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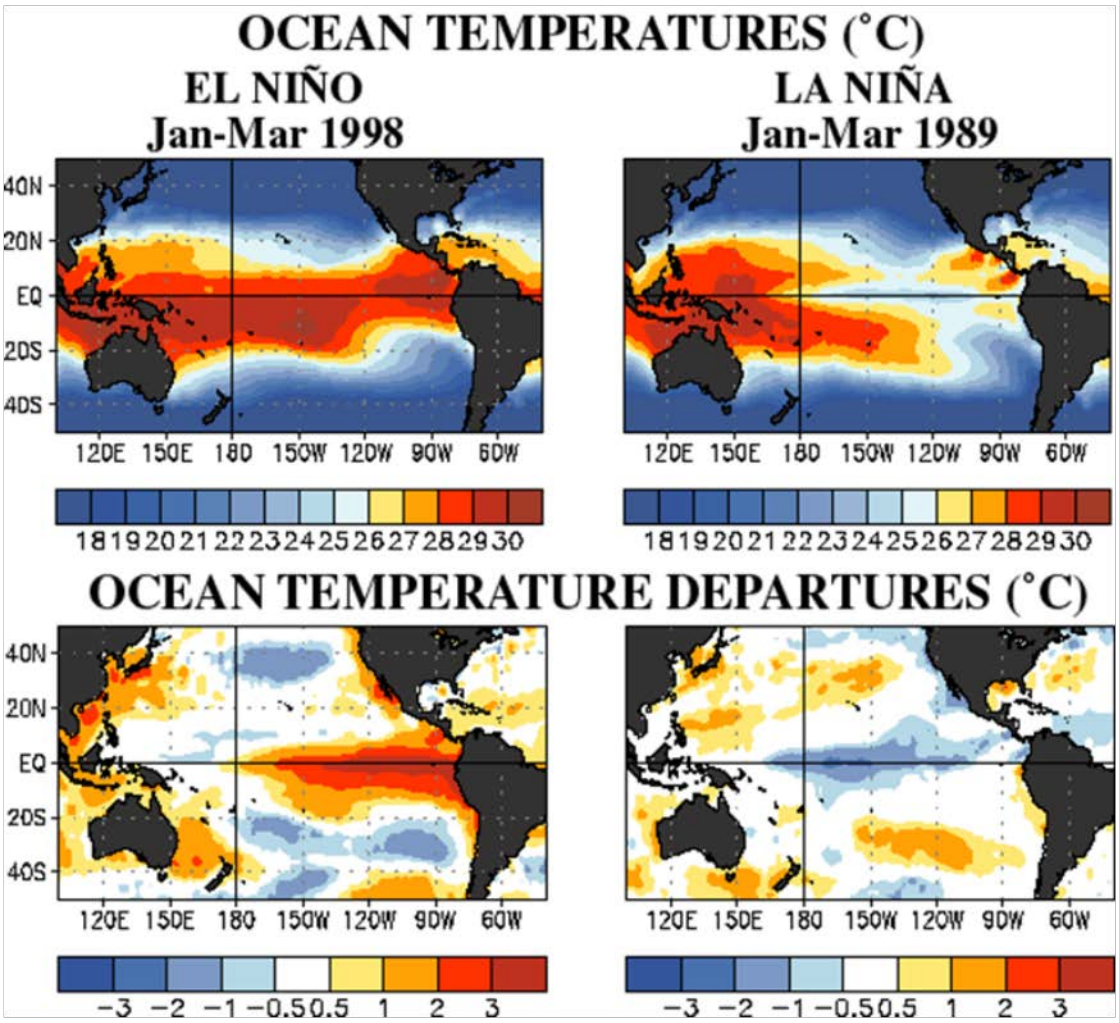
Closer Look: The Pacific El Niño Oscillation

The ocean plays a critical role in determining climate because it is involved in the mixing of heat into the deep ocean layers. The ocean can also alter climate in regions where surface water is strongly coupled with the atmosphere. Ocean currents are primarily driven by forcing functions within the atmosphere including wind stress, solar heating, and moisture fluctuations. In the tropical/equatorial regions, however, the ocean exerts the strongest feedback on the atmosphere due to intense sea surface heat exchanges. Thus, in the tropical regions, the interannual to decadal modes of climate variability are coupled ocean-atmosphere modes. The most famous mode of all is the Pacific El Niño Southern Oscillation (ENSO) that has been extensively studied since the early 1980s. It is important for the climate impacts of ENSO to be well understood in order to avoid confusion with other recent anthropogenic causes of climate change.

ENSO is a natural phenomenon caused by a build-up of either warm ocean water (called the El Niño phase) or cool ocean water (called the La Niña phase) in the eastern Pacific equatorial surface waters (see figure above). Each phase lasts one-two years, followed by a neutral phase, with the onset of the opposite phase completing the oscillation cycle. ENSO greatly impacts



El Niño episodes (left hand column) reflect periods of exceptionally warm sea surface temperatures across the eastern tropical Pacific. La Niña episodes (right hand column) represent periods of below-average sea-surface temperatures across the eastern tropical Pacific. These episodes typically last approximately 9-12 months. Sea-surface temperature (top) and departure (bottom) maps for December - February during strong El Niño and La Niña episodes are shown above.

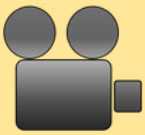
global temperatures and precipitation, and is correlated with the frequency of cyclones.

During the El Niño, a large pool of warm surface water accumulates near western South America extending westward to the mid-Pacific or farther. This

warm pool of water increases evaporation rates providing moisture for increased rainfall in nearby continental areas of North and South America. At the same time, the western Pacific near Australia, Indonesia, India, and parts of African coastal areas are exposed to cold Pacific surface water that reduces evaporation and causes drought.

La Niña periods are the opposite of El Niño; characterized by a cold pool of up-welling nutrient-rich water near South America that stimulates algal blooms attracting large populations of sardines and anchovies, forming the largest fisheries in the world. However, La Niña also causes drought in the western United States, Mexico, and parts of South America, while its warm western component encourages heavy rains and flooding in eastern Australia, Indonesia, Southeast Asia, India, and parts of Africa. La Niña also produces a large high pressure ridge off of California, which may disrupt and block Pacific storms from producing rains in the Sierra Madres of eastern California, which is critical to the buildup of the snow pack that provides 30% of California's water supply for irrigation and people's needs. In 2013-14, a weak snow pack resulted in serious water shortages for agricultural activity and household water shortages.

The degree of impact of drought during a La Niña may be amplified by anthropogenic activities such as that which occurred in the southern plains of the United States in the 1930s. Considered the largest environmental disaster in U.S. history, the intensity of the Dust Bowl drought was amplified by poor farming practices that left plowed soil exposed to winds, which picked up the soil and produced huge dust clouds that rolled across the plains, causing enormous damage.



View a video about the Dust Bowl by Ken Burns.

ENSO is extremely important for the maintenance of regional climates worldwide, and itself appears to be seriously altered by climate change.