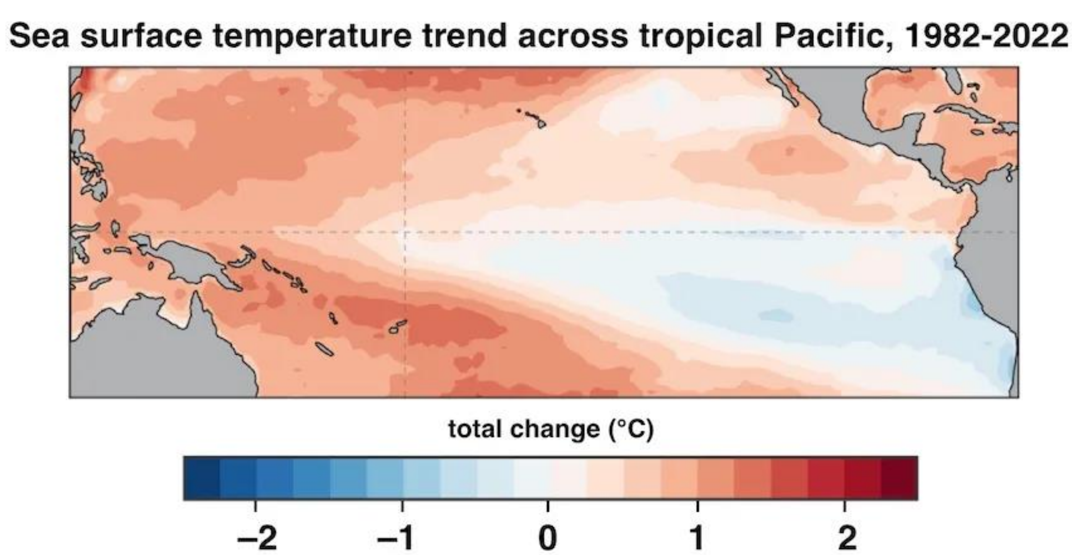
The Mystery of The Pacific "Cold Tongue"

You've likely come across several articles or headlines regarding the state of the expansive warming we've observed within the oceans globally. That by now probably doesn't result in a reaction since it always appears as if another warm record has once again manifested. However, what if we deviate from the standard "norm" and analyze a mysterious **cold** anomaly that has climate scientists quite puzzled.

A zonally broad cold "tongue", which extends off the South American coast for thousands of miles, has cooled by approximately a half of a degree over the past four decades. Natural variability within the oceans can only explain so much, but trying to decipher the increasing greenhouse gases and to what impact it's having in the oceans is a difficult feat. The persistence as to what the driver is has dealt much uncertainty as to simply "why"?

Visually appealing data taken from NOAA reveals the stark contrast between both the warming across the Pacific Basin in both hemispheres, and more importantly the cooling you see that extends off the western coastline of South America. This is the net change since 1982, showcasing the Pacific cool anomaly that top climate models had not foreseen coming. In fact, they consistently showed for more than twenty years that the tropical Pacific should've taken on a more persistent El-Nino regime.

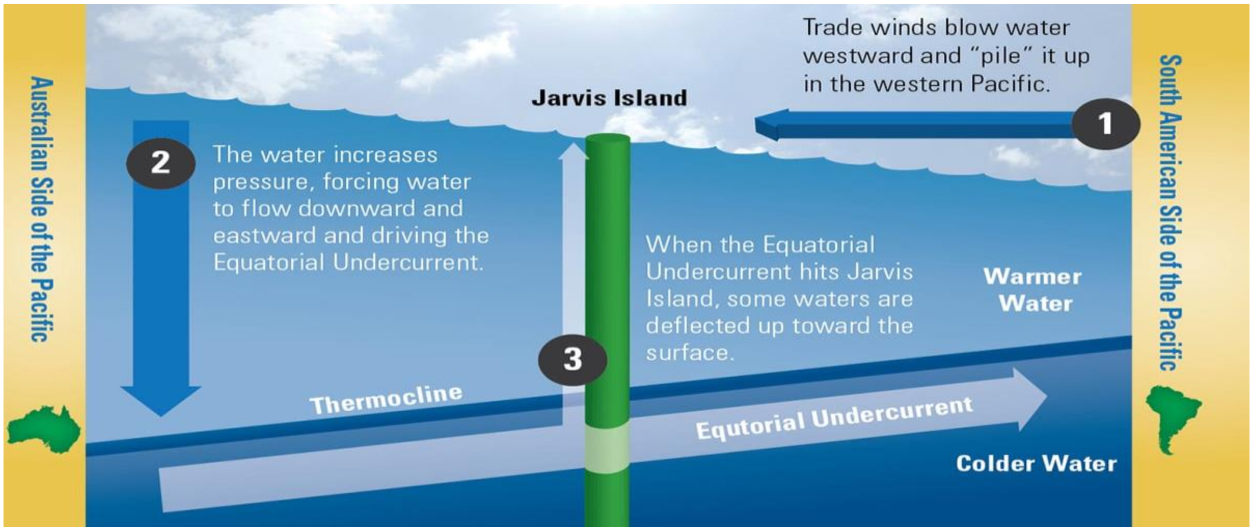


We're going to dig into several bona-fide hypotheses as to what has led to this cool patch, which also may be a culmination of several factors that'll be presented.

The Strengthening Equatorial Undercurrent

Nearly 330 feet below the surface in the Pacific lies a cold current. This fast-flowing current travels from west to east expanding across the entire equator from Australia to South America. Thanks to just over two decades of observations, scientists have been able to analyze this data and monitor its progression. Held in place by the combination of the Earth's spin and lack of Coriolis effect along the equator (where it's at its weakest), it drives cold water from deep below upwards toward the surface. As it approaches the Galapagos islands (volcanic islands about 560 miles west of South America), it intensifies dramatically. According to scientists from the University of Colorado Boulder, not only has this strengthening current been getting colder, but it has also expanded.

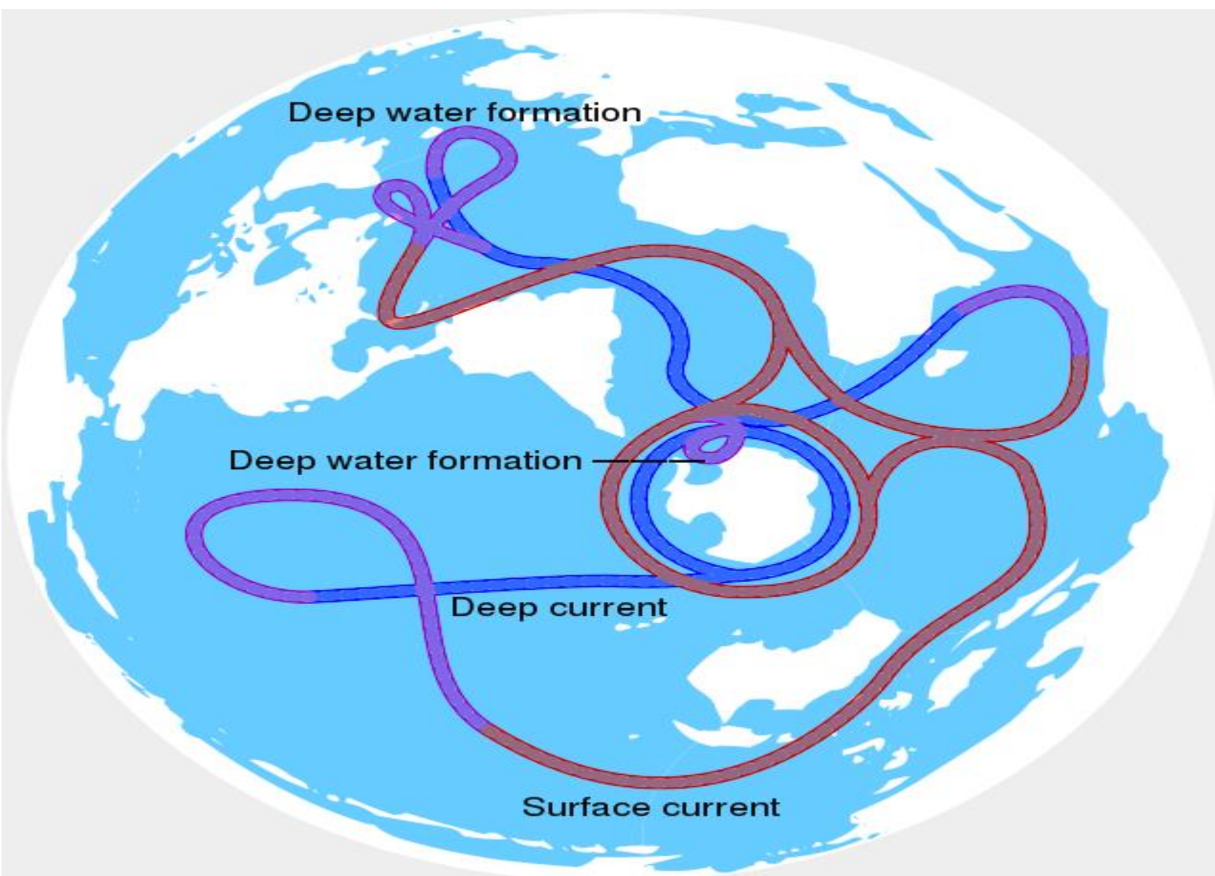
While this has been observed, one can speculate that this likely is a contribution to the evident cooling we've seen. With the helpful graphic below, we can see how this entire system works. Surface trade winds blow from east to west, which if enhanced (i.e., La Nina), this augments evaporation of the water on the surface. As this increases the warm water push to the Western Pacific, eventually that cold water from deep below in the Eastern Pacific upwells creating a positive feedback loop.



Linkage Between The Tropical Pacific & Cold Southern Pacific Around Antarctica

Another cooling trend we've observed are the cold waters surrounding Antarctica and in the Southern Pacific ocean. Research from MIT reveals a few factors that have led this cooling, which includes ozone depletion (stratospheric ozone can modify the ocean's circulation by modifying the winds), sea ice melting, and overall slow warming from below to upwell to the surface.

This is all relevant because now the Antarctic Circumpolar Current – a current that is driven by the unimpeded surface winds that encircles Antarctica flowing from west to east – is connected to the global ocean thermohaline circulation. Another legitimate hypothesis is that this enhanced cooler water surrounding this continent is transported toward south of the Equator, thereby "feeding" this cold patch.

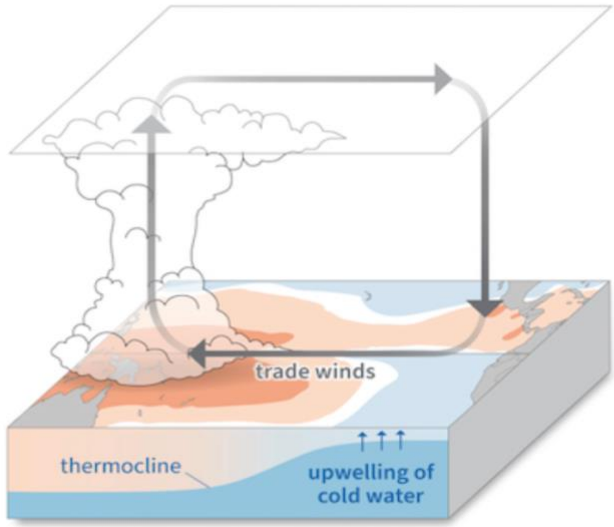


A Trend Toward A More La Nina-Like Pacific

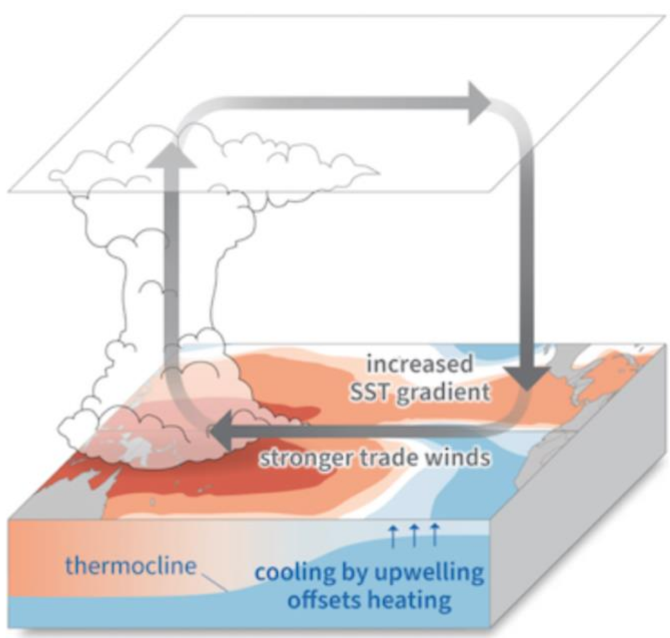
One of the more interesting and prominent hypotheses is the tropical Pacific that has shifted and behaved toward a La Nina background state. During the 21st century, we've seen more La Nina's evolve over the past few decades whereas climate numerical models consistently showed a trend toward an El Nino base state. For example, since 2003 we've had declared officially ten La Nina's to six El Nino's, and we're just coming off a three-year consecutive La Nina event. Though a bit rare, it's not unprecedented since it has happened three other times since 1950.

Diving a bit deeper into this sub-topic, scientists from Columbia University have done a good deal of research and continue to monitor the state of the El Nino-Southern Oscillation. They've revealed that data collected from a combination of ships, satellite, and buoys have supported the Eastern Pacific cooling trend since 1997 (Link).

Let's take a step back and analyze this objectively. A very helpful visual image (credit: climate.gov) below shows the Walker Circulation in its neutral state. Trade winds blow from east to west along and near the equator toward the warm water that surrounds the Maritime Continent and Western Pacific. Air converges there, rises (forms clouds and where we see convection), and then the upper part of the circulation finishes the loop with air parcels flowing west to east before moving vertically downward in the Eastern Pacific. In a La Nina, this circulation is enhanced. When we enter an El Nino state, this circulation is reversed where the sinking air occurs across the Western Pacific and rising air happens in the Eastern Pacific.



Michelle L'Heureux, a physical scientist and climate expert who works for the NOAA Climate Prediction Center, has studied the nature of ENSO and the tropical Pacific. In a paper done with other climate experts and scientists, data has supported the notion that the Walker Circulation has strengthened and accelerated. Below (taken from again climate.gov), shows how in a warming climate, the temperature gradient is theoretically enhanced. This involves net warming (enhances convection) and rising temperatures, which augments persistent upwelling of cold water in the East. In the Western Pacific, the thermocline extends to about 450 feet below the surface. Compare that to only about 50 feet in the Eastern Pacific. Now you understand why it's easier to allow for cold water to be transported to the surface.



While this area of uncertainty continues to be an active area of research, these theories described above help in the very least to explain what could be yielding this tenacious cooling trend. Despite the unrelenting search for answers, this entire domain has climate impacts globally. The tropical Pacific plays a substantial role in administering energy in the form of heat and moisture globally. A change here has a trickle-down effect.

During La Nina's or a sea surface temperature configuration akin to a La Nina, there are correlations such as drier eastern Africa and wetter Sahel; a more flooding-prone eastern Australia from exacerbated rainfall; increase in West Pacific typhoons; increased Atlantic hurricane activity; and a stronger Indian monsoon season. Another significant impact is that the drought across the Southwestern region, especially California, persists since beneficial precipitation remains lackluster (though there can be a few unusual years we see natural variability yield in abundance of precipitation). This is just to name a few climate impacts that La Nina's render (credit: Bob Henson).

As all of this remains a mystery as it continues to bring into the light the uncertainty, scientists are able to gather the data they have now to compare to numerical computer models as we move forward with time. Within a warming climate, you'd have to wonder just how much more cooling can occur and sustain itself in the Eastern Pacific. We'd like to believe nature has a way to balance itself out in the long-term, but uncertainty of it all is what makes this science fascinating.