How climate patterns contribute to coral bleaching in the Great Barrier Reef

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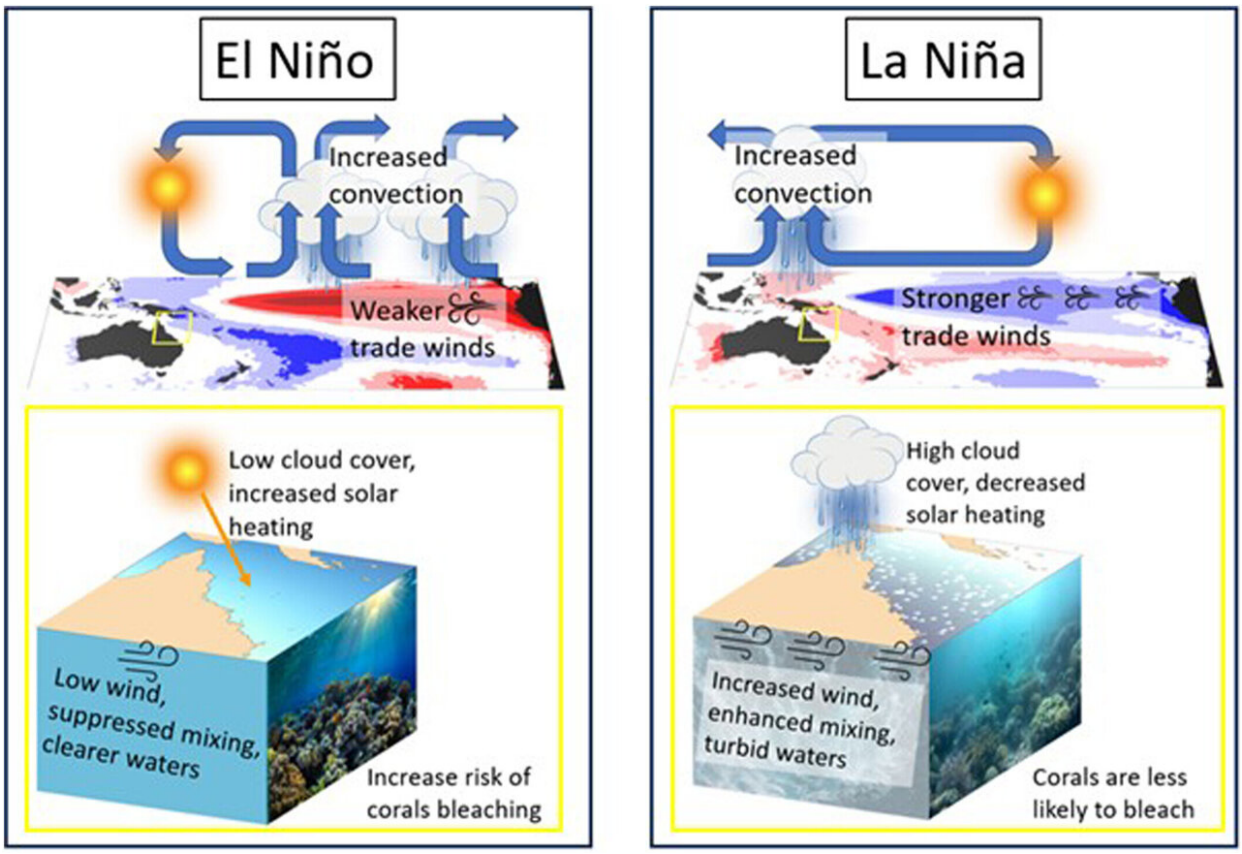

Schematics showing the large-scale ocean-atmosphere feedback processes that occur during El Niño and La Niña in the Pacific Ocean (blue indicates cool SST anomalies while red indicates warm SST anomalies), and the influence on local weather patterns over the GBR that contribute to significant ocean temperature variability and coral exposure to solar radiation. Credit: *Geophysical Research Letters* (2024). DOI: 10.1029/2024GL108810

A new study finds a significant impact of the Madden-Julian Oscillation (MJO) and El Niño Southern Oscillation (ENSO) on coral bleaching events in the Great Barrier Reef (GBR).

The GBR, covering almost 350,000 square kilometers along Australia's northeastern coast, is the world's largest coral ecosystem. Renowned for its biodiversity, cultural significance, and economic value, it contributes around $6.4 billion annually to the Australian economy. However, it faces serious threats from increasing ocean temperatures due to climate change.

A *Geophysical Research Letters* paper, titled "Combined Role of the MJO and ENSO in Shaping Extreme Warming Patterns and Coral Bleaching Risk in the Great Barrier Reef", co-authored by the Institute for Marine and Antarctic Studies and the ARC Center of Excellence for Climate Extremes, led by UNSW Sydney, highlights how climatic phenomena influence weather conditions over the GBR, contributing to the rising threat of coral bleaching.

What the study found

Corals are particularly sensitive to weather conditions in the GBR. Sunny, calm weather typically leads to high ocean temperatures, increasing the risk of coral bleaching.

Conversely, stormy, rainy weather can cool the ocean, providing some protection to corals. This is because calm, sunny days allow more sunlight to penetrate the water, heating the ocean's surface, while storms and rain increase cloud cover and wind, promoting the mixing of cooler, deeper waters with warmer surface waters.

The study found that while ENSO—a recurring climate pattern involving changes in the temperature of waters in the central and eastern tropical

Pacific Ocean—influences weather patterns over the GBR on a seasonal scale, the MJO—a major fluctuation in tropical weather on weekly to monthly timescales—can alter these patterns on shorter, sub-seasonal timescales. This leads to unexpected impacts on ocean temperatures and corals.

Catherine Gregory, the study's lead author and a Ph.D. candidate at the Institute for Marine and Antarctic Studies, supported by the ARC Center of Excellence for Climate Extremes, explained, "We find that the MJO can significantly influence the weather variability over the GBR, altering the expected states of El Niño and La Niña periods.

"While these findings do not tell us all the possible causes of extreme warming and coral bleaching in the GBR, they emphasize the need to consider drivers beyond ENSO, including the compounding impacts of multiple drivers."

Why are these findings important?

Understanding how ENSO and MJO influence weather patterns can help anticipate coral bleaching events. ENSO phases, like El Niño and La Niña, impact weather and ocean temperatures, with El Niño often leading to higher ocean temperatures and increased coral bleaching risk, while La Niña can bring cooler conditions.

However, the MJO can disrupt these patterns, leading to unexpected weather variations that also affect ocean temperatures and coral health.

Gregory said, "I'd often heard in the media that during El Niño periods the GBR is more likely to experience bleaching. Then during 2022, the reef experienced mass bleaching during a La Niña period, and it was reported that La Niña should mean cooling in the GBR.

"However, in my research, I had examined this relationship and not found a strong connection between the ENSO index and ocean temperatures in this region. This motivated me to understand other drivers that could be influential. The MJO, as the leading driver of sub-seasonal weather variability, seemed like an important one to consider."

Gregory emphasized, "While ENSO provides insight into the expected synoptic states, it lacks details of anticipated sub-seasonal weather variability at local scales."

These findings underscore the need for comprehensive forecasting models that include both ENSO and MJO impacts to better predict and manage coral bleaching events.

As climate change continues to pose the greatest threat to corals, she urged understanding these climatic drivers and their interactions, which could be useful for developing adaptive strategies to safeguard the GBR's future.

More information: Catherine H. Gregory et al, Combined Role of the MJO and ENSO in Shaping Extreme Warming Patterns and Coral Bleaching Risk in the Great Barrier Reef, *Geophysical Research Letters* (2024). DOI: 10.1029/2024GL108810

Provided by ARC Centre of Excellence for Climate Extremes