Impacts of El Niño on Climate and Ecosystems in Guam

The dry season gets even drier during El Niño

El Niño vs. La Niña

The El Niño-Southern Oscillation (ENSO) is a naturally recurring warming of sea surface temperature (SST) in the central and eastern tropical Pacific Ocean. This warming, and subsequent cooling of ocean waters happens over years, and is brought on by periodic changes in surface winds that move water across the Pacific Ocean along the equator. Changes in SST ultimately affect large-scale patterns of atmospheric circulation which can influence rainfall.

During the **La Niña** (cool water) phase of ENSO, stronger trade winds move cooler water quickly from east to west across the Pacific basin, resulting in cooler SSTs around Guam. During the **El Niño** (warm water) phase easterly trade winds are weaker or even reverse direction to westerly across the central Pacific, allowing warmer waters to spread eastward. Additionally, the slower moving water has the ability to absorb more heat energy, resulting in warmer SST.

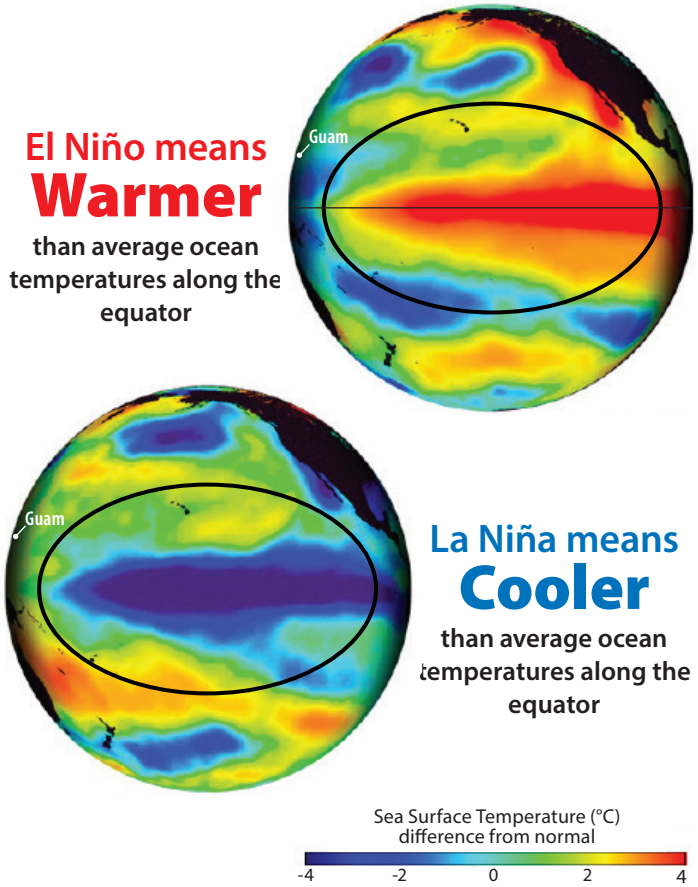

Figure 1 (left): Ocean temperatures during the El Niño and La Niña phases of ENSO. **Credit: Steve Albers, NOAA**

El Niño Weather in Guam

In Guam, rainfall is strongly influenced by both El Niño and La Niña events. El Niño events are typically associated with lighter winds, lower sea levels, and lower than average rainfall between January to June, which is Guam's dry season (Figure 2)[1]. During the La Niña phase of ENSO, winds are typically stronger, sea level is higher, and there is above-average rainfall during the dry season.

Individual El Niño and La Niña events can vary in strength and are classified as either strong or weak depending on how warm or cool SSTs are in the tropical Pacific. During a strong El Nino, Guam receives about 50% less rainfall but up to 71% less rainfall during the dry season than long-term averages. During a strong La Niña event, rainfall is about 44% above average during the dry season. These cycling ENSO phase changes are the most important drivers of inter-annual rainfall variations in Guam[2].

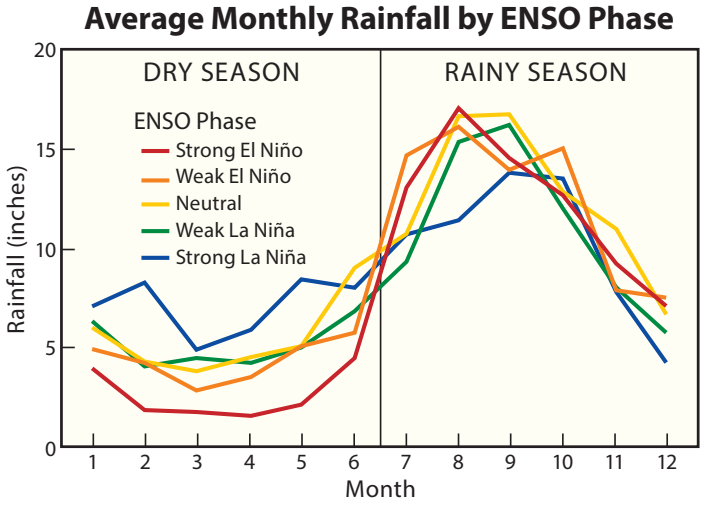

Figure 2 (above): Long-term (1960–2021) monthly average rainfall during five unique ENSO phases.

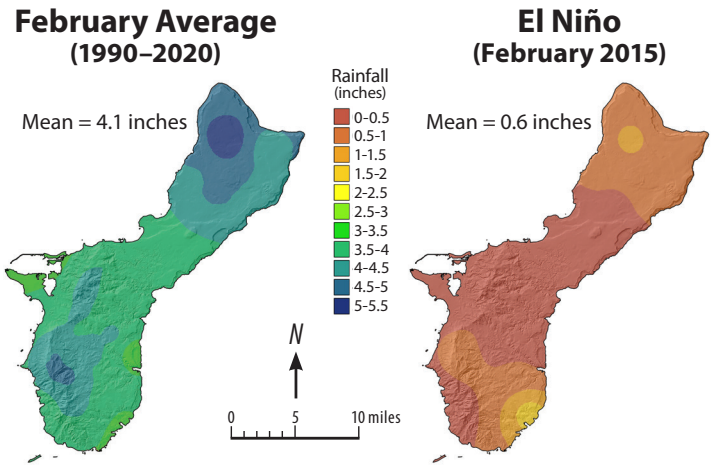

Figure 3: February average rainfall (left) and February 2015 rainfall (right).

Effects of El Niño on Rainfall in Guam

Island-wide average monthly rainfall during the dry season is about 5 inches per month, but during a Strong El Niño event, average rainfall typically declines by 2.5 inches per month. During the El Niño event in February 2015, rainfall was 3.5 inches (85%) drier than the long-term average for that month, and consequently the driest month in instrumental record[2].

Why are Changes in Rainfall Important?

Extreme rainfall variability, changes in SSTs and changes in sea level associated with the phase changes of ENSO can result in a number of negative impacts on the environment and on society. Reduced rainfall can cause or intensity droughts, with longer or more severe declines in rainfall affecting ecosystem function, water supplies used for people and agriculture, and the number and severity of wildland fire events[3].

Lower sea levels during El Niño can result in extreme low tides and shallow coastal waters that can leave parts of the reef exposed to air. Combined with higher SSTs, these changes to sea level can cause coral bleaching (Figure 4), with extensive die-offs happening during the strongest (warmest) events[4]. Loss of corals has the potential to negatively impact nearshore fisheries and the tourism industry.

Warmer SSTs can lead to increases in the occurrence and intensity of tropical cyclones. Strong storms can impact uplands, coastlines, and nearshore ecosystems by damaging homes and infrastructure, contaminating drinking water supplies and reducing food security due to damage to agriculture and loss of near-shore resources. Conversely, drought events reduce stream flow and reservoir reserves which can lead to a loss in agriculture productivity and clean water supply.

During the La Niña phase of ENSO, sea levels are typically higher than average and coastlines can see an increase in flooding. Especially during extreme high tide or storm events.

Human health and wellbeing can be greatly impacted by destructive storms, water contamination, food shortages, coastal flooding, and the inhalation of smoke during fire events.

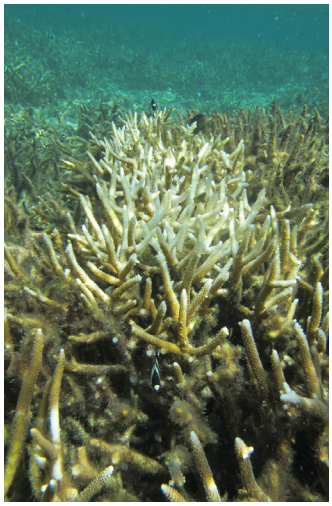

Figure 4: Bleached coral at Guam's West Agana site in 2014.
Credit: Laurie Raymundo.
https://www.washingtonpost.com/news/energy-environment/wp/2016/08/03/i-cried-right-into-my-mask-these-coral-reefs-have-seen-a-devastating-four-years-of-bleaching/

"Understanding how different phases of ENSO result in a large variability of weather hazards, as well as the associated impacts these hazards have on humans and natural resources, is an important first step in building resilience, strengthening adaptive capacities and mitigating damage."

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Acknowledgements
The National Weather Service of Guam for their critical scientific review

[1] Longman et al., (In preparation) Mapping Monthly Rainfall in Guam (1960–2021). Note: Rainfall values calculated as an area (Guam) average.

[2] Guam Hydrological Survey (2022) https://guamhydrologicsurvey.uog.edu/index.php/climate-and-weather/#:~:text=Whereas%20wild%20weather%20patterns%20(e.g.,in%20the%20post%2DPeak%20phase.

[3] Minton (2006) Fire, Erosion and Sedimentation in the Asan-Piti Watershed and War in the Pacific NHP, Guam. http://hdl.handle.net/10125/836

[4] Grecni et al. (2020). Climate Change In Guam DOI:10.5281/zenodo.4037481

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