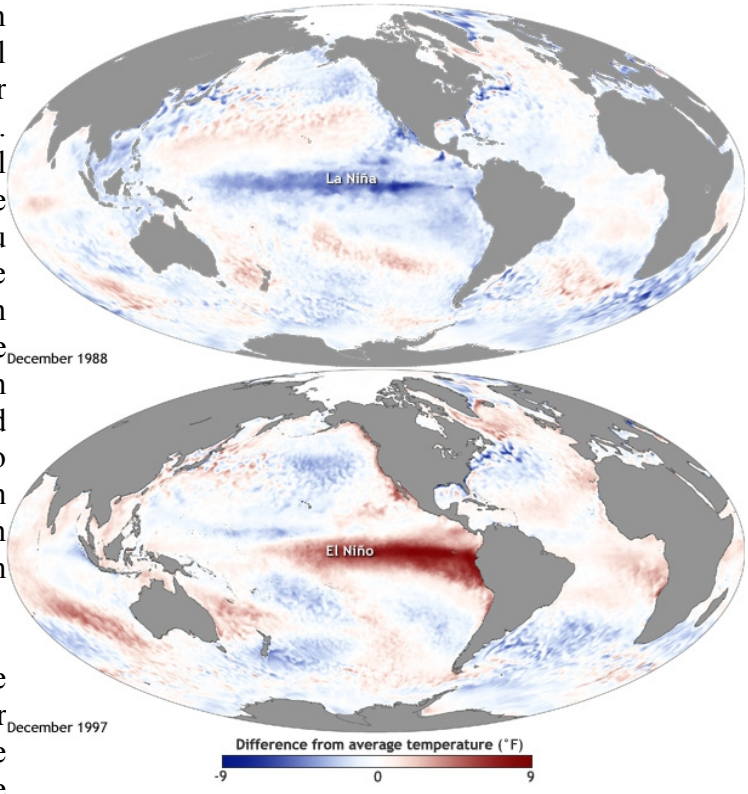
What is the El Niño–Southern Oscillation (ENSO) in a nutshell?



Go to any agency that is focused on weather or climate forecasting and you'll hear scientists buzzing to one another about "ENSO" (pronounced "en-so"). After glancing at the stereotypical scientist, you might immediately assume "En-so" is a Star Wars character, but you would be mistaken. ENSO is one of the most important climate phenomena on Earth due to its ability to change the global atmospheric circulation, which in turn, influences temperature and precipitation across the globe. We also focus on ENSO because we can often predict its arrival many seasons in advance of its strongest impacts on weather and climate.

Though ENSO is a single climate phenomenon, it has three states, or phases, it can be in. The two opposite phases, "El Niño" and "La Niña," require certain changes in both the ocean and the atmosphere because ENSO is a coupled climate phenomenon. "Neutral" is in the middle of the continuum.

El Niño: A warming of the ocean surface, or above-average sea surface temperatures (SST), in the central and eastern tropical Pacific Ocean. Over Indonesia, rainfall tends to become reduced while rainfall increases over the tropical Pacific Ocean. The low-level surface winds, which normally blow from east to west along the equator ("easterly winds"), instead weaken or, in some cases, start blowing the other direction (from west to east or "westerly winds").
La Niña: A cooling of the ocean surface, or below-average sea surface temperatures (SST), in the central and eastern tropical Pacific Ocean. Over Indonesia, rainfall tends to increase while rainfall decreases over the central tropical Pacific Ocean. The normal easterly winds along the equator become even stronger.
Neutral: Neither El Niño or La Niña. Often tropical Pacific SSTs are generally close to average. However, there are some instances when the ocean can look like it is in an El Niño or La Niña state, but the atmosphere is not playing along (or vice versa).

So, by now, you might have noticed that while "ENSO" is a nice catchall acronym for all three states, that acronym doesn't actually have the word La Niña in it. Why is that? Well, that is a fluke of history. Before La Niña was even recognized, South American fisherman noticed the warm up of coastal waters occurred every so often around Christmas. They referred to the warming as "El Niño," (niño being Spanish for a boy child) in connection with the religious holiday.

Sir Gilbert Walker discovered the "Southern Oscillation," or large-scale changes in sea level pressure across Indonesia and the tropical Pacific. However, he did not recognize that it was linked to changes in the Pacific Ocean or El Niño. It wasn't until the late 1960s that Jacob Bjerknes and others realized that the changes in the ocean and the atmosphere were connected and the hybrid term "ENSO" was born. It wasn't until the 1980s or later that the terms La Niña and Neutral gained prominence.

What are El Niño and La Niña?

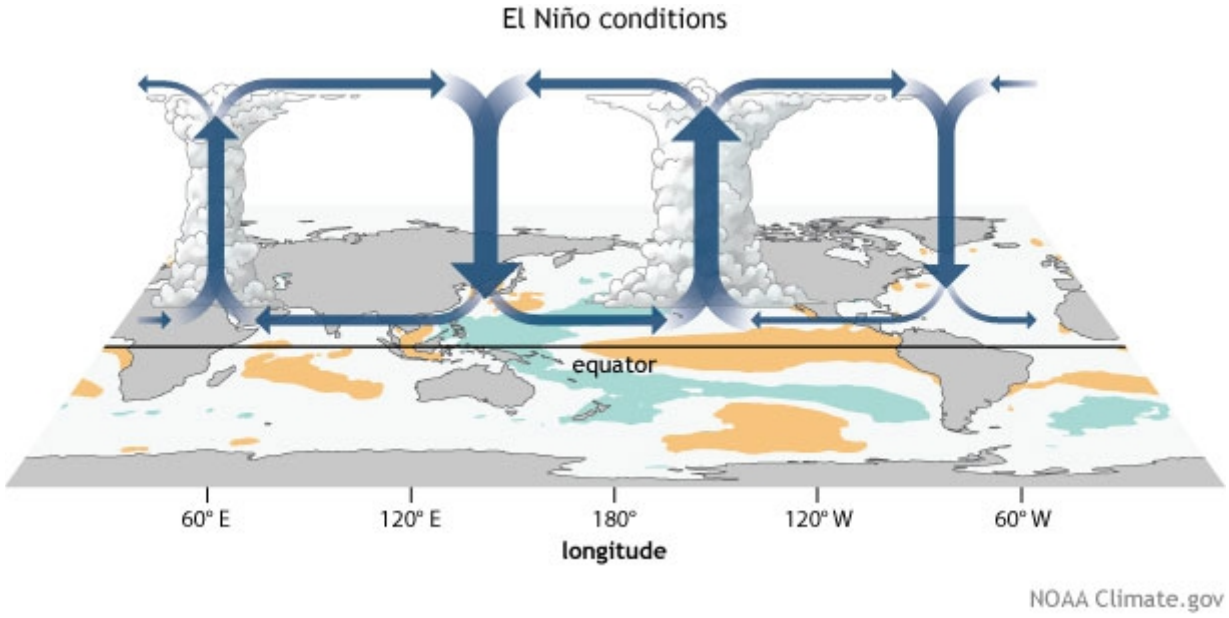
El Niño and La Niña are opposite phases of a natural climate pattern across the tropical Pacific Ocean that swings back and forth every 3-7 years on average. Together, they are called ENSO (pronounced “en-so”), which is short for El Niño-Southern Oscillation.

The ENSO pattern in the tropical Pacific can be in one of three states: El Niño, Neutral, or La Niña. El Niño (the warm phase) and La Niña (the cool phase) lead to significant differences from the average ocean temperatures, winds, surface pressure, and rainfall across parts of the tropical Pacific. Neutral indicates that conditions are near their long-term average.

What happens during El Niño and La Niña?

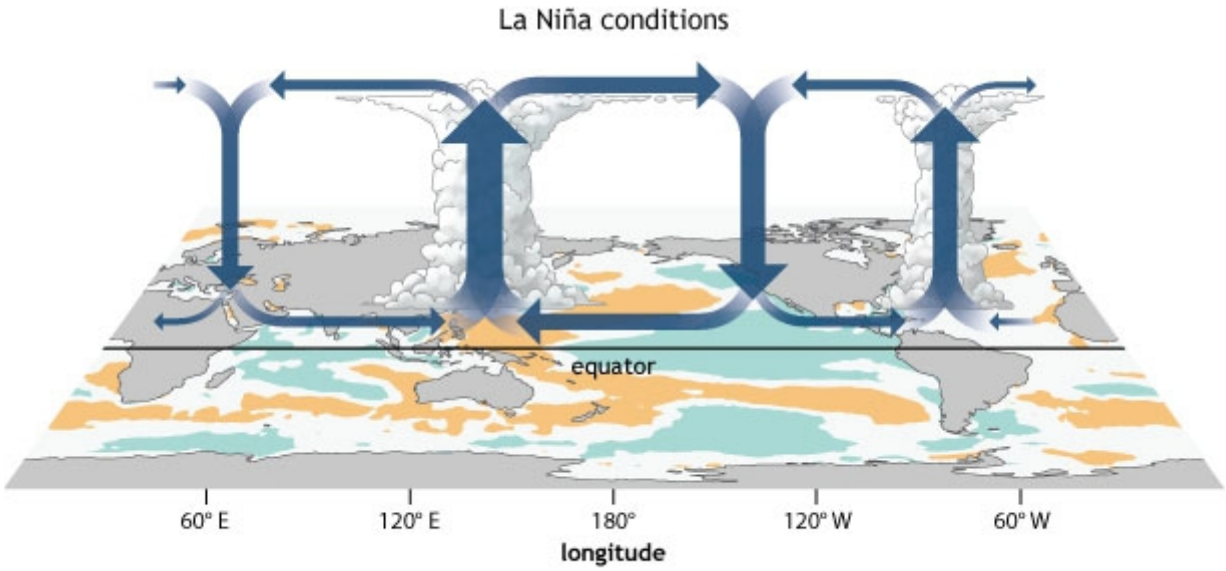
During El Niño, the surface winds across the entire tropical Pacific are weaker than usual. Ocean temperatures in the central and eastern tropical Pacific Ocean are warmer than average, and rainfall is below average over Indonesia and above average over the central or eastern Pacific.

Rising air motion (which is linked to storms and rainfall) increases over the central or eastern Pacific, and surface pressure there tends to be lower than average. Meanwhile, an increase in sinking air motion over Indonesia leads to higher surface pressure and dryness.



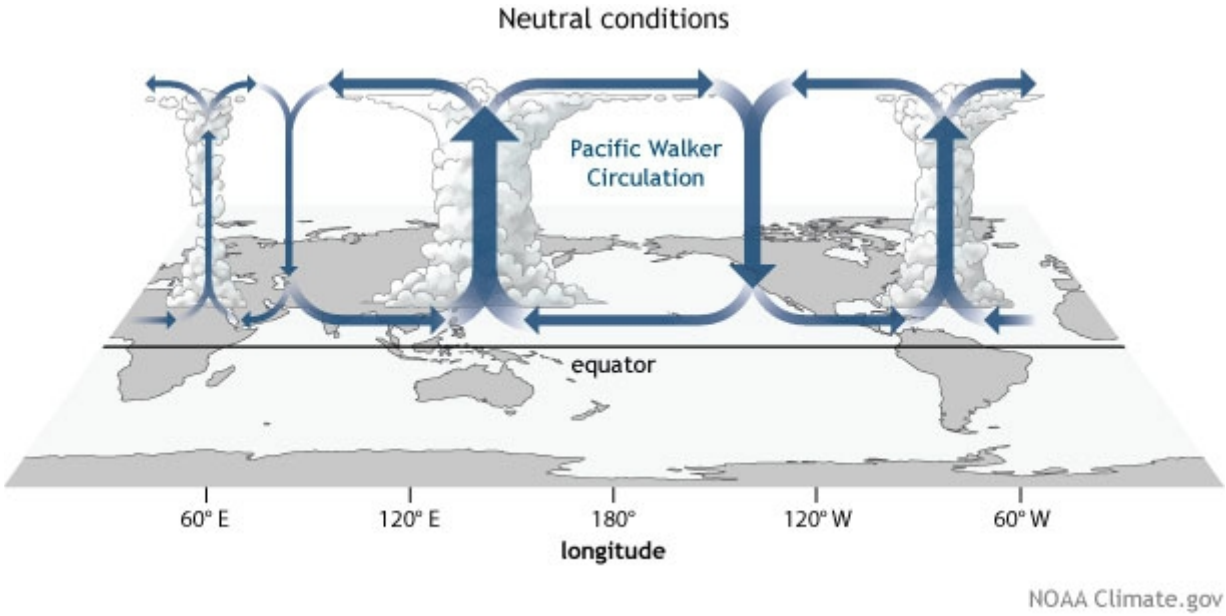
Generalized Walker Circulation (December-February) anomaly during El Niño events, overlaid on map of average sea surface temperature anomalies. Anomalous ocean warming in the central and eastern Pacific (orange) help to shift a rising branch of the Walker Circulation to east of 180°, while sinking branches shift to over the Maritime continent and northern South America.

During La Niña, it’s the opposite. The surface winds across the entire tropical Pacific are stronger than usual, and most of the tropical Pacific Ocean is cooler than average. Rainfall increases over Indonesia (where waters remain warm) and decreases over the central tropical Pacific (which is cool). Over Indonesia, there is more rising air motion and lower surface pressure. There is more sinking air motion over the cooler waters of the central and eastern Pacific.



Generalized Walker Circulation (December-February) anomaly during La Niña events, overlaid on map of average sea surface temperature anomalies. Anomalous ocean cooling (blue-green) in the central and eastern Pacific Ocean and warming over the western Pacific Ocean enhance the rising branch of the Walker circulation over the Maritime Continent and the sinking branch over the eastern Pacific Ocean. Enhanced rising motion is also observed over northern South America, while anomalous sinking motion is found over eastern Africa.

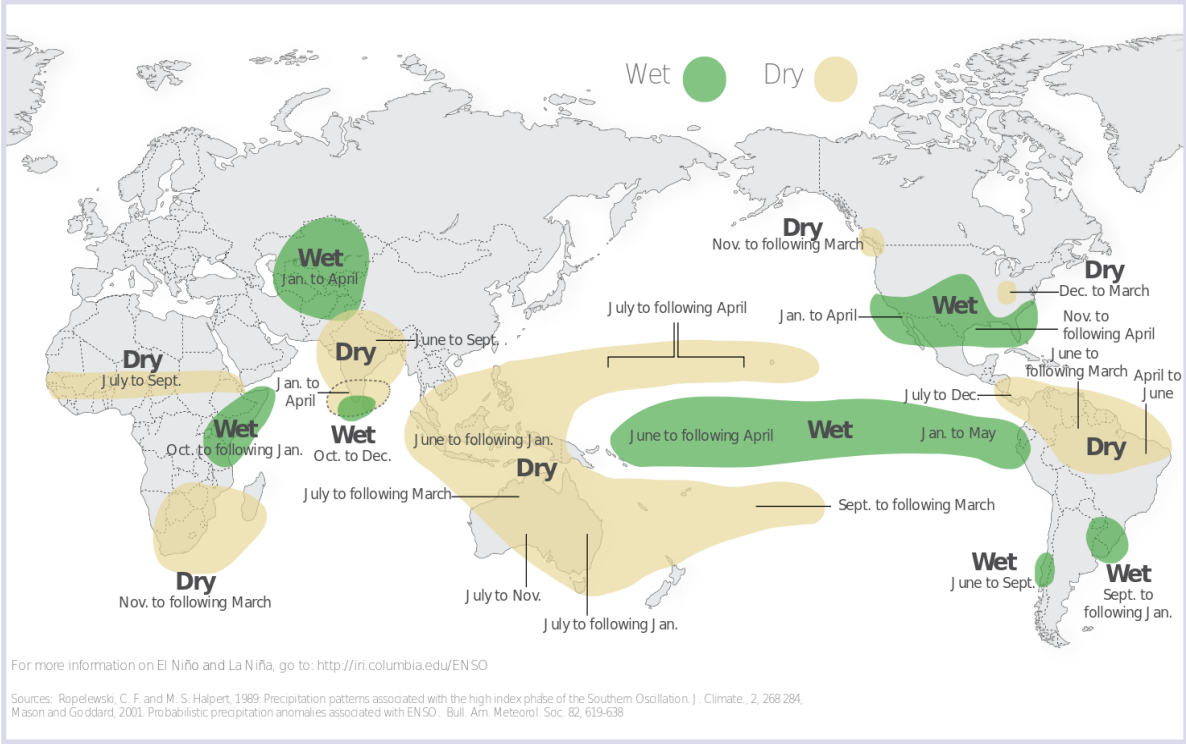
Between the warm phase (El Niño) and cool phase (La Niña), scientists describe conditions as "ENSO-neutral." Neutral means that the temperatures, winds, convection (rising air), and rainfall across the tropical Pacific are near their long-term averages.



Generalized Walker Circulation (December-February) during ENSO-neutral conditions. Convection associated with rising branches of the Walker Circulation is found over the Maritime continent, northern South America, and eastern Africa.

El Niño and Rainfall

El Niño conditions in the tropical Pacific are known to shift rainfall patterns in many different parts of the world. Although they vary somewhat from one El Niño to the next, the strongest shifts remain fairly consistent in the regions and seasons shown on the map below.



For more information on El Niño and La Niña, go to: http://iri.columbia.edu/ENSO

Sources: Ropelewski, C. F. and M. S. Halpert, 1989: Precipitation patterns associated with the high index phase of the Southern Oscillation. J. Climate., 2, 268-284.
Mason and Goddard, 2001: Probabilistic precipitation anomalies associated with ENSO. Bull. Am. Meteorol. Soc. 82, 619-638

What causes El Niño and La Niña to occur?

The winds near the surface in the tropical Pacific usually blow from east to west. For reasons scientists don't yet fully understand, these relatively steady winds sometimes weaken or strengthen for weeks or months in a row.

Weak winds allow warm surface waters to build up in the eastern Pacific. Sometimes, but not always, the atmosphere responds to this warming with increased rising air motion and above-average rainfall in the eastern Pacific. This coordinated change in both ocean temperatures and the atmosphere begins an El Niño event. As the event develops, the warmed waters cause the winds to weaken even further, which can cause the waters to warm even more.

El Niño is often (but not always) followed by La Niña the following year, particularly if the El Niño is strong. During La Niña conditions, the easterly trade winds near the equator get even stronger than they usually are. Stronger winds push surface water into the western Pacific. Meanwhile, cool water from deeper in the ocean rises up in the eastern Pacific. If the cooling persists, it can inhibit rising air movement and rainfall in the eastern Pacific, beginning a La Niña event. As the event develops, the cooled waters cause the winds to strengthen even further, which can cause the waters to cool even more.

How long do El Niño and La Niña typically last?

El Niño and La Niña episodes typically last 9-12 months. They both tend to develop during the spring (March-June), reach peak intensity during the late autumn or winter (November-February), and then weaken during the spring or early summer (March-June).

Both El Niño and La Niña can last more than a year, but it is rare for El Niño events to last longer than a year or so, while it is common for La Niña to last for two years or more. The longest El Nino in the modern record lasted 18 months, while the longest la Niña lasted 33 months. Scientists aren't sure why the duration of the two types of events can be so different.