

## Background: What is El Niño?

The term "El Niño" refers to a series of changes in the normal state of the ocean and atmosphere in the tropical Pacific. We will describe these changes, as well as how they influence weather conditions around the world. First, however, we must understand the normal conditions in the tropical Pacific.

### Normal Conditions in the Tropical Pacific

There are two important physical characteristics of the ocean and atmosphere that work together to determine the climate of the Tropical Pacific:

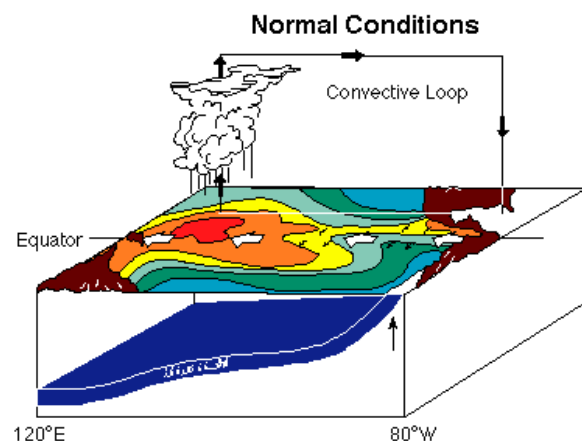
1. In the ocean, the warmest water is found at the surface, and water temperature decreases downward. This occurs because the ocean surface is strongly heated from above by the sun, and warm water is lighter (less dense) than colder water.
2. In the atmosphere, the equatorial regions are dominated by the trade winds. These steady, westward blowing winds are generated by pressure differences caused by solar heating. They are strongest over the oceans, and are disrupted in the vicinity of continents.

The interaction between these atmospheric and oceanic characteristics produces the following "normal" structure:

- The trade winds push surface water from near the coast of South America toward Indonesia. This causes a buildup of warm surface water in the western Pacific, where sea-level is several cm higher than further east.
- To replace the warm surface water carried away by the trade winds, cold subsurface water rises up along the South American coast (this process is called upwelling). Since this cold water contains many nutrients and supports more microscopic sea life (plankton) than warm water, this upwelling process creates a very productive fishing region near the coast of Peru.
- The presence of warm water in the western Pacific destabilizes the atmosphere and fuels the development of thunderstorms. Conversely, the cold water near the South American coast stabilizes the atmosphere and suppresses rainfall. Thus, heavy rain falls near Indonesia, and little rain falls further east.

These conditions are shown schematically in the cross-section of the Pacific Ocean to the right:

In this figure, land areas are shown as brown. Sea surface temperatures are represented by blue and green (colder) and yellow, orange and red (warmer). The white arrows show the trade winds. The cloud symbol shows the area of heavy rainfall, which is located over the warmest water. The black arrows



show how air rises in the area of heavy rain, and sinks over the eastern Pacific. The black arrow under the ocean shows upwelling.

### El Niño Conditions in the Tropical Pacific

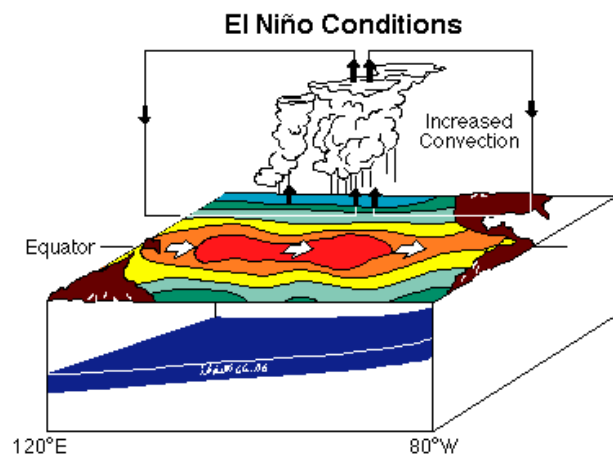
The term "El Niño" was originally used by fisherman along the coast of Peru to describe the periodic appearance, at roughly 2-7 year intervals, of warmer than normal sea surface temperatures. These warm waters typically appear late in the year, near Christmas (hence the term El Niño, which translates to "The Christ Child"), and last several months. Fish become less abundant during these warm spells, as they migrate to colder waters that contain more nutrients. Thus, El Niño disrupts the fishing industry along the South American coast, and for many years El Niño was viewed primarily as a local problem.

More recently, it has become known that the occurrence of El Niño along the Peru Coast is associated with large-scale changes across the Tropical Pacific. In particular,

1. The westward blowing trade winds become weaker than normal. Sometimes, they even reverse direction.
2. The weakened trade winds lead to a decrease in the amount of surface water being pushed westward. Therefore, coastal upwelling near Peru weakens or ceases. This is responsible for the appearance of the warm water that disrupts the fishing industry.
3. The decreased trade winds allow the warm pool in the western Pacific to surge eastward. This causes sea surface temperatures to become much warmer than normal in the central and eastern Pacific, and colder than normal in the western Pacific. Also, sea level rises in the eastern Pacific and falls in the western Pacific.
4. As warm surface water shifts eastward, the region of heavy rainfall shifts with it. This leads to drought conditions in the western Pacific (Indonesia, Australia) and heavy rains further east (including South America).

The conditions during El Niño are summarized in the schematic to the right, which should be compared with the previous figure:

In this figure, land areas are shown as brown. Sea surface temperatures are represented by blue and green (colder) and yellow, orange and red (warmer). The white arrows show the trade winds. The cloud symbol shows the area of heavy rainfall, which is located over the warmest water in the central Pacific (compare the "normal conditions", where the heavy rain is further west). The black arrows show how air rises in the area of heavy rain, and now sinks over the western Pacific.



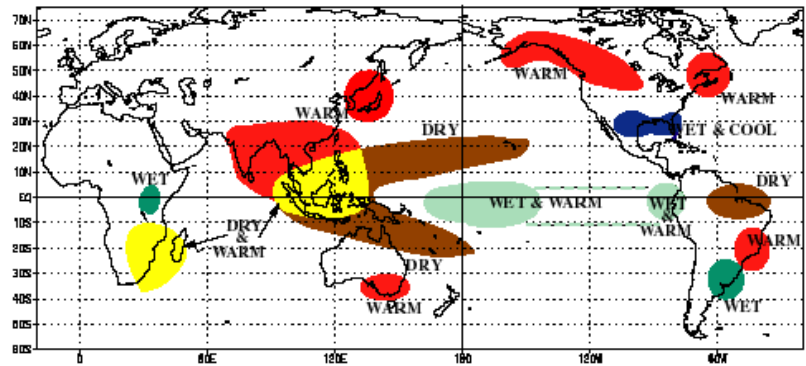
### Global Effects of El Niño

Initially, the primary impacts of El Niño are felt in the tropical Pacific and nearby areas, as described above. However, if the El Niño persists long enough or become strong enough, weather conditions can

be altered on a global scale. The mechanisms that produce these changes are very complicated. However, the large-scale eastward shift of heavy precipitation from the western to the central/eastern Pacific is sufficient to distort global wind-flow patterns (the jet stream) at higher latitudes, which changes the development regions and subsequent paths of storms. Also, the widespread area of warmer than normal sea surface temperature adds heat and moisture to the atmosphere, and these are transported to higher latitudes.

The map shown below was produced by studying the El Niño events during the past 100 years, and averaging the resulting deviations from normal. It represents an "average" El Niño, and can serve as a prediction (hypothesis) for the current event. For example, in the northern hemisphere winter of an El Niño year, the northern United States are typically warmer than normal; while the southern United States are colder and wetter.

**WARM EPISODE RELATIONSHIPS DECEMBER - FEBRUARY**

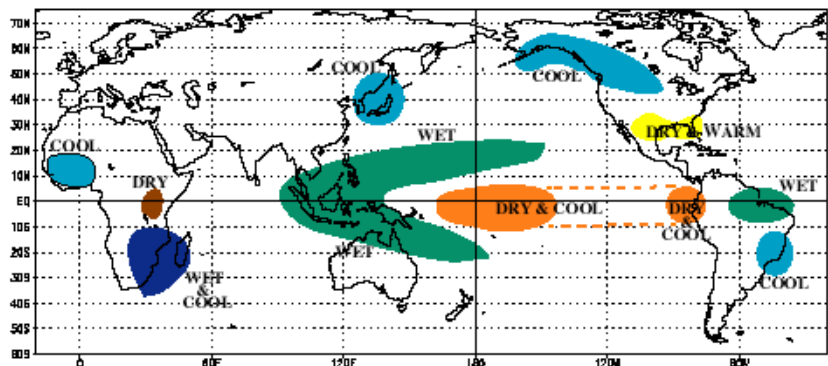


Note, however, that each El Niño event is different. For example, some are short-lived, while others can persist for over a year. Some feature relatively small changes in sea surface temperature, others much larger changes. Also, there are other factors that can influence weather conditions in a region. Therefore, the current El Niño may produce conditions different than those pictured in the above diagram.

**La Niña**

La Niña is essentially the opposite of El Niño, and tends to occur slightly less frequently. During a La Niña event, sea surface temperatures in the eastern Pacific are colder than normal. As might be expected, La Niña also affects global weather patterns, typically causing changes opposite to those experienced during El Niño. The map below shows typical Northern Hemisphere winter conditions observed during past La Niña events:

**COLD EPISODE RELATIONSHIPS DECEMBER - FEBRUARY**



**Questions:**

1. What effects, if any, will the changes in sea-level have on various parts of the Pacific Ocean?
2. It was stated that warm water is lighter than cold water, so the ocean temperature decreases downward. However, when water freezes, the ice forms a layer on top of the water. How is this possible? How is this beneficial to ocean life?