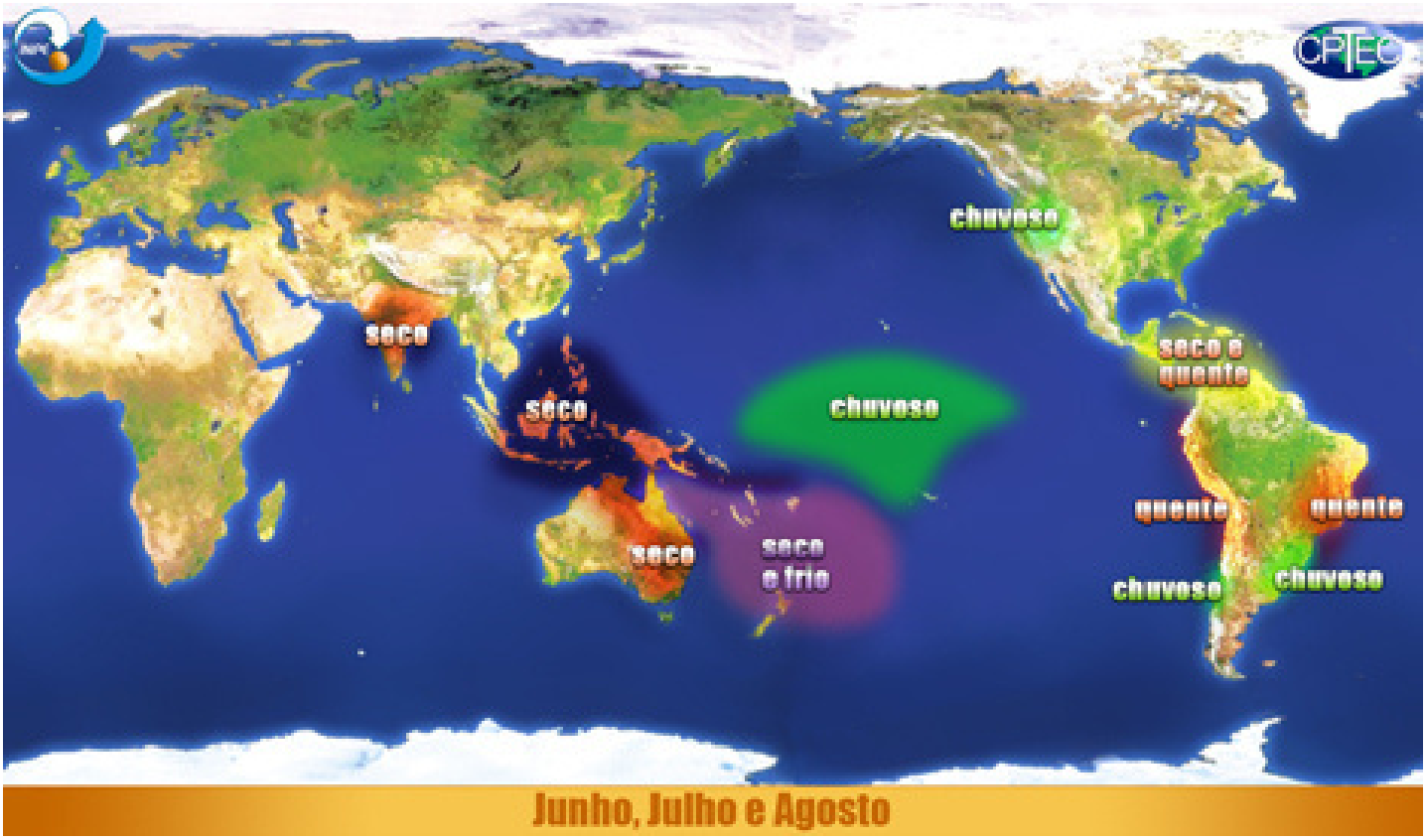


Figure 3: Global El Niño effects in the June- August quarter.
Source: NOAA, Bureu of Meteorology e CPTEC-INPE.

Potential impacts of El Niño effects on Amazonian countries:

Brazil:
Extended droughts and increased fires in the Amazon.

Peru:
Droughts affecting agriculture and water resources.

Colombia:
Rainfall variations affecting biodiversity and local communities.

Venezuela:
Extended droughts affecting agriculture and local resources.

Ecuador:
Floods and landslides due to heavy rains.

Bolivia:
Rainfall variation, risk of forest fires.

Guyana:
Droughts affecting water resources and agricultural production.

Suriname:
Weather pattern changes, impact on biodiversity.

Introduction

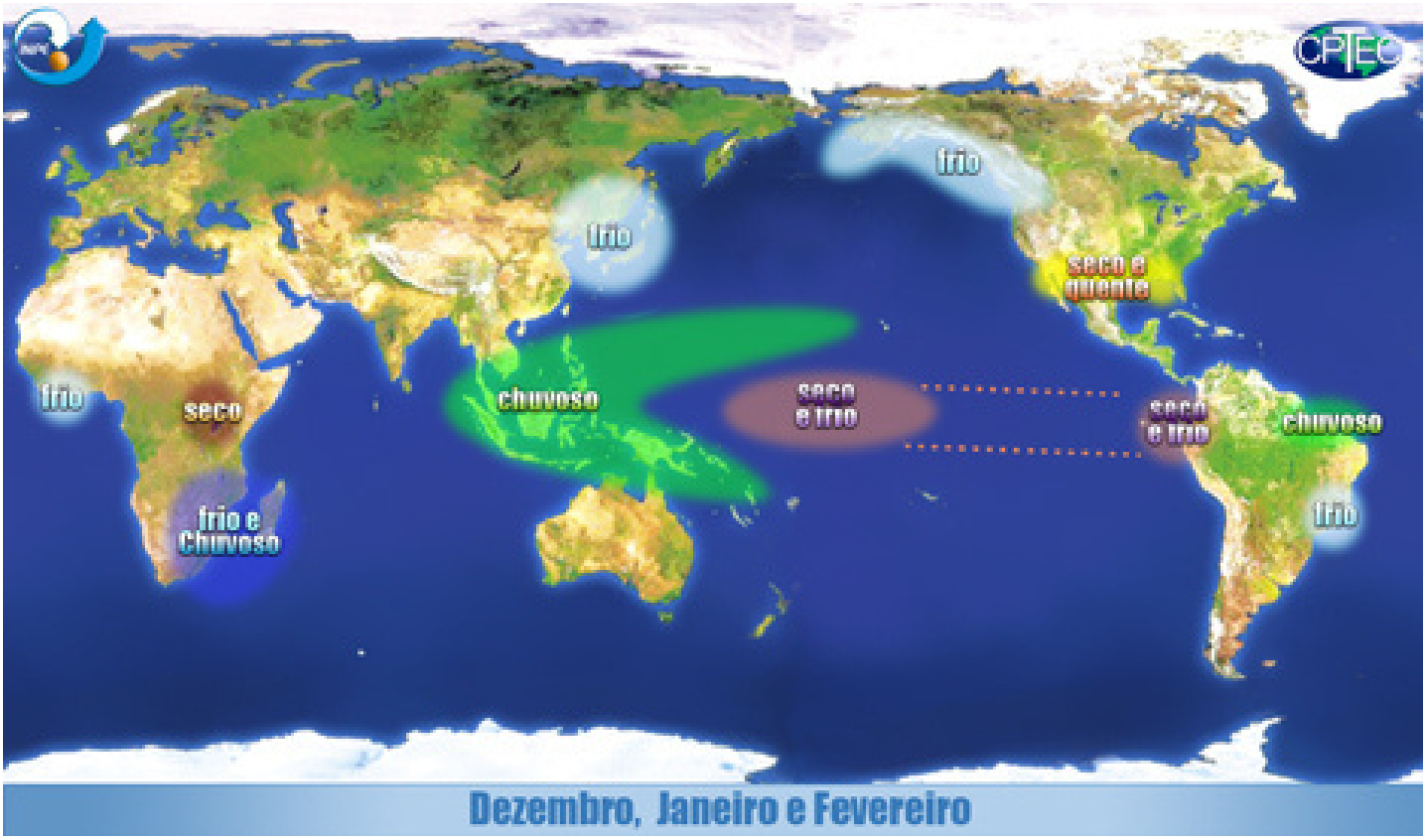


Figure 4: Global El Niño effects in the December-February quarter.
Source: NOAA, Bureu of Meteorology e CPTEC-INPE

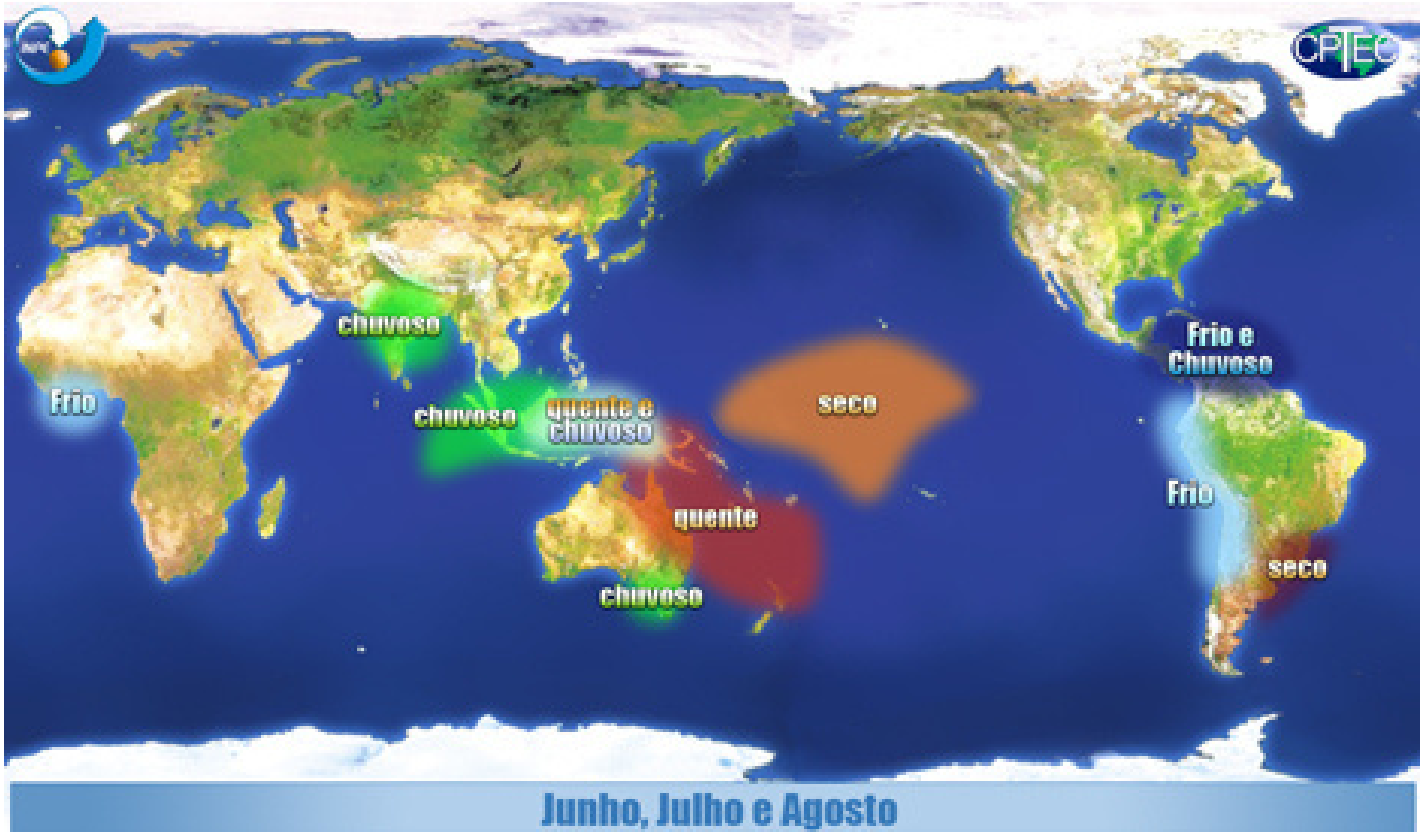


Figure 5: Global El Niño effects in the June- August quarter.
Source: NOAA, Bureu of Meteorology e CPTEC-INPE

Introduction

Potential impacts of La Niña effects on Amazonian countries:

Brazil:
Increased rainfall, potential flooding in the Amazon region.

Peru:
Heavy rainfall, risk of flooding and landslides.

Colombia:
Chuvas acima da média, impactando comunidades e biodiversidade.

Venezuela:
Increased rainfall, potential for flooding and landslides.

Ecuador:
Heavy rainfall, potential flooding and damage to infrastructure.

Bolivia:
Increased rainfall, risk of flooding and agricultural issues.

Guyana:
Increased rainfall, impact on local water resources.

Suriname:
Weather pattern changes, potential for flooding.

It is important to emphasize that the specific impacts can vary between different El Niño events, requiring Amazonian countries to tailor their risk management and response strategies accordingly. Collaborative regional efforts are crucial to effectively address the shared challenges posed by these extreme weather phenomena.

The El Niño Southern Oscillation (ENSO) is a major driver that shapes seasonal weather patterns, resulting in warmer (El Niño) or cooler (La Niña) than usual surface waters in the tropical Pacific Ocean.

During November, sea surface temperatures in the equatorial Pacific Ocean continued to above average, suggesting the persistence of El Niño. Anomalies increased in the central and east-central Pacific with the latest Niño Index values confirming the strengthening of the El Niño. The ocean temperature in the reference region (Niño 3) remained very strong, exhibiting anomalies ranging from 2.0°C to 2.5°C.

Forecasts predict the persistence of the El Niño during the fall season of 2024, with a 62% probability between April and June 2024. Models also project the intensification of El Niño, with more than 55% chance of persistence between January and March 2024, and a 35% chance of becoming historically strong. Consequently, climatic and meteorological conditions in the Amazon region will be influenced by this phenomenon.

Rainfall in the Amazon Region in November was not significant, resulting in below-normal rainfall anomalies in the central, eastern and southern parts of the region. In other western areas, including Bolivia, Peru and parts of northern Brazil, rainfall was irregular, with slightly above-average precipitation, but still below average to determine the start of the rainy season.

The climate forecast for the next quarter (December 2023 to February 2024) suggests that rainfall estimates improved slightly, reaching normal to near-above-average values in some locations in the region during the month of December. Heavier rains are expected in the upper part of the basin, including the Andean countries of Peru and Bolivia, especially in the second week of December. However, the trend from January 2024 onwards points to significantly below-average values, especially in the central, southern and eastern Amazon region.

Ocean-Atmospheric Conditions

1- Pacific Ocean Sea Surface Temperature (SST)

The tropical Pacific atmospheric anomalies have remained above the global average since March 2023, following patterns consistent with the occurrence of the El Niño phenomenon. Positive Sea Surface Temperature (SST) anomalies have been observed, exceeding 1.5°C, as depicted in Figure 6. The Climate Prediction Center (CPC) considers conditions of El Niño or La Niña when monthly sea surface temperature anomalies in the Niño3.4 region reach or exceed +/- 0.5°C, along with consistent atmospheric characteristics. In addition, these anomalies are expected to continue for three consecutive months.
The most recent ONI value (September - November 2023) is 1.8°C.

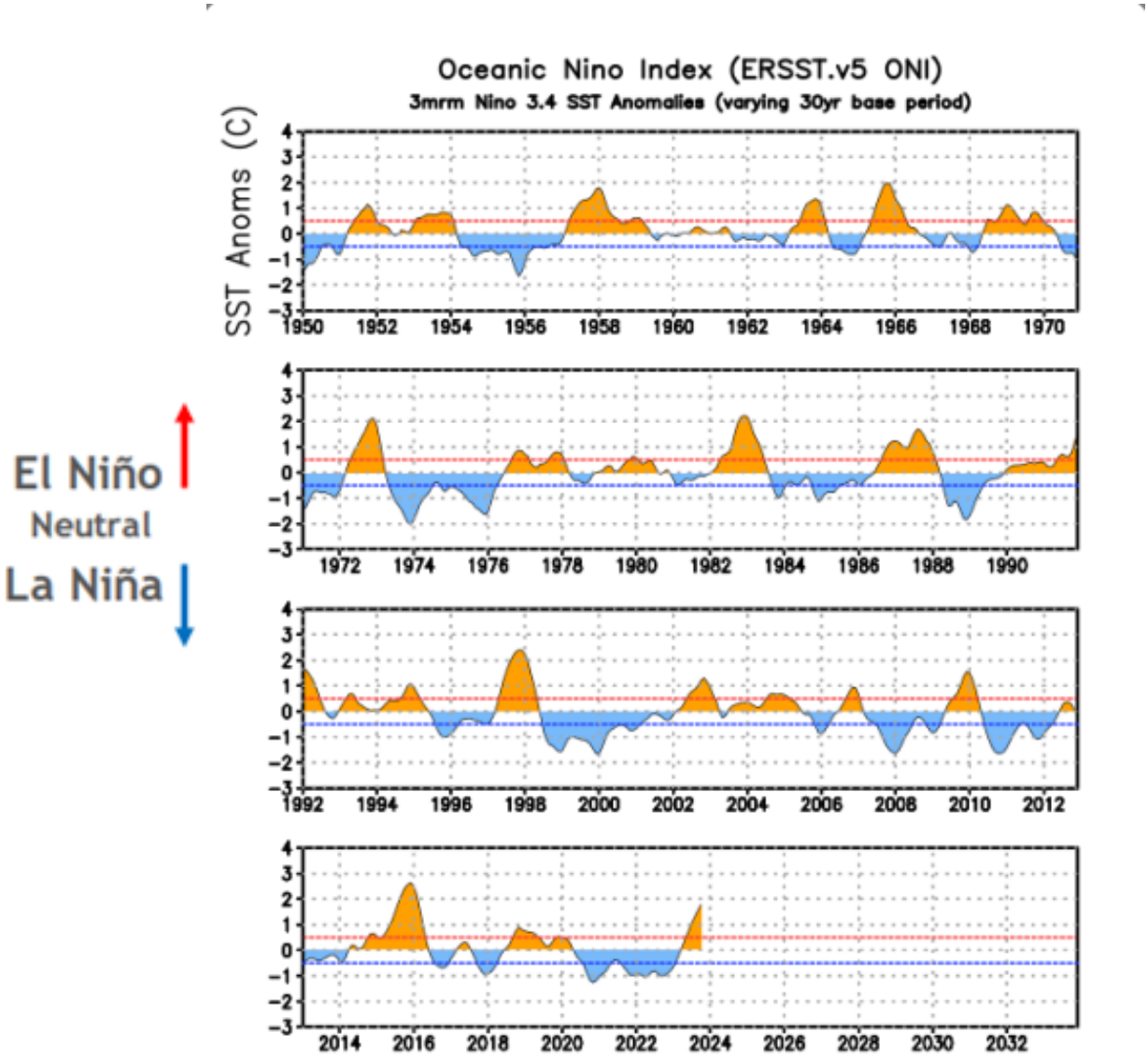


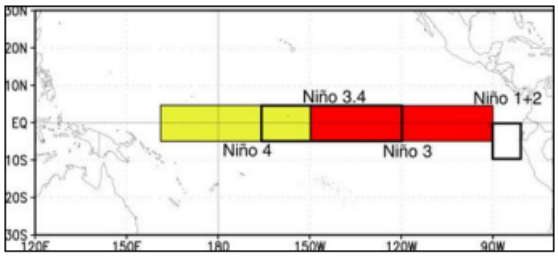
Figure 6. Oceanic Niño Index (ONI) from January 1950 to October 2023 with 3-month 3-month running averages of SST anomalies ERSST. V5 in Niño 3.4 (5N-5S, 120- 170W). Source: Climate Prediction Center /

1.1SST evolution in El Niño regions

In November, SST (Sea Surface Temperature) anomalies have remained above average and strengthened over much of the Equatorial Pacific Ocean. Although the ocean temperature anomaly in one of the reference regions, Niño 3, decreased by 0.1°C compared to the previous month, it remains above the historical average, reaching 2°C. Thus, it is still classified as a very strong El Niño (anomalies of 2.0°C to 2.5°C), as illustrated in Figure 7.

Therefore, the oceanic conditions currently observed are in line with favorable patterns for the continuation of the El Niño phenomenon, which shows a progressive intensity increase.

Anomalias de Temperatura (°C)	Classificação
0,5 – 1,0	Fraco
1,0 – 1,5	Moderado
1,5 –2,0	Forte
2,0 – 2,5	Muito Forte
Maior que 2,5	Super



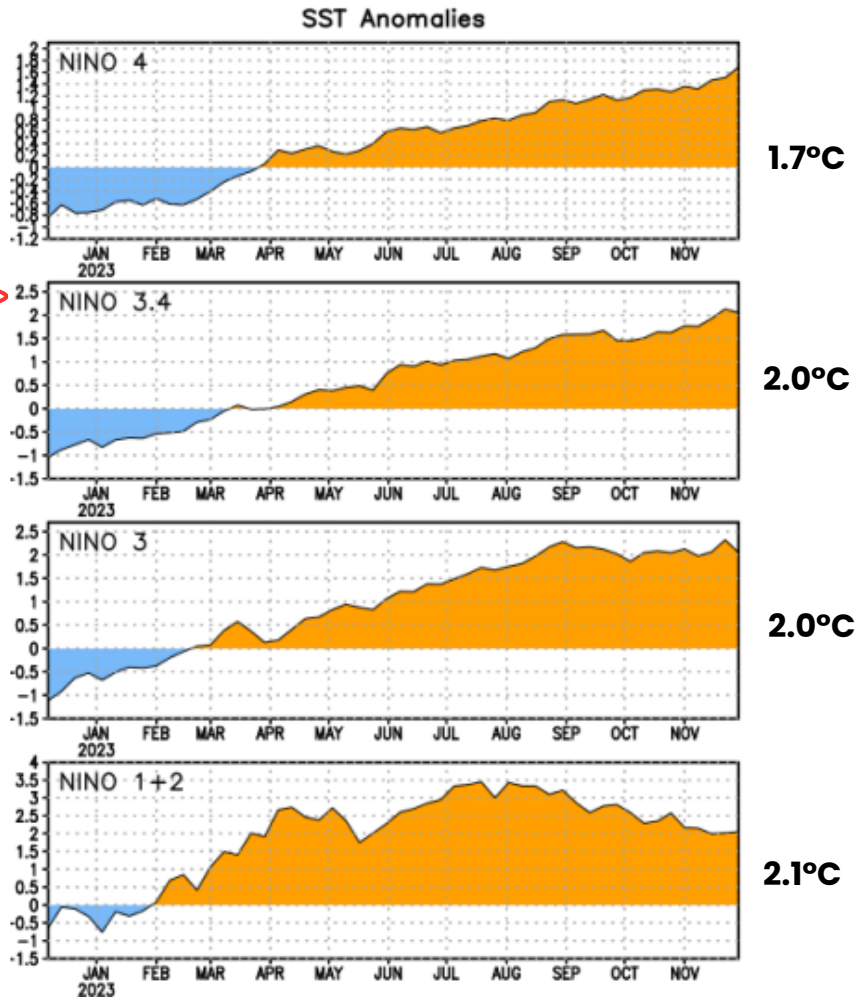


Figure 7: Pacific SST anomaly behavior at Niño 4, 3.4, 3 and 1+2 - between 60°S and 60°N. Source: Climate Prediction Center / NCEP

Ocean-Atmospheric Conditions

Figure 8 illustrates the evolution of global mean sea surface temperature (°C) from January 1, 1981 to 31 November 2023, which is presented as year time series. The year 2023 is highlighted in black bold lines, while the orange line represents the temperature for 2022. The other years are presented with thinner lines and shaded according to the corresponding decade. The dashed line and the gray area represent, respectively, the threshold of 1.5°C above the pre-industrial level (1850-1900) and its uncertainty, as well as the mean for the period 1982 to 2011.

It is observed that since mid-March 2023, the mean sea surface temperature has registered historical monthly records until the last observed period in November 2023. The mean sea surface temperature in November, above 60°S-60°N, was 20.9°C, being the highest recorded for a November month since measurements began in 1981.

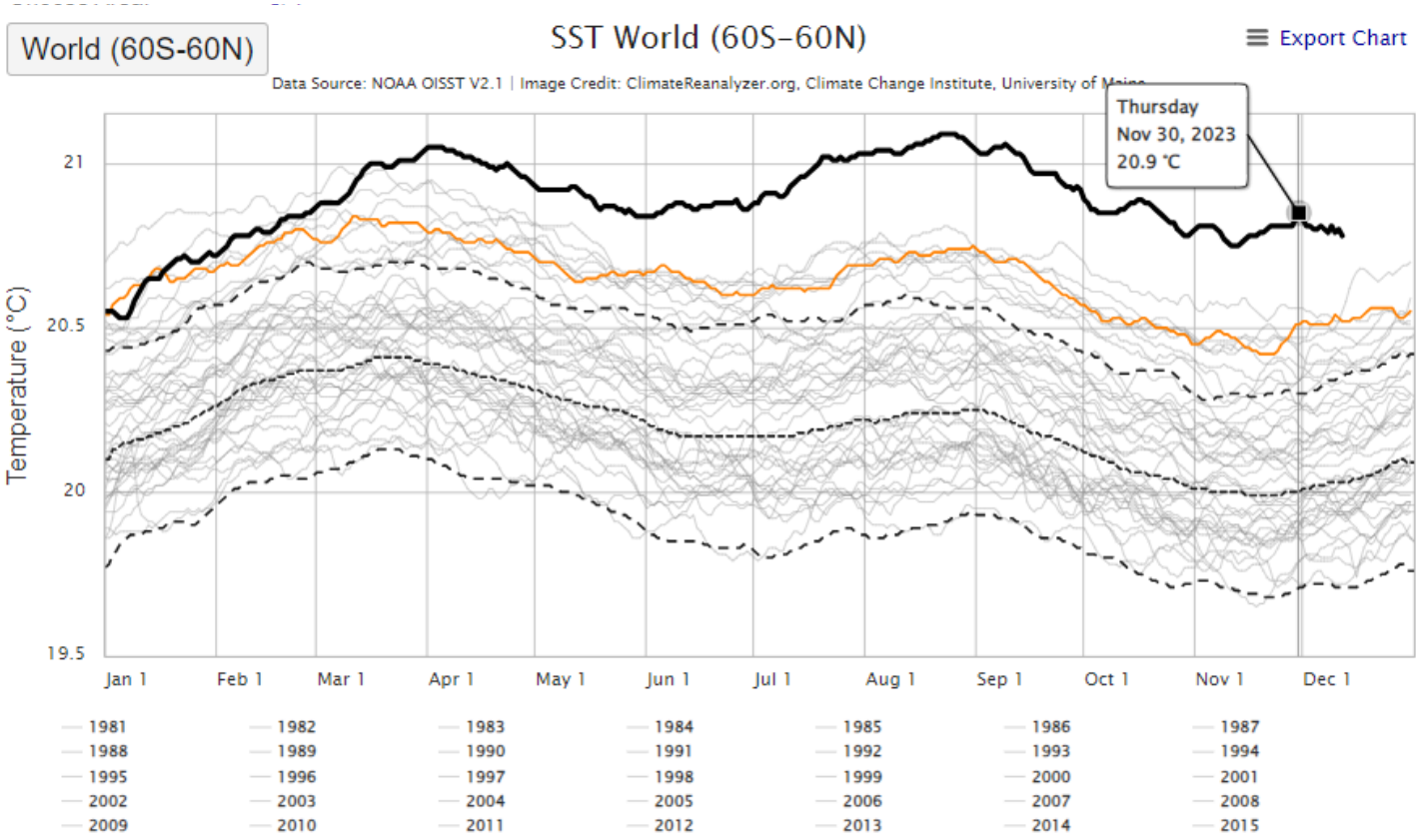


Figure 8: Global SST time series graph - between 60°S and 60°N. Data source: ERA5. Credits: C3S/ECMWF.

Ocean-Atmospheric Conditions

Based on the ERA5 data, which represents the fifth-generation analysis of global climate spanning from 1940 to the present, conducted by the European Centre for Medium-Range Weather Forecasts (ECMWF), it has been observed that November 2023 registered the highest globally recorded average surface air temperature to date, reaching 14.2°C. This figure implies a rise of 0.85°C when compared to the average from November 1991 to 2020, and it surpasses the previous record set in November 2020 by 0.32°C (refer to Figure 9). Similarly, the global temperature anomaly observed in November 2023 closely paralleled that recorded in October 2023, with only a slight deviation from the anomaly recorded in September 2023, which reached 0.93°C. Notably, November 2023 exhibited a temperature approximately 1.75°C higher than the mean estimate for November during the designated pre-industrial reference period (1850-1900).

From January to November 2023, the global average temperature reached unprecedented levels, marking the highest on record with a notable surge of 1.46°C above the pre-industrial average of 1850-1900 and a slight 0.13°C surpassing the eleven-month average for 2016. The latest data from Copernicus confirms that 2023 is presently acknowledged as the warmest year ever recorded (Figure 10).

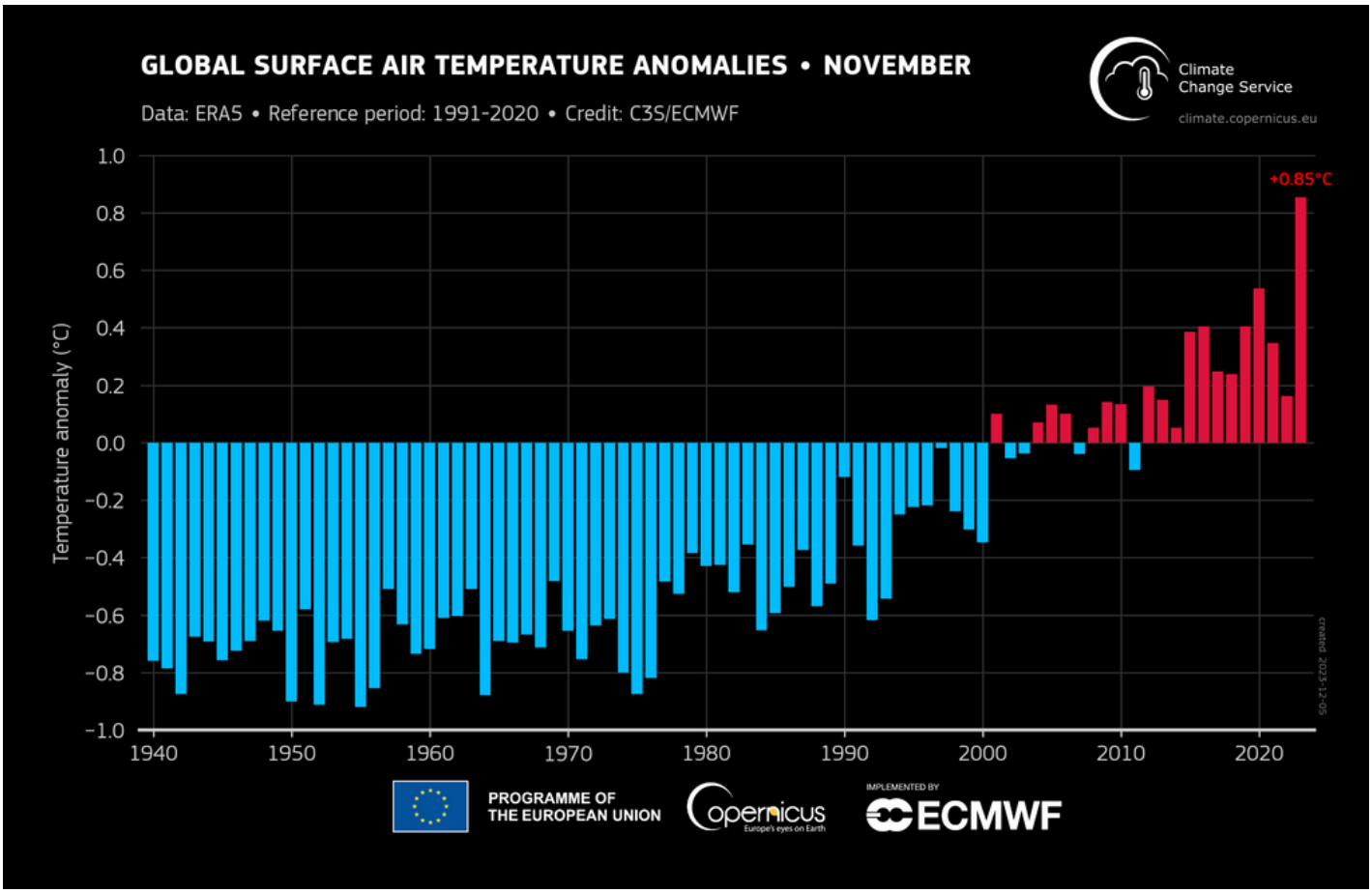


Figure 9: Global records of surface air temperature anomalies, relative to the reference period of 1991 to 2020, have been documented monthly from 1940 to 2023, specifically for the month of November. Data Source: ERA5. Credit attributed to C3S/ECMWF

Condições Oceano-Atmosfera

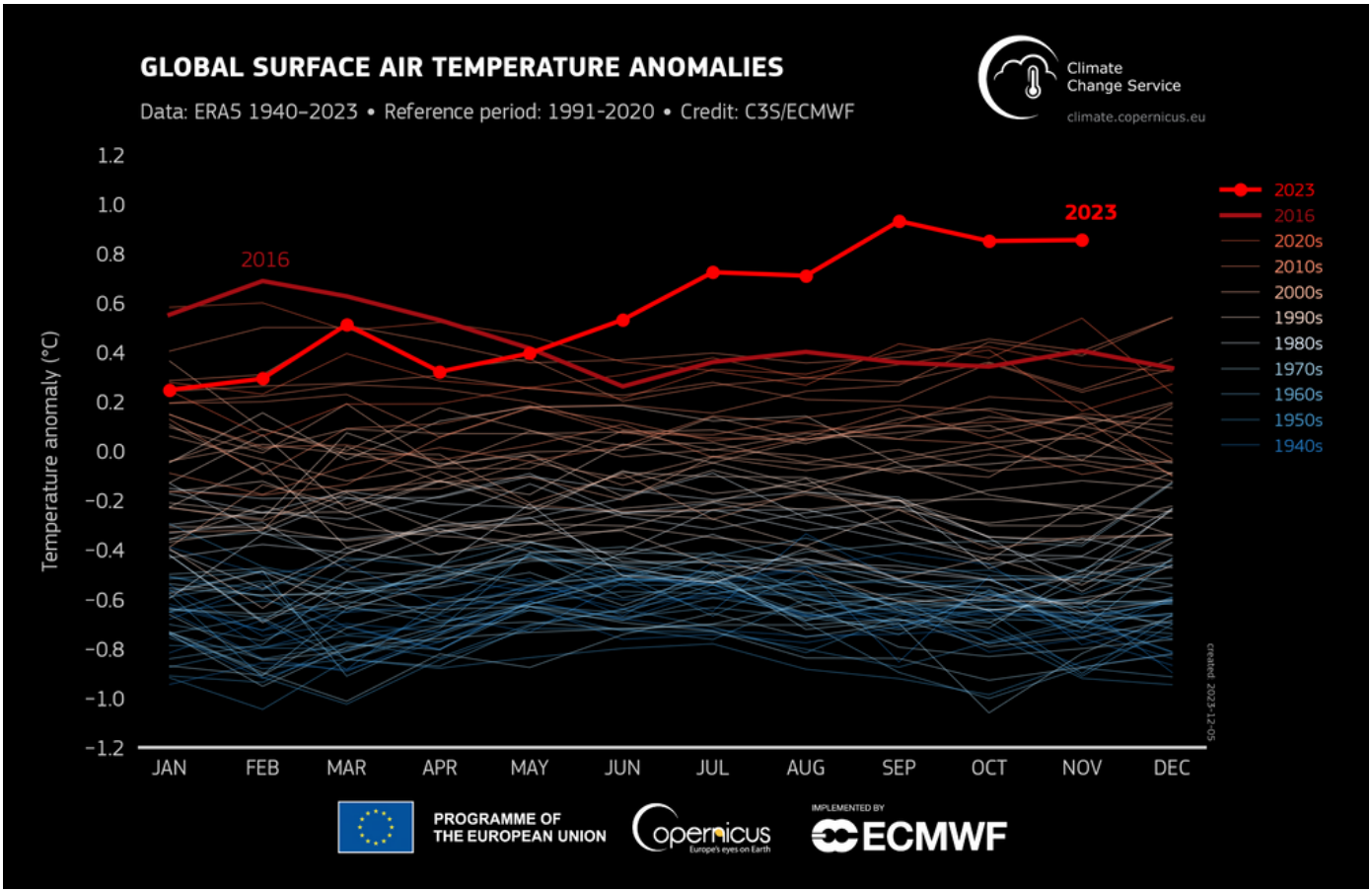


Figure 10: Monthly variability in surface air temperature globally (°C) based on the time series from January 1940 to November 2023. The thick red line represents the year 2023, with the year 2016 shaded in red. Other years are depicted by thin lines and shades ranging from blue (1940s) to brick red (2020s), indicating the corresponding decades. Data obtained from ERA5 Credits: Copernicus Climate Change Service/ECMWF

In Figure 10, it is evident that from June to November 2023, six months have witnessed record-breaking temperatures, and November stands out as the month with two instances of setting new temperature records. The extraordinary global temperatures experienced in November, notably featuring two days where temperatures exceeded 2°C above the pre-industrial level, solidify the assertion that 2023 is recognized as the warmest year on record since 1940, as stated in the monthly climate update from the Copernicus Climate Change Service (C3S).

Ocean-Atmospheric Conditions

Based on the ERA5 data spanning from 1940 to 2023, two particular days in November showcased notable extremes in global temperatures, exceeding a 2°C deviation from the pre-industrial era. On November 17, the air temperature anomaly soared to 2.07°C above the average since 1940, and on the following day, the model recorded a temperature anomaly of 2.06°C, clearly indicating values surpassing those from the pre-industrial period (Figure 11).

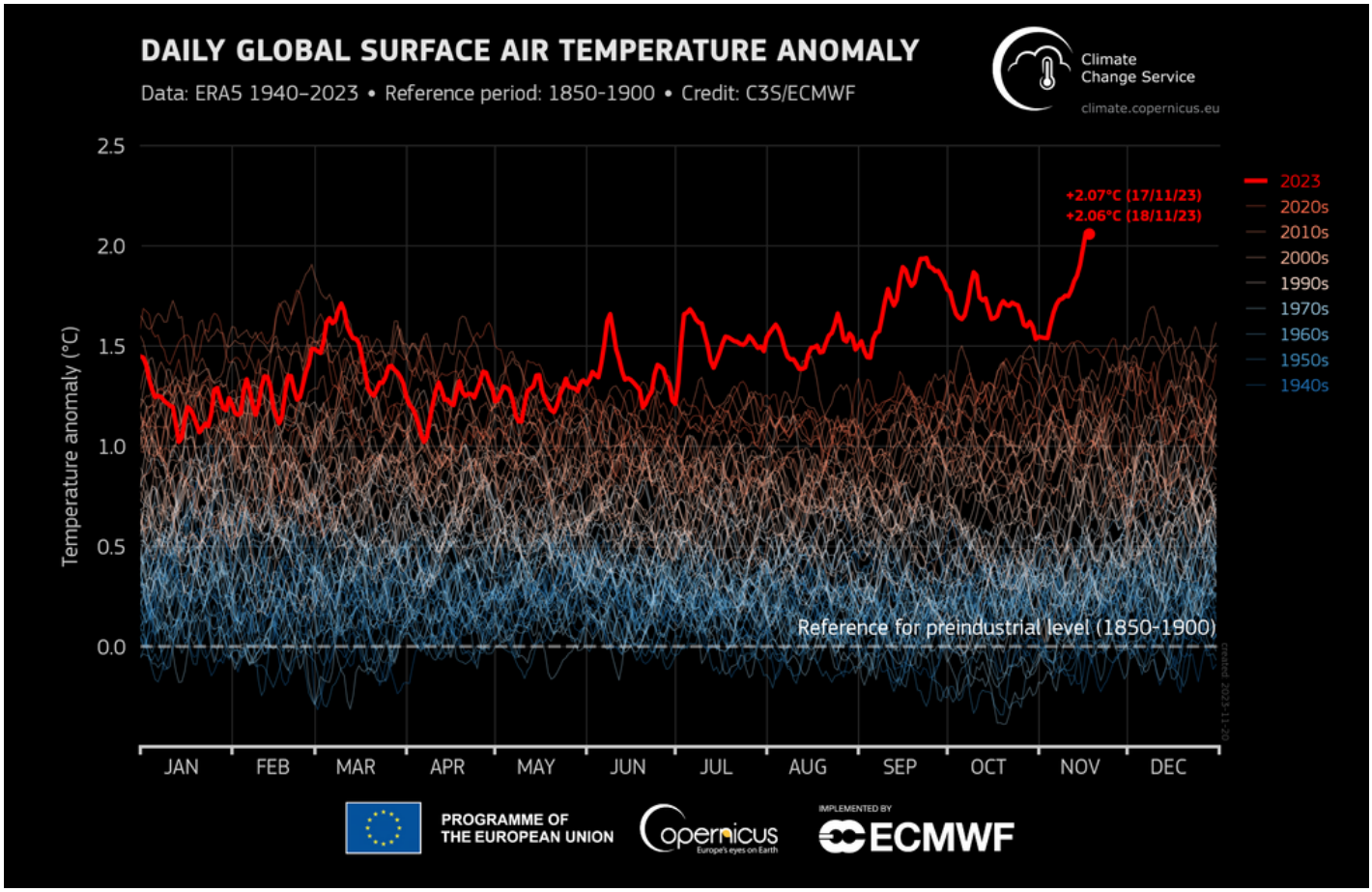


Figure 11: The variability in average daily surface air temperature (°C) is depicted in a time series plot covering the period from January 1, 1940, to November 30, 2023, with estimated values for the baseline period of 1850-1900. The year 2023 is shown with a bold red line, and the other years are presented with thin lines and shading according to decade, from blue (1940s) to brick red (2020s). Dotted horizontal lines highlight the 1850-1900 reference and 1.5°C and 2°C above this reference. Data Source ERA5. Credits: C3S/ECMWF.

Diagnosis

In addition to the abnormal warming in the central Pacific resulting from the El Niño configuration, the intensity of this phenomenon is significantly influenced by the combined impact of warmer-than-normal atmospheric and oceanic conditions, exacerbated by ongoing global warming. The global average temperature has surged by 1.2°C since the pre-industrial period, with approximately 90% of this excess heat absorbed by the oceans.

Notably, the current robust El Niño event differs significantly from that of 2015, particularly affecting the Brazilian Amazon region. This phenomenon intensifies drought conditions, particularly in the northern part of South America, with the elevated temperatures in the North Atlantic further compounding the severity of the situation.

It is crucial to underscore that the conclusion of November reveals anomalies in SST in the equatorial region, registering above-average values across most of the Pacific Ocean. The Niño 3 and 1+2 areas continued to show anomalies above 2°C until the end of the month, as illustrated in Figure 12.

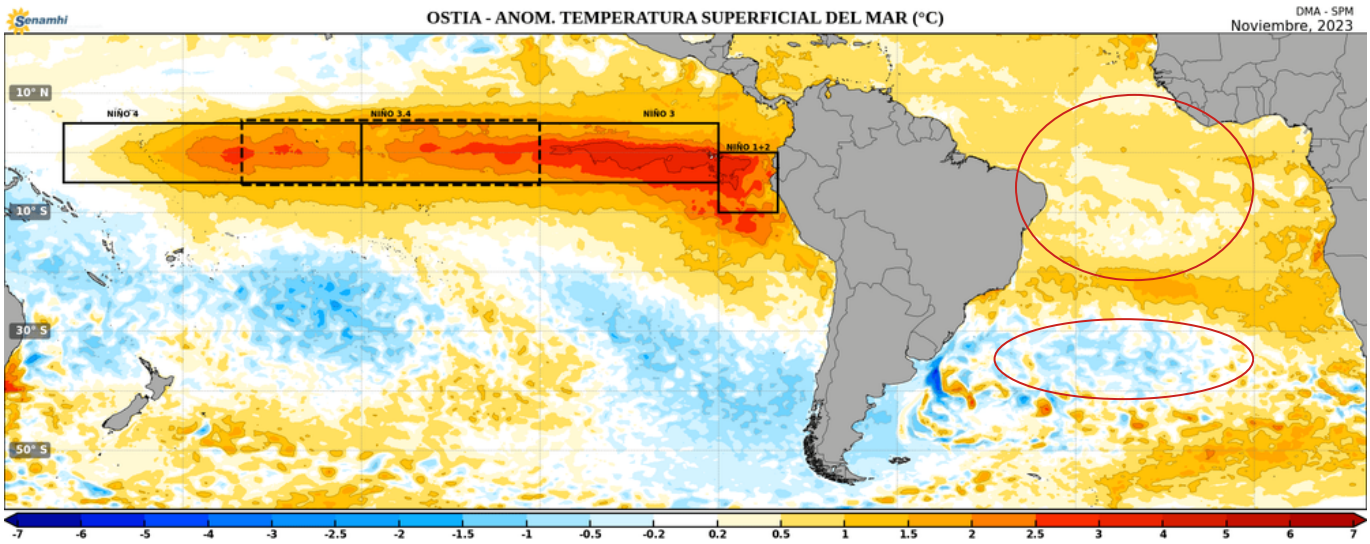


Figure 12: Anomaly (difference between the recorded value and the historical mean) of sea surface temperature in the Pacific Ocean region during November 2023.
Source: OSTIA product "The Operational Sea Surface Temperature and Sea Ice Analysis" - Senamhi.

3 -North Atlantic Sea Surface Temperature

Similar to the preceding month, November witnessed a notable elevation in sea surface temperatures, a phenomenon attributed to the South Atlantic dipole. This dipole, notably unfavorable, was influenced by the condition of the Atlantic Ocean north of the equator, which exhibited significantly higher temperatures compared to its southern counterpart. Consequently, an amplitude of approximately 1°C was observed throughout November. (Figure 13).

Diagnosis

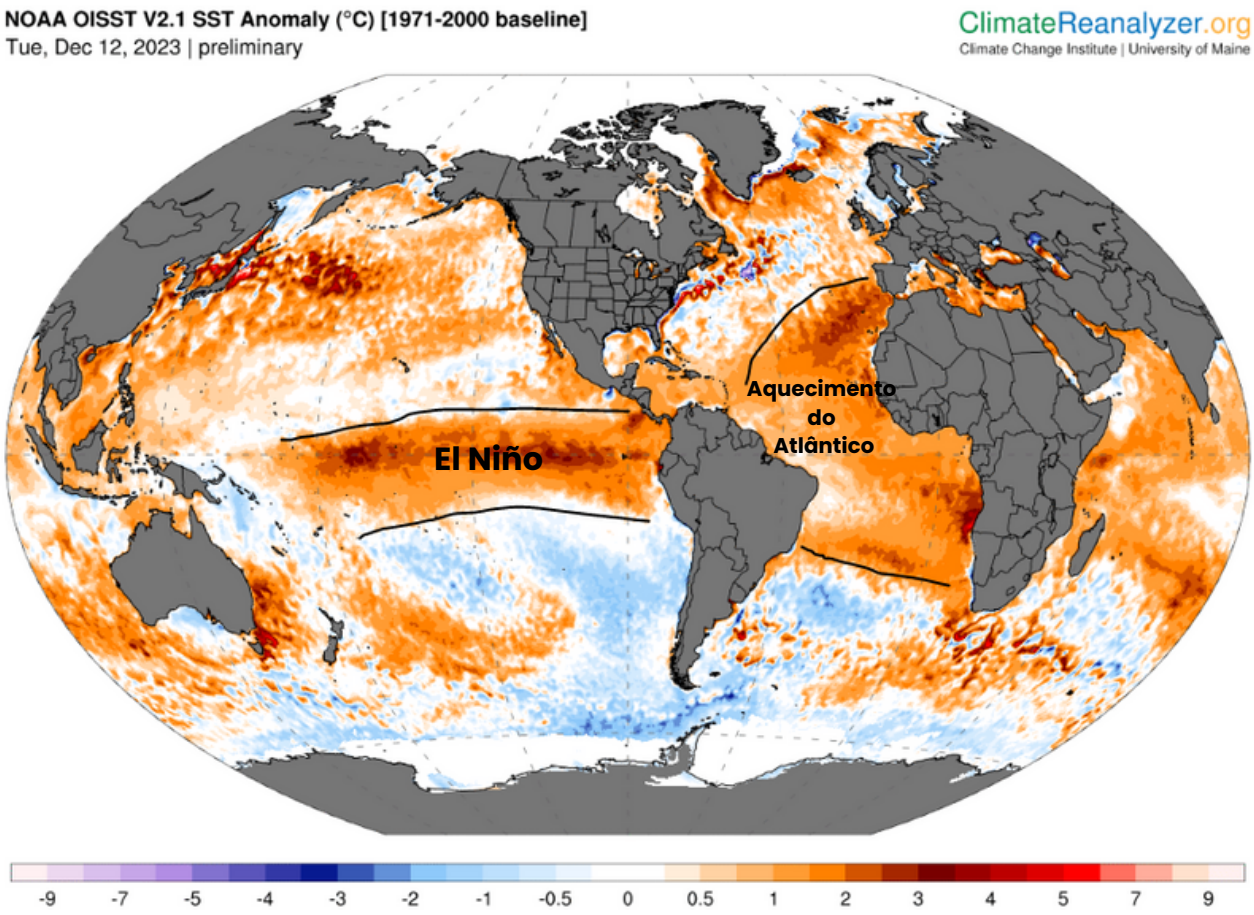


Figure 13: Climatological maps of global daily mean Sea Surface Temperature (SST) anomaly. Source: NOAA, Climate Reanalyzer.

The temperature of the Atlantic Ocean plays a pivotal role in modulating both the intensity and movement of the Intertropical Convergence Zone (ITCZ), a phenomenon that directly impacts precipitation patterns in the Amazon region. The cloud masses laden with moisture, linked to the ITCZ, gravitate towards regions characterized by elevated water temperatures. Elevated temperatures in the North Atlantic prompt southeastward trade winds that displace the Intertropical Convergence Zone (ITCZ) away from the Amazon region, consequently suppressing rainfall.

Conversely, distinct influences come into play regarding the effects of El Niño. The increase in SST in the North Atlantic has contributed to weakening the monsoon system, which plays a crucial role in regulating rainfall in the Amazon. Moreover, anthropogenic factors such as fires, and deforestation play a significant role in soil degradation across all Amazon biomes. This degradation exacerbates the effects of El Niño in the region, leading to severe phenomena such as extended droughts and elevated temperatures.

Diagnosis

Analyzing the temporal progression of the mean sea surface temperature between latitudes 60°S-60°N in November, it was noted that the average sea surface temperature in the North Atlantic has consistently remained elevated. This persistent configuration has been observed since March 2023. This pattern marks the highest recorded for a November month since measurements commenced in 1981.

Alongside this upward trend, Figure 12 illustrates the North Atlantic Sea Surface Temperature (SST) reaching 22.3°C on the 30th, concluding the month.

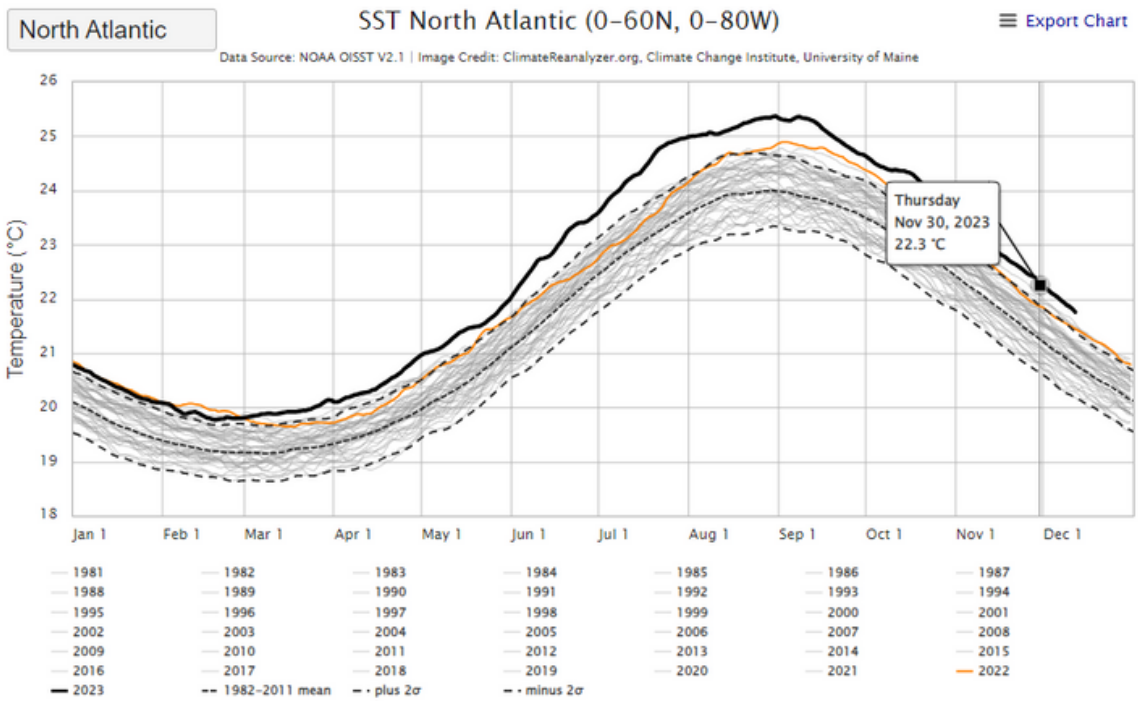


Figure 12: Time series of historical mean sea surface temperature (SST) over the last 30 years. Source: NOAA.

4- Analysis of the Intensity of the Drought in the Amazon Region

The drought intensity map from the Lapis Laboratory, comparing conditions between November 20 and 28, illustrates that sporadic rainfall in the Amazon region during the final week of November has led to a modest alleviation in drought intensity.

This improvement is evident in the diminished extent of affected areas in eastern Brazil, Peru, and Bolivia as of November 28. Nevertheless, compelling evidence of an extraordinary drought persists in central and eastern Amazon when compared to the historical average (1961 to 2010), as depicted in Figure 14:

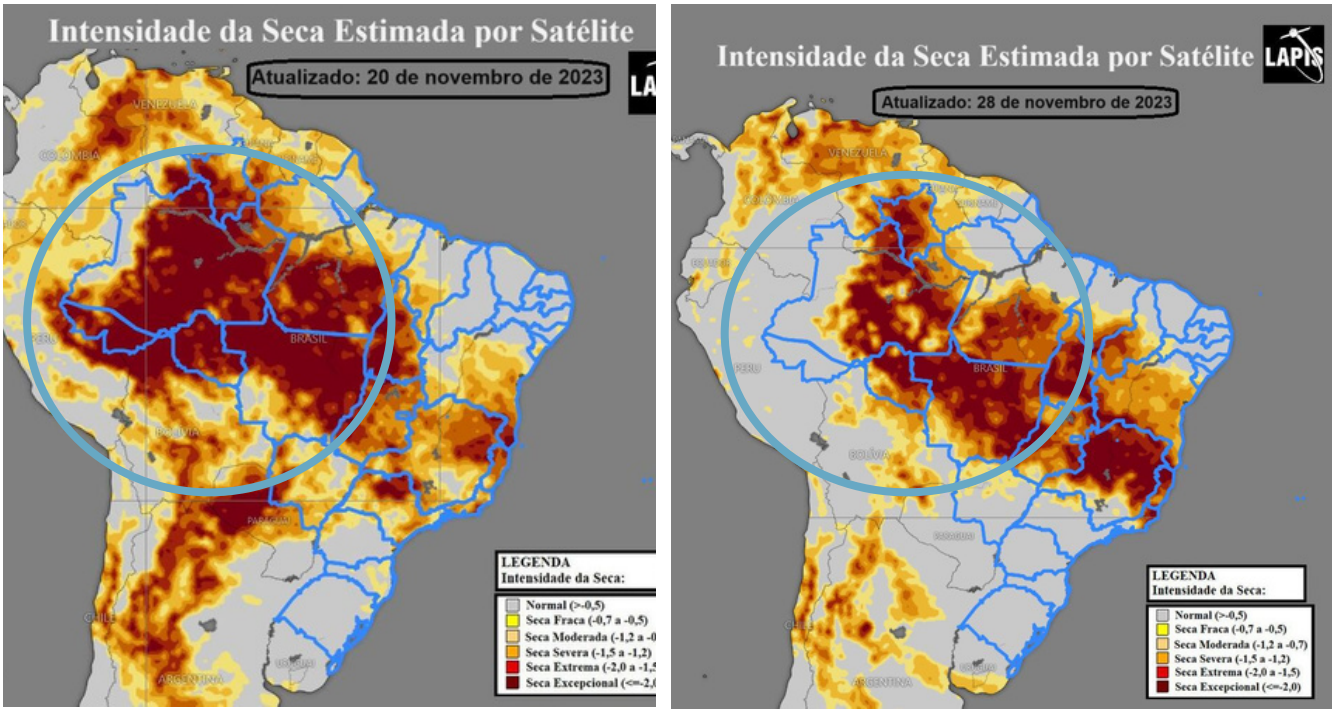


Figure 14: Satellite Estimated Drought Intensity on November 20 and 28, 2023, relative to the 1961 and 2010 historical average. Source: LAPIS.

Probabilistic Forecasting

5- ENSO Forecast - Climate Prediction Center (CPC/NOAA)

The latest assessment from NOAA's National Centers for Environmental Prediction (NCEP) suggests a substantial probability of El Niño persisting through the fall of 2024 in the Southern Hemisphere. The peak activity is anticipated in the January-March quarter, with a probability exceeding 55% for maintaining its strength, characterized by a seasonal average SST at or above 1.5°C in the El Niño 3 region. There is a 35% chance of this event evolving into a historically robust El Niño, defined by SST surpassing 2°C during the November-January 2024 quarter. Additionally, the model suggests a 62% probability of El Niño persisting until the April to June 2024 quarter. Subsequently, a transition to neutral ENSO conditions is foreseen for the May to July quarter of 2024 (Figure 15).

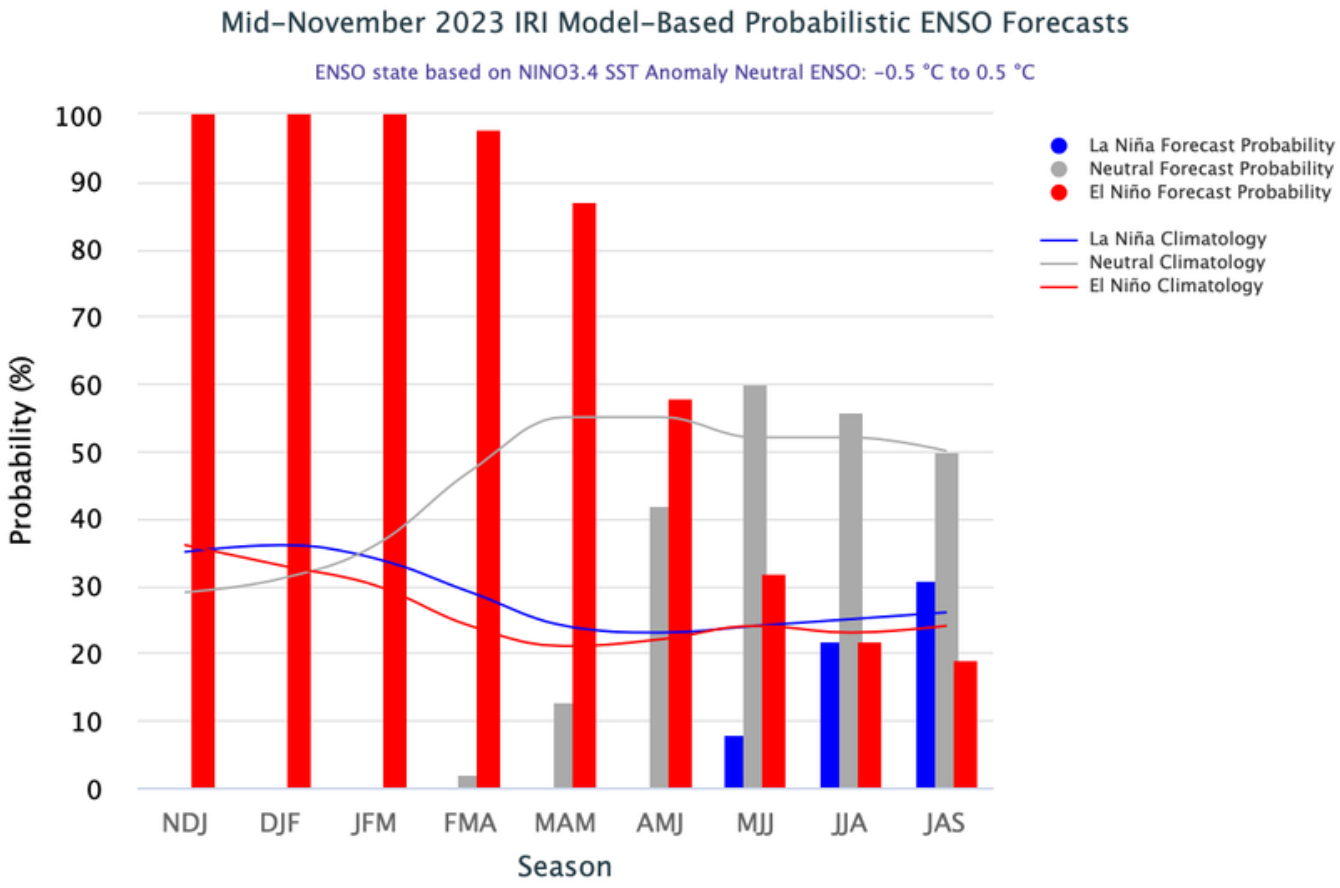


Figure 15: El Niño Southern Oscillation (ENSO): Forecast Updated by CPC on November 09, 2023. Source: NOAA/CPC.

Probabilistic Forecasting

6- ENSO Forecast - International Research Institute (IRI)

The ENSO model forecasts, generated by IRI, utilize a combination of dynamic and statistical models focused on Sea Surface Temperature in the Niño-3.4 region. This encompasses nine overlapping three-month periods. The most recent model update, conducted on November 20, strongly suggests a high probability of sustained El Niño conditions throughout the latter part of 2023 and the initial quarter of 2024. To elaborate, the probability of El Niño persisting during the summer and fall of 2024 ranges from 100% to 87% (covering December 2023 to February 2024). 100%, January to March: 100%, February to April: 98% and March to May, 2024: 87% Subsequently, a rapid decrease in the probability of El Niño was observed (April-June): 58%, May-July: 32%, June-August: 22% and July-September, 2024: 19% The second most probable scenario throughout the forecast period is ENSO neutral conditions, with a likelihood of 60% during May-July 2024, standing at 56% for June-August and 50% for July-September 2024.

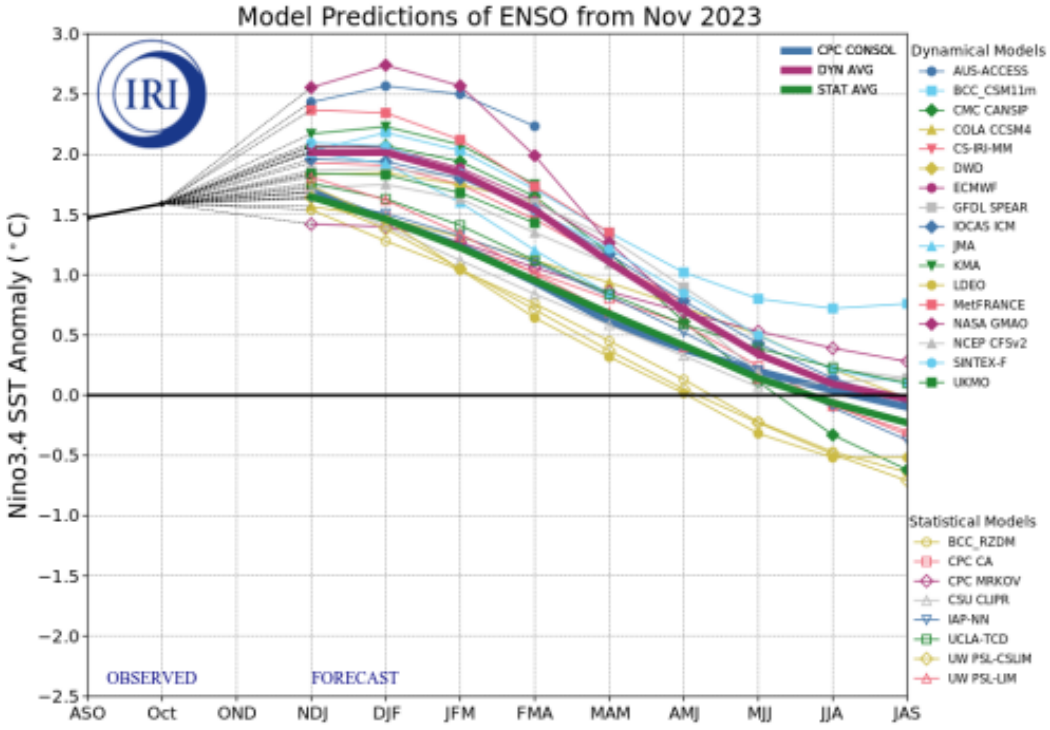


Figure 16: Columbia Climate School International Research Institute (IRI) Multi-Model Sea Surface Temperature (SST) forecast for ENSO, in the Niño 3.4 region, updated on November 20, 2023. Source: IRI.

7-ECMWF Precipitation Forecast:

The European model's rainfall forecast suggests a gradual resurgence of precipitation in the western sector of the Amazon throughout the December to February quarter (Figure 17). Anticipated rainfall levels vary from normal to above normal in the elevated areas of the Amazon basin, encompassing Colombia and Peru; and in the Brazilian territory, the forecast indicates rainfall ranging from normal to below normal, with a significant decrease in rainfall levels well below normal anticipated in the central-eastern and southern regions of the Amazon.

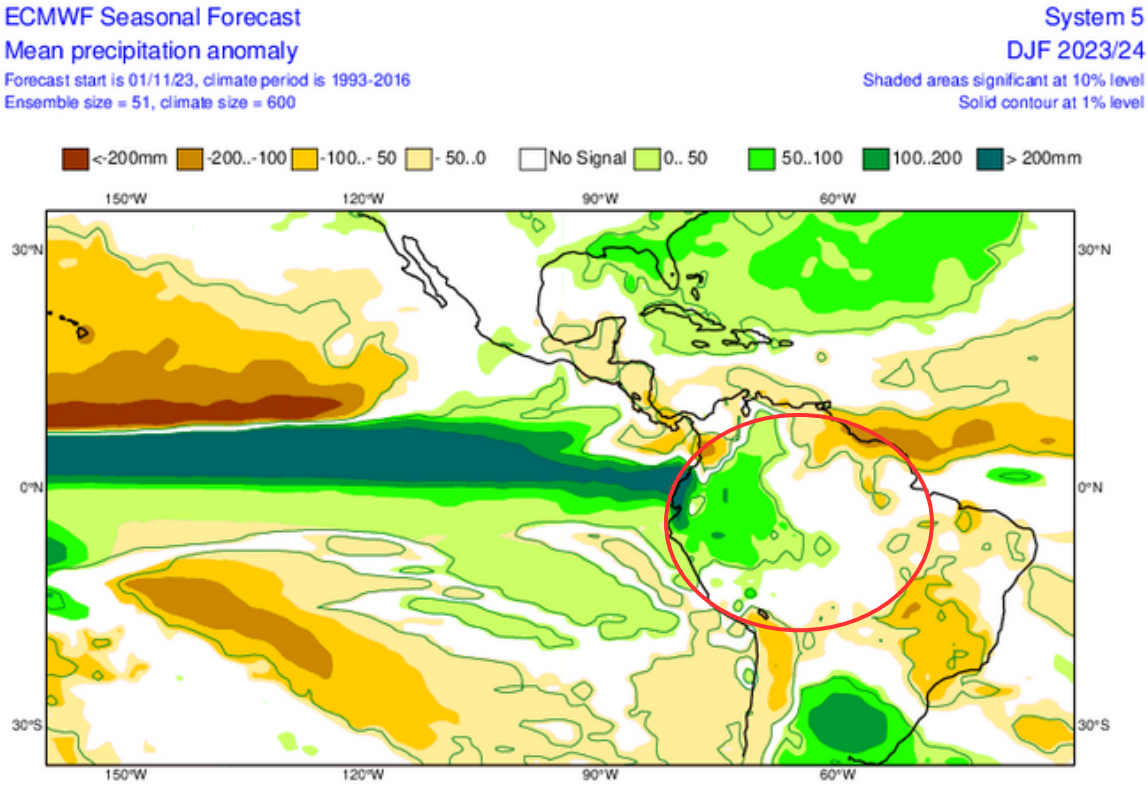


Figure 17: Mean precipitation anomaly for the period December 2023 February 2024.
Source: ECMWF model, Copernicus, Climate Change Service.

8- ECMWF Temperature Forecast:

Based on the European model, the two-meter temperature forecast signals a gradual rise in temperatures for the December to February quarter (Figure 18) in the western segment of the basin. Nevertheless, temperatures persist above the average for the month. This slight improvement is potentially attributed to anticipated rainfall in that region. However, the most concerning scenario, marked by above-normal temperature deviations, is particularly evident in the Brazilian and Venezuelan Amazon. Air temperature anomalies at two meters soar even higher than the norm, encompassing the central, eastern, northeastern, northern, and southern regions of the Amazon.

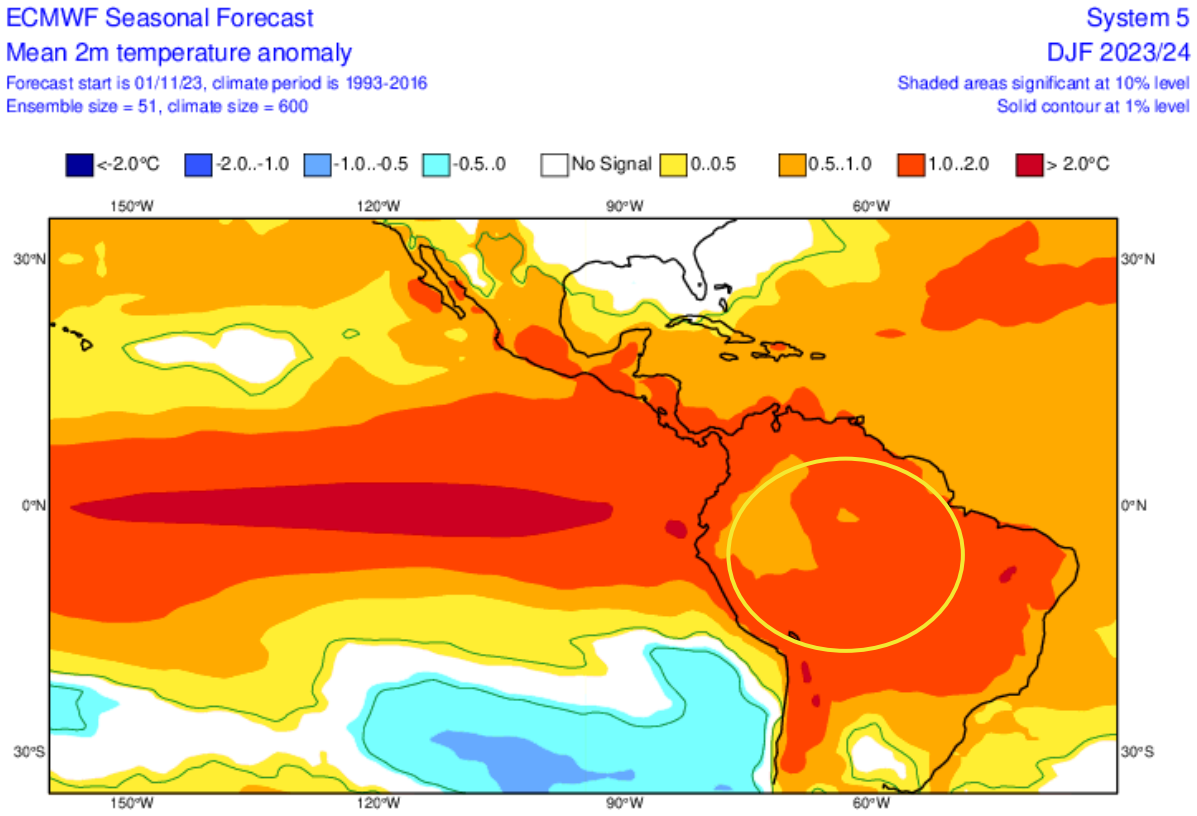


Figure 18: Mean temperature anomaly at two meters for the period December 2023 to February 2024. Source: ECMWF model, Copernicus, Climate Change Service.

9 – IRI Precipitation Forecast:

The American Multi-Model's seasonal rainfall forecast for the December 2023 to February 2024 quarter suggests precipitation levels ranging from normal to slightly above normal in the western sector of the Amazon region, with emphasis on regions in Colombia and Peru. However, the model consistently maintains projections of significantly reduced rainfall, particularly in the central, northern, northeastern, and eastern sections of the basin (Figure 19).

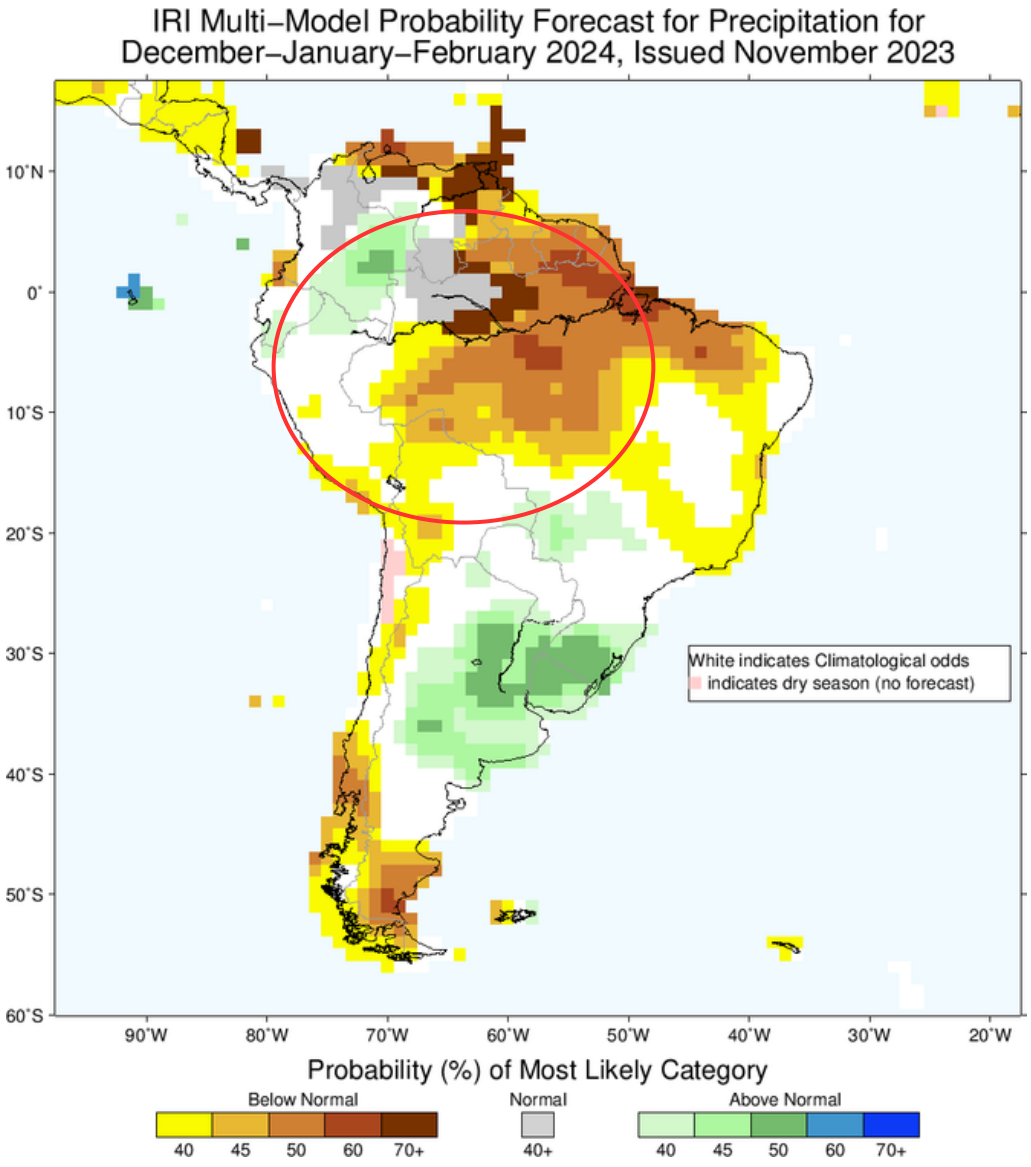


Figure 19: Percent precipitation predicted for the period November 2023 to February

10- IRI Temperature Forecast:

The seasonal temperature forecasts from the IRI, released in November, underscore a sustained prevalence of warmer-than-average conditions throughout almost the entire Amazon region for the December to February quarter (Figure 20). The only exception is limited to isolated areas in the southern part of Colombia, where a slight improvement in temperatures was noted during the analyzed period.

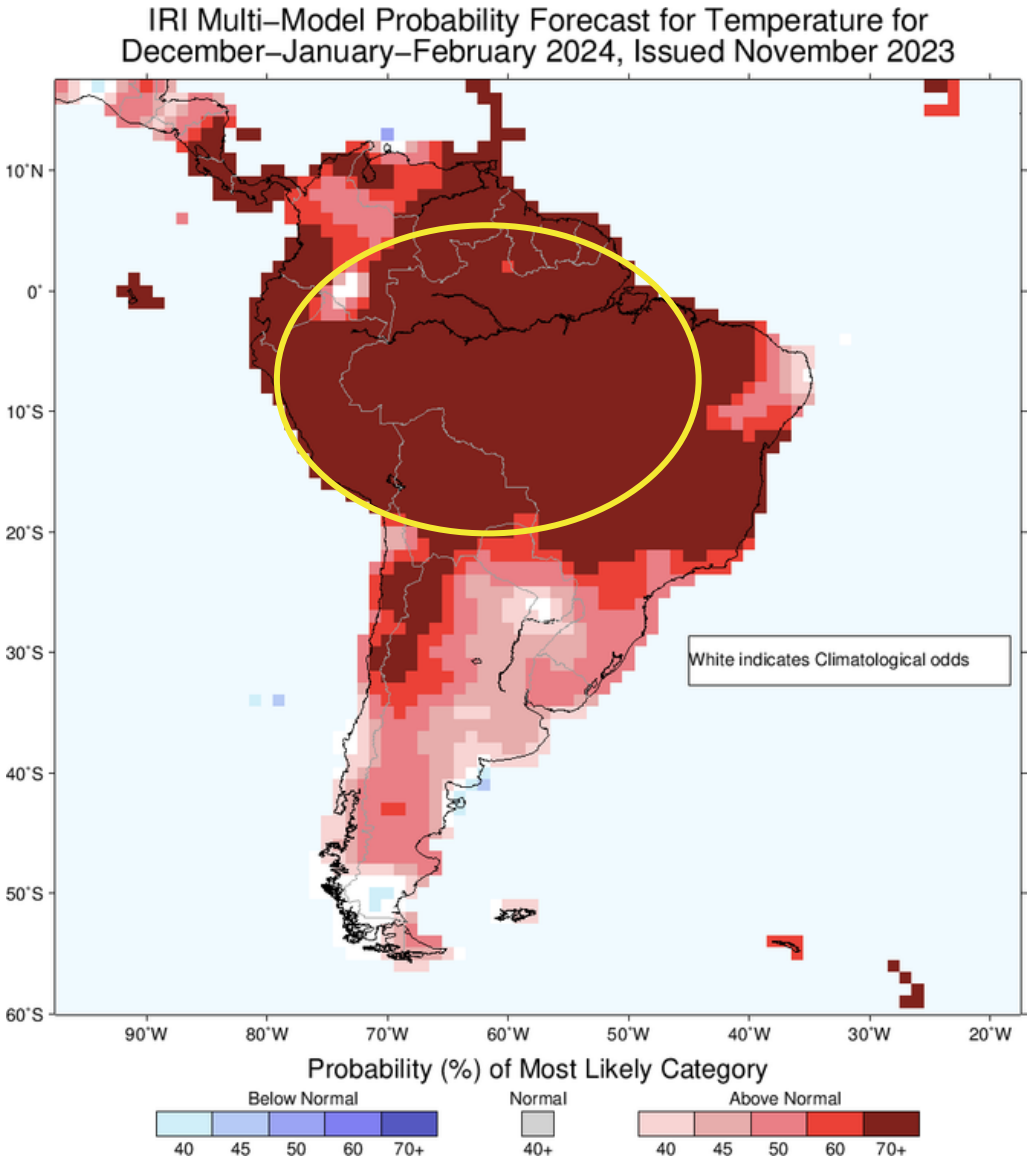


Figure 20: Percent of temperature predicted for the period of December 2023 to February 2024, IRI Model.

11 - SST forecast from NCEP coupled forecast system model version 2 (CFSv2)

Analysis of the data, focused on the CFS.v2 ensemble mean (represented by the black dashed line), reinforces the prospect of a prolonged El Niño in the Southern Hemisphere through the fall of 2024and transition for ENSO neutral between April and June 2024 (Figure 21 and 22)

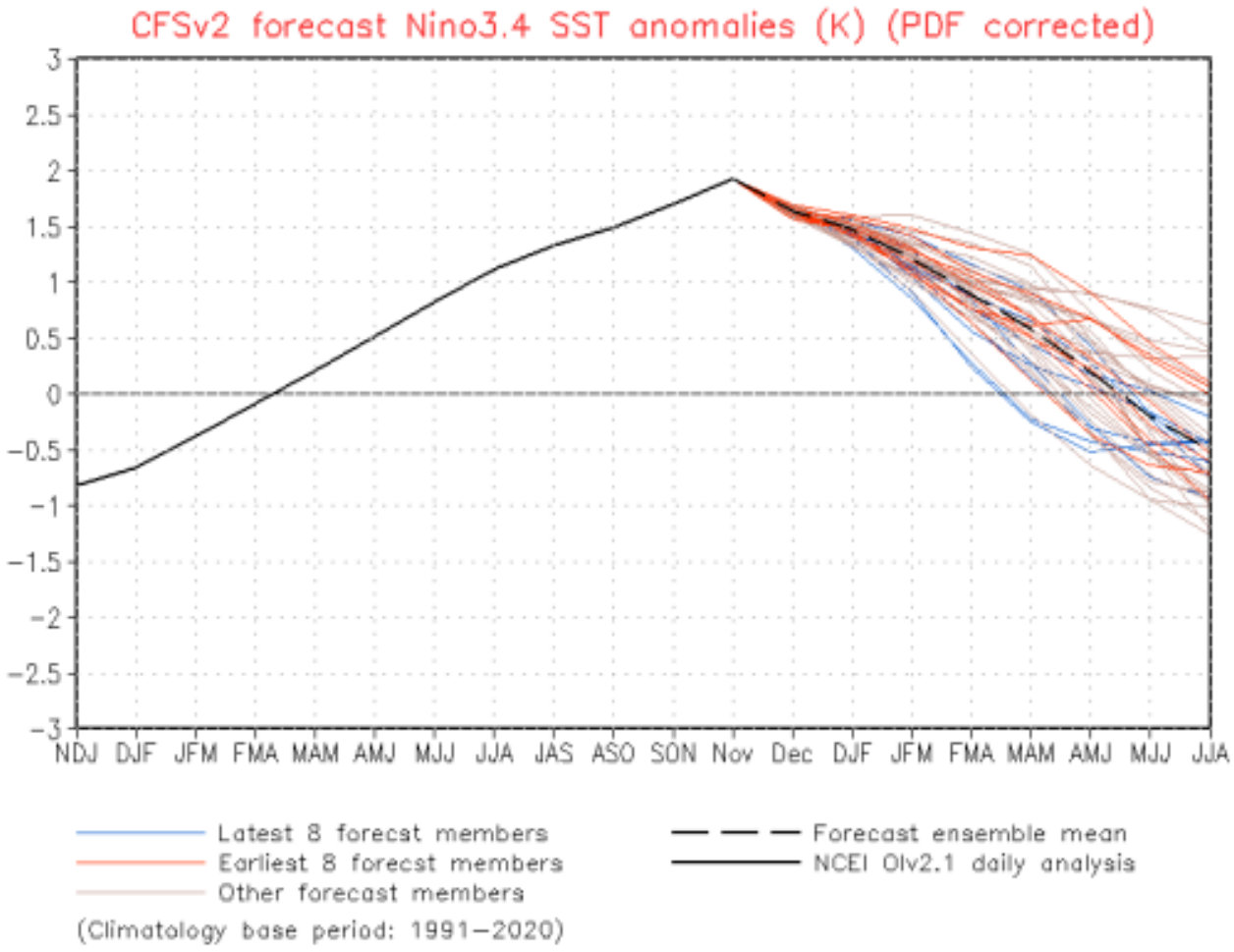


Figure 21: Forecast based on the Oceanic Niño Index (ONI). Source: Climate Prediction Center / NCEP

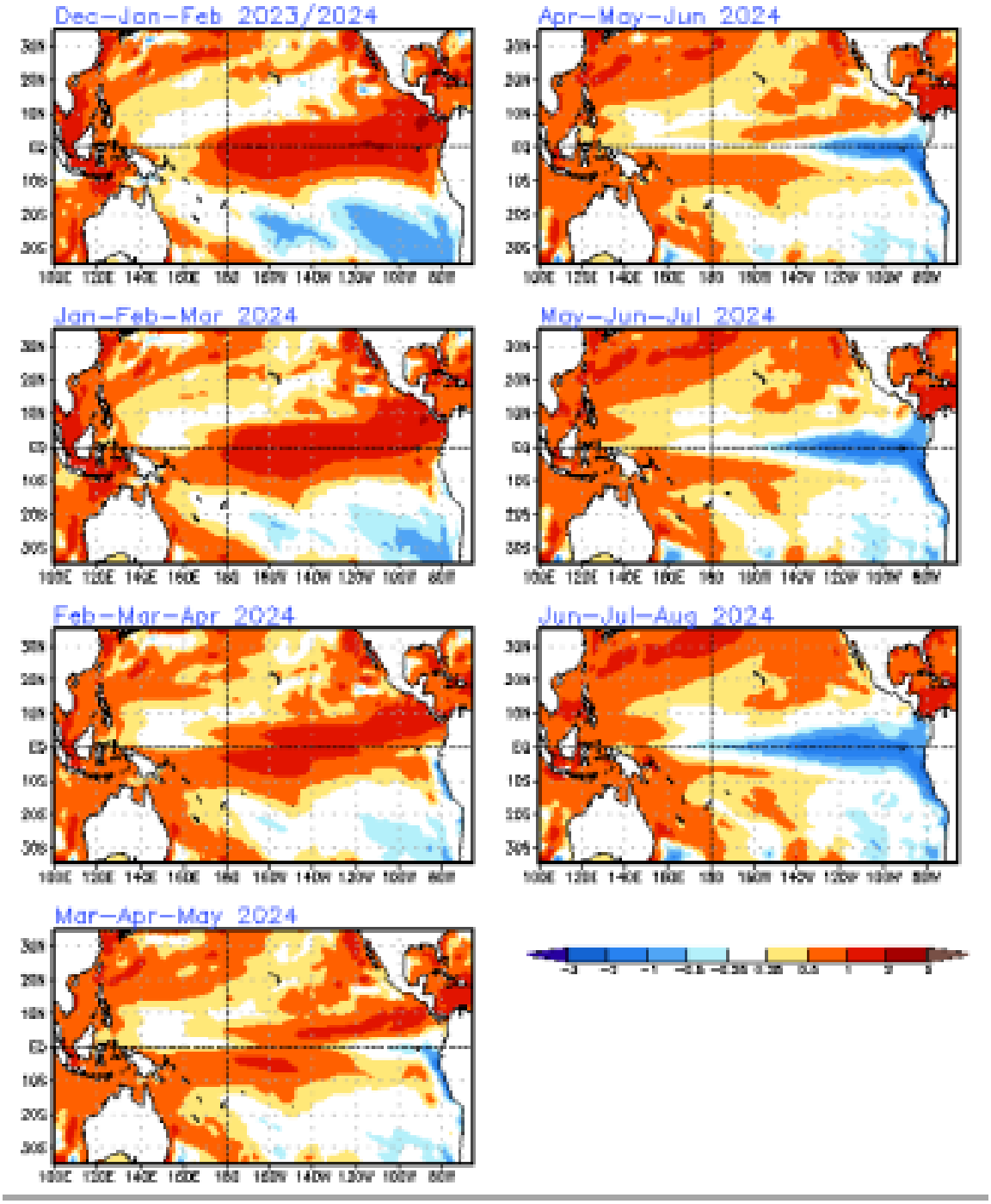


Figure 28: Seasonal anomalies of the CFCv2 Sea Surface Temperature (SST) for the period November 2023 to August 2024. Source: Climate Prediction Center / NCEP

Glossary

El Niño study areas: Equatorial Pacific area used to monitor the El Niño Phenomenon (niño4, niño3.4, niño3 and niño 1+2).

Niño Southern Oscillation (ENSO): Refers to a periodic oscillation of the ocean-atmosphere system in the tropical Pacific, with climatic effects at the global level. The intensity of its phases triggers modifications in the usual rainfall, temperature and pressure patterns in the tropical region of the Pacific Ocean, influencing climate significantly on a global scale.

El Niño: Warm phase of El Niño Southern Oscillation (ENSO) phenomena.
La Niña: Cold phase of El Niño Southern Oscillation (ENSO) phenomena.

Data Source

- **Climate Prediction Center (CPC/NOAA).** https://www.cpc.ncep.noaa.gov
- **Seasonal climate forecast from CFSv2**. Link: https://www.cpc.ncep.noaa.gov
- **Senamhi.** Link: https://www.senamhi.gob.pe
- **Climate Change Service**, Copernicus. https://climate.copernicus.eu
- **European Centre for Medium-Range Weather Forecasts (ECMWF):** https://www.ecmwf.int/en/about
- **International Research Institute for Climate and Society (IRI):** Link: https://iri.columbia.edu

Ocean-Atmospheric Monitoring Output of ARO Situation Room

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