Climate Science

Zero Carbon Analytics

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What to expect from La Niña

Key points:

- La Niña is a natural, reoccurring climate phenomenon whereby cold, deep water moves to the ocean surface and cools the central and eastern Pacific Ocean, and warmer water moves to the western Pacific Ocean.
- There is an 85% chance of a transition from the current El Niño state to neutral conditions between April and June this year, and a 60% chance of La Niña developing by June to August.
- La Niña strongly influences rainfall and weather patterns in various regions of the world and has been responsible for catastrophic droughts and floods, which have severely threatened agricultural production and food security, and caused major economic losses.
- La Niña episodes usually last nine to 12 months, but may last for years. The frequency of multi-year La Niña's has risen in the past several decades, and the longer duration increases risks from weather extremes. The previous La Niña, which lasted from 2020-2023, had devastating consequences for several regions of the world.
- Human-caused climate change is at least partly responsible for increases in the variability and frequency of extreme La Niña events.
- Some regional trends that can be associated with La Niña include:
    - Drier than usual conditions in Ethiopia, Somalia, northwestern and eastern Kenya, northeastern Tanzania, southern and southeastern US, southern Brazil, Uruguay, northern Argentina and southern Bolivia, potentially leading to drought and crop failures.
    - Wetter than usual conditions in eastern South Africa, Mozambique, Zimbabwe, Botswana, northern and eastern Australia, southeast Asia, India, northern Brazil, Colombia and Venezuela, with potential for flooding.
    - Increased Atlantic hurricane activity, with potentially severe consequences for the southeast coast of North America.

The El Niño-Southern Oscillation cycle

The El Niño-Southern Oscillation (ENSO) cycle – entailing periodic fluctuations in sea surface temperature and atmospheric pressure over the tropical Pacific Ocean – is a natural, reoccurring climate phenomenon that strongly influences rainfall and weather patterns in various regions of the world. La Niña is the cool phase of the ENSO cycle, while El Niño is the warm phase, with a neutral period following these phases.

During La Niña, trade winds – the east-to-west winds that blow along the earth's equator – intensify, which causes cold, deep water to move to the ocean surface and cool the central and eastern Pacific Ocean, and warmer water to be pushed to the western Pacific. During El Niño, roughly the opposite happens, with weakened trade winds causing central and eastern Pacific ocean water to warm up.

El Niño and La Niña episodes usually last nine to 12 months, but may last for years. While the transitions among various phases occur irregularly, the cycling between the warm and cool phases takes place every two to seven years and brings about predictable changes to ocean temperatures, wind and rainfall patterns.[1] ENSO events are described as Eastern Pacific (EP) or Central Pacific (CP) events depending on where the maximum warming or cooling is located.[2] Some impacts of EP and CP events differ. For example, CP El Niño events are associated with more severe droughts in Australia than EP events. There has been an increase in the frequency of CP events in the last four decades.

Based on changes in sea surface temperatures and atmospheric conditions in the tropical Pacific, the National Atmospheric and Oceanic Administration is confident that there is an 85% chance of a transition from the current El Niño state to neutral conditions between April and June this year, with a **60% chance of La Niña developing by June to August.** Long-range models predict an EP La Niña event this year.

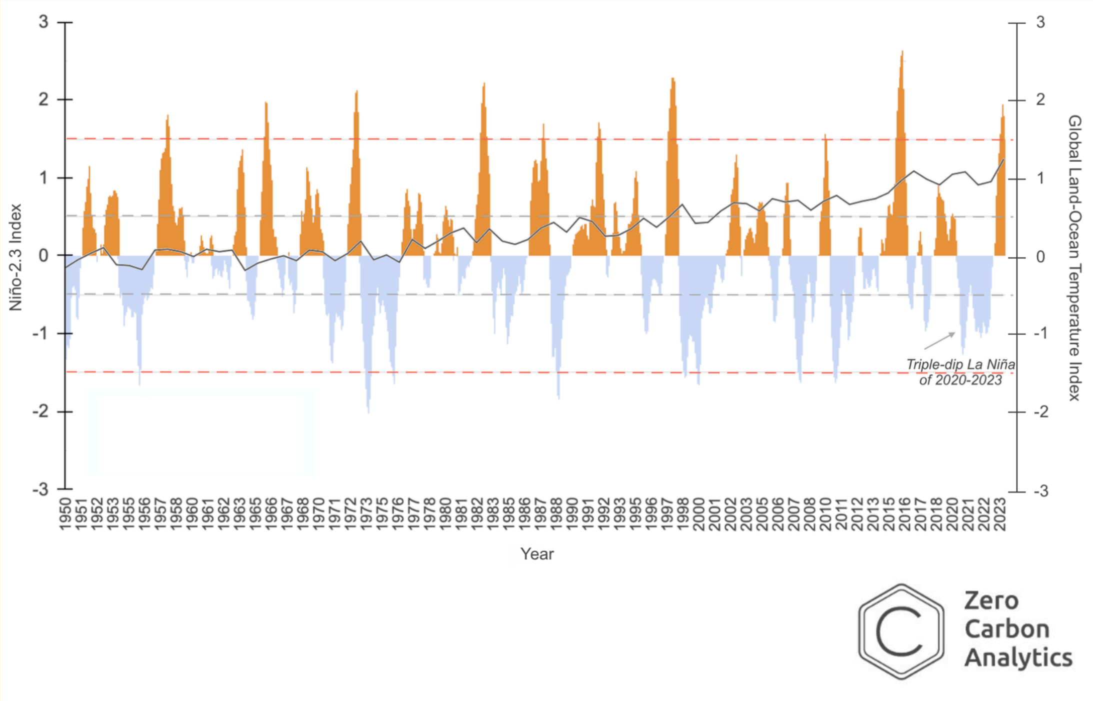
How are La Niña and El Niño predicted?

Scientists use a combination of climate models and observational data, such as sea surface temperature and trade wind strength data from satellites and ocean buoys, to predict the onset of ENSO events several months in advance. Models can forecast La Niña events up to two years' in advance if the La Niña follows a strong El Niño rather than any other state.[3]

La Niña and El Niño events are characterised as weak to strong based on the sea surface temperature anomaly - the deviation from the average or baseline - with cooling or warming of 1.5°C or more considered strong. Figure 1 shows the values of the Nino-3.4 index - a measurement of sea surface temperatures in the equatorial Pacific Ocean - from 1950 to 2024. The grey dashed line shows when the sea surface temperature anomaly meets the requirement for an El Niño or La Niña event, generally defined as an anomaly of 0.5°C or more. The red dashed line shows strong La Niña and El Niño events. However, multi-year events that do not exceed this threshold can also have severe consequences, leading to increased risks from droughts, floods and weather extremes due to their long duration - as observed with the 2020-2023 'triple-dip' La Niña. The grey solid line is the global land-ocean temperature index and shows the change in the global surface temperature from 1950 to 2023.

Fig. 1: Sea surface temperature anomalies in the equatorial Pacific and global land-ocean temperature index from 1950-2024

[1] A cold phase does not always immediately follow a warm phase, and *vice versa*. In many cases, a cool phase follows from a cool phase, with a varying number of neutral condition months in between.
[2] CP events may also be referred to as ENSO 'Modoki'.
[3] There have been significant improvements in models' ability to forecast ENSO events, but these models still face some challenges - for example, they generally overestimate La Niña and El NIño strength.



Data source for Niño-3.4 index: US National Weather Service. Data are three-month running averages with a centered baseline. Data source for global land-ocean temperature index: NASA's Goddard Institute for Space Studies. Values are annual means in reference to a 1951 to 1980 baseline.

By forecasting when El Niño or La Niña will occur, better predictions can be made about possible extreme weather events, helping people to prepare for and mitigate against potential damage associated with these events.

Multi-year La Niña's are becoming more common

The frequency of multi-year La Niña's has increased – five of the 10 multi-year La Niña's over the last 100 years happened in the last 25 years. Multi-year La Niña events have longer-lasting impacts compared to single-year events, such as prolonged above-average rainfall over Australia, Indonesia, tropical South America and southern Africa, and below-average rainfall over the southern United States, Equatorial Africa, India and southeast China.

A study found that multi-year La Niña events are more likely to follow a 'super El Niño', which is a particularly strong El Niño – such as the current El Niño, or a CP El Niño. The previous 'triple-dip' La Niña event – which lasted from 2020 to 2023 – was a scientific anomaly because it did not match the conventional scientific theories of how prolonged La Nina events develop. Experts reported that it was one of the strongest La Niña events in the past half century. The impacts of this triple-dip La Niña were devastating and included severe flooding in northern Australia, extreme drought in the Horn of Africa – creating one of the worst food security crises in the region for decades, widespread drought in the southwest US, record-breaking hurricane activity, one of the worst droughts on record in South America and heavy rainfall and flooding in Pakistan and northwestern India, with around 15% of the population of Pakistan negatively impacted by the rainfall.[4]

[4] Climate is complex and influenced by multiple processes. For instance, the extreme rainfall in Pakistan was also attributed to human-caused climate change.

La Niña and the Indian Ocean Dipole

The Indian Ocean Dipole (IOD), which is thought of as the Indian Ocean counterpart of El Niño and La Niña, refers to sea surface temperature anomalies in the Indian Ocean that show a 'dipole pattern'. When the western Indian Ocean is cooler than usual and the eastern Indian Ocean is warmer than usual, this is referred to as a negative IOD. When the eastern Indian Ocean is cooler and the western Indian Ocean is warmer than usual, this is referred to as a positive IOD. Though independent of La Niña, the IOD is frequently triggered by ENSO events, with negative IOD events typically accompanying La Niña events. Negative IOD events have been linked to extreme rainfall in Indonesia and Australia, and drought in East Africa. Stronger negative IOD events have also been found to make La Niña stronger, and CP La Niña events are also typically linked to stronger IOD events. However, the relationship between ENSO and the IOD is complex due to the diversity and substantial variation in regional feedbacks of ENSO.

Influence of human-caused warming

While ENSO events are natural phenomena, they are occurring against a background state of a warming world, which likely influences their characteristics and impacts. Some changes in ENSO characteristics have been observed over the last few decades, including an increase in the frequency of extreme events and an increase in the variability of events. Similarly, one analysis projects that extremely positive IOD events – linked to drought and wildfires in Indonesia and Australia and flooding in East Africa – will become almost three times more frequent in the 21st century due to climate change. As ENSO is naturally a highly variable phenomenon, determining with certainty whether its characteristics are changing as a result of human-caused climate change is complex – especially as sea surface temperature records have only been available since the 1950s. However, the scientific consensus is that human-caused climate change is at least partly responsible for changes in ENSO variability. Climate change may also be making it less easy to predict extreme El Niño and La Niña events, making it more difficult for people to prepare for potential negative impacts.

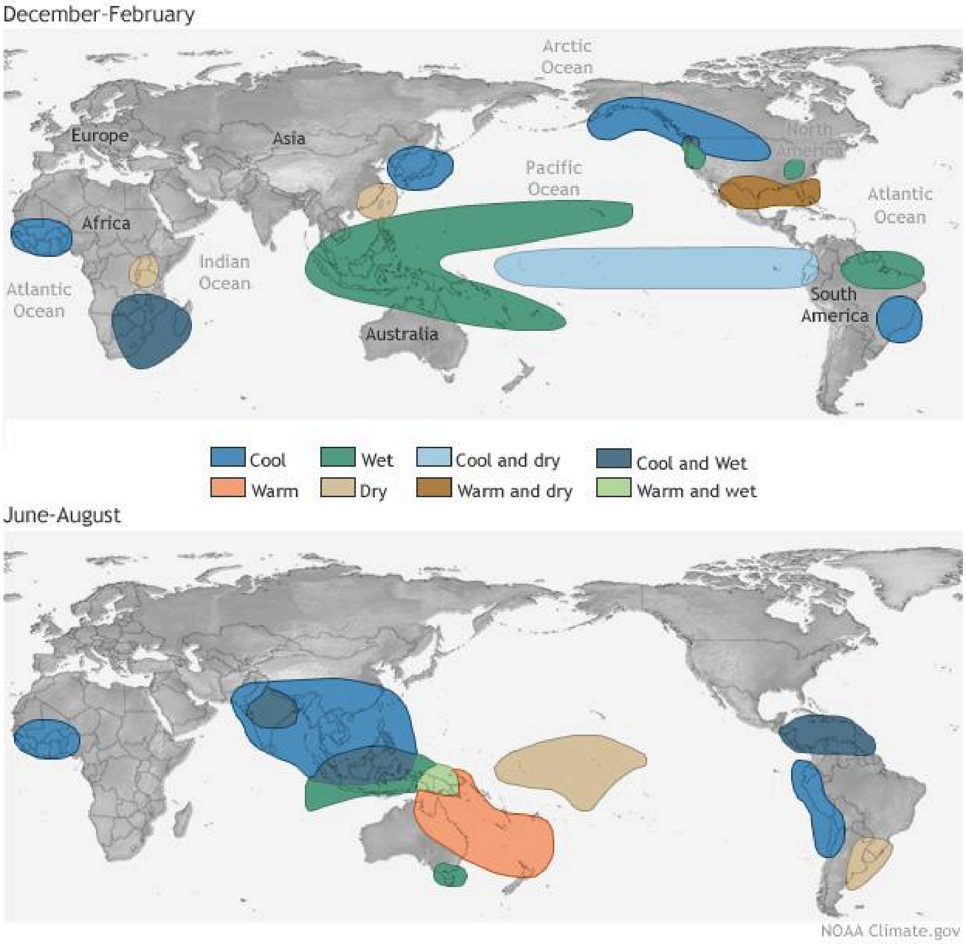
Cooler conditions under La Niña do not offset global warming

Though La Niña does cause a decrease of around one tenth of a degree Celcius in the earth's average surface temperature, this cooling is temporary and is only a fraction of the total average warming of the earth by human-produced greenhouse gases – since industrial times the earth's average temperature has risen about 1.36°C. To put this number into context, average global temperatures during recent La Niña years have been higher than the average temperatures during El Niño years in past decades, highlighting how much the planet has warmed over the last century (Figure 1). In fact, recent La Niña years have been in the top 10 hottest years ever. Despite the decreased average global temperatures under the upcoming La Niña, 2024 will still likely be one of the top five hottest years on record.

Potential regional impacts of La Niña

As weather patterns around the world are influenced by multiple climate drivers, experts warn against concluding what the impacts of an event will be based on one climate driver alone. However, as La Niña brings about predictable changes to ocean temperatures, wind and rainfall patterns, some general trends can be anticipated (Figure 2).

Fig. 2: Regional impacts of La Niña on rainfall and temperature



Source: [National Oceanic and Atmospheric Administration](), 2016.

Africa

La Niña is typically associated with drier conditions over December–January in East Africa, including in Ethiopia, Somalia, northwestern and eastern Kenya, and northeastern Tanzania, with implications for crops harvested in February and March and negative effects on livestock. In South Sudan, above-average rainfall could be expected, which might increase crop yields or cause flooding.

La Niña is associated with above-average summer rainfall in eastern South Africa, Mozambique, Zimbabwe and Botswana. In terms of agricultural productivity, South Africa tends to see higher yields of maize, sorghum and wheat, whereas Zimbabwe tends to experience increased maize and soybean yields.

Oceania

In Australia, CP El Niño events tend to bring above-average rainfall to the northern and eastern regions and is linked to severe flooding.

North America

The increase in cold water in the Pacific during La Niña pushes the polar jet stream - a fast air current in the polar region of the Northern Hemisphere - northwards, which tends to cause drier winter and spring conditions in the southern and southeastern US and heavy rains and stormy weather in Alaska, western and central Canada, and the northern US.

Generally, the effects of La Niña in the northern hemisphere are most felt during winter, as it brings colder and wetter winters. There is also an increase in the frequency and strength of Atlantic hurricanes.

The arrival of La Niña around September could benefit maize production in the corn belt of the US but could also reduce water levels in Midwest rivers, with implications for grazing pastures.

Asia

Southeast Asia, including Indonesia, Malaysia and the Philippines, experiences above-average rainfall during CP La Niña events, potentially causing severe flooding. However, rice and palm oil production in the region could be boosted. Due to increased rainfall and cooler conditions, La Niña tends to have a net positive impact on grain yields in China.

In India, La Niña will likely cause above-average monsoon rainfall from July to September and may result in decreased production of pulses, sugarcane and wheat in the Indo-Gangetic Plains, but could increase rice production.

South America

Southern Brazil, Uruguay, northern Argentina and southern Bolivia tend to experience below-average rainfall, potentially leading to drought. Crops such as soybean and maize could be negatively impacted. Northern Brazil, Colombia, Venezuela, and parts of Ecuador and Peru typically experience wetter conditions, with potential for flooding.