

## *EL NIÑO - SOUTHERN OSCILLATION*

El Niño (The Christ Child) is named for the unusual warm current of water flowing south near the coast of Peru whose onset is often felt near Christmas. This mostly regular event has a great effect on the Peruvian anchovy industry, at one time, one of the most productive fisheries in the world. When cold-water upwelling stops reducing the amount of nutrients in the surface waters off the South American coast, there is an associated decline in the fishing. Additionally, El Niño occurs in association with the Southern Oscillation, a shift in the equatorial weather and air flow pattern over the Pacific Ocean. The El Niño - Southern Oscillation, or hereafter referred to as ENSO, results in major global weather changes.

### *Helpful ENSO Links*

This page is a must!

<http://www.cdc.noaa.gov/ENSO/>

This page should be printed out.

<http://www.ucar.edu/communications/factsheets/elnino/>

Ditto with this!

<http://www.pmel.noaa.gov/tao/elnino/nino-home.html>

Current El- Niño status and forecasts.

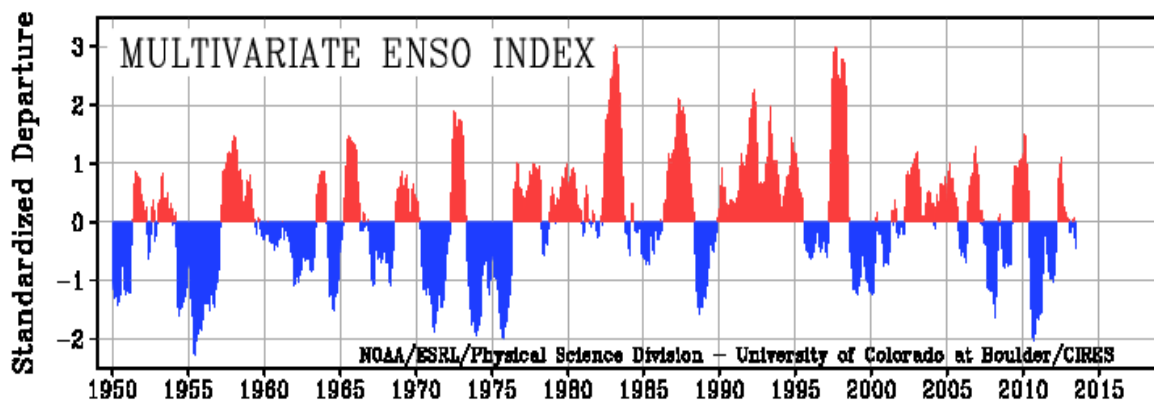
[http://www.cpc.ncep.noaa.gov/products/analysis\\_monitoring/lanina/](http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/)

Another one for you.

<http://www.elnino.noaa.gov/>

You want a great resource to help you understand what we talk about in class?

<http://www.bom.gov.au/climate/glossary/elnino/elnino.shtml>



Using various methods of determining the occurrence and strength of an El Niño or its counterpart La Niña (referring to cold SST anomalies in the Pacific), the Multivariate ENSO Index shows the history of warm and cold episodes.

### *The Canonical ENSO Event*

(Canonical - Conforming to orthodox or well-established rules or patterns. (From dictionary.com))

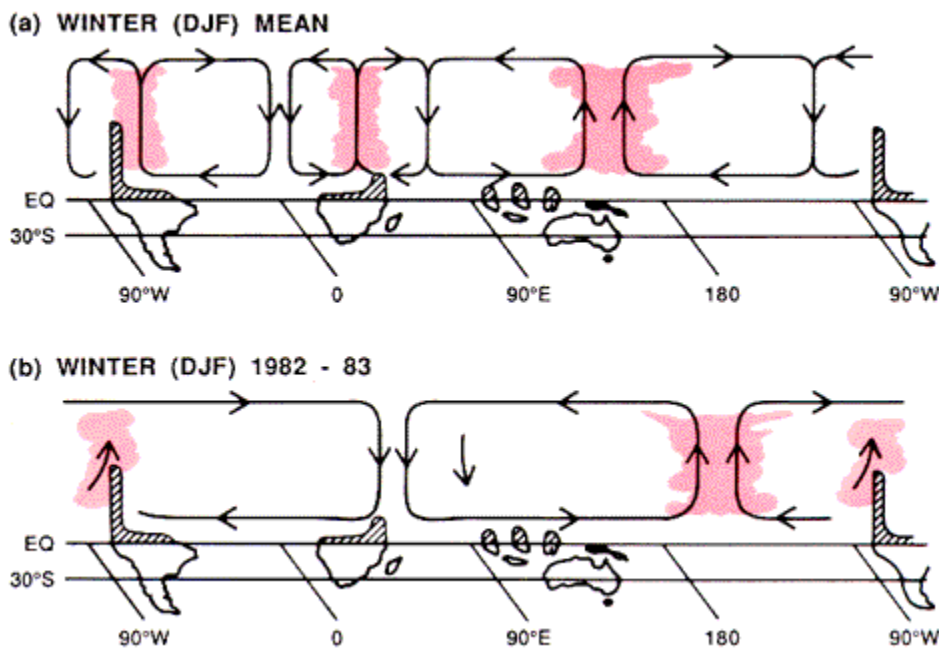
Water near Peru is typically cool due to the north flowing (flowing toward the equator) Peru Current. Surface water is driven off-shore allowing cold water upwelling. In December, the cold water is replaced by warmer water from the equator until spring.

Main ENSO events may last upwards of a year. The 1982-83 ENSO saw SST's more than 7°C warmer than normal with similar anomalies in 1998-99.

See [http://www.cdc.noaa.gov/map/clim/sst\\_olr/el\\_nino\\_anim.shtml](http://www.cdc.noaa.gov/map/clim/sst_olr/el_nino_anim.shtml)

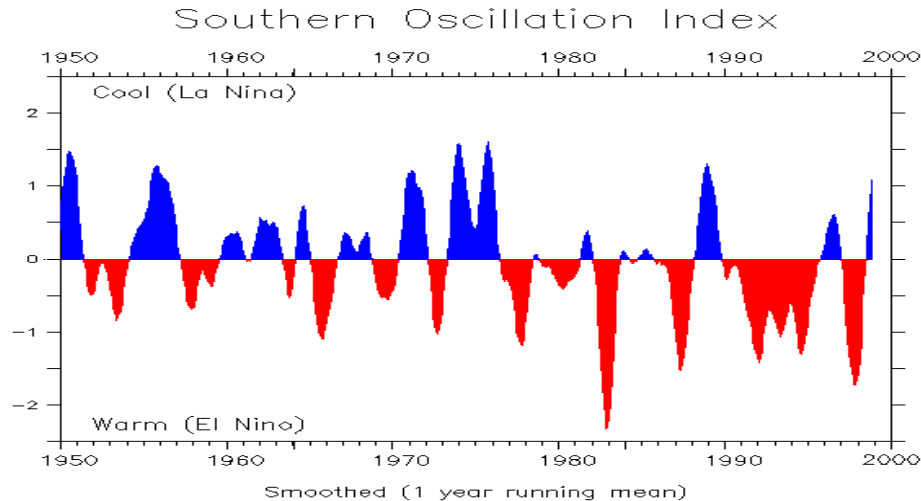
The Walker Cell is an east to west and thermally direct circulation in the Pacific. The Southern Oscillation is defined as a "seesaw" in the surface pressure in the South Pacific. Generally over Indonesia and Australia, the pressure is lower than the pressure at Easter Island giving rise to an easterly wind. A reversal in the pressure gives rise to westerlies in the Pacific equatorial zones. The causes for this reversal are not well understood.

More specifically, the Southern Oscillation is a coherent pattern of pressure, temperature, and rainfall fluctuations of which the primary manifestation is a "see-saw" in atmospheric pressure between the southeastern Pacific subtropical high and the region of low pressure stretching across the Indian Ocean from Africa to northern Australia.



Schematic of the Walker Circulation based on computations of upper and lower tropospheric divergent winds. (a) Winter (DJF) mean east-west overturning Walker Circulation. (b) ENSO Winter 1982-83 pattern. Note the shift of the ascending branch to the east of the date line and suppressed convection (subsidence) over the rest of the tropics. (From *The Global Climate System: A Critical Review During 1982-1984*, World Climate Data Programme, WMO, Geneva, Switzerland, 1984.)

The strength of the wind patterns in the Walker Cell can be quantified by the Southern Oscillation Index. This basically relates the pressure differences between Tahiti and Darwin, Australia. Negative numbers indicate lower pressure in Tahiti and higher pressures in Australia.



As warm water piles up in the western Pacific, the **thermocline**, the transition zone between the warm surface water and the colder deep waters, is depressed. In the ENSO year, the trade winds subside which allows for the water to traverse the ocean eastward.

The warm water travels eastward in sub-surface waves known as **Kelvin** waves. Each Kelvin wave takes about three months to cross the Pacific. (For a slightly advanced look at oceanic waves, see <http://iri.columbia.edu/climate/ENSO/theory/waves.html>) The amplitude of the Kelvin waves indicates the magnitude of changes along South American coast. Kelvin waves generate anomalous eastward currents and lower the South American coastal thermocline. Both lead to increased sea surface temperatures.

The heating in the eastern Pacific creates changes in the central Pacific circulation creating an upwelling, which in turn give rise to westward propagating Rossby waves. Rossby waves travel even slower than Kelvin waves traversing the Pacific in a year. See <http://www.soc.soton.ac.uk/JRD/SAT/Rosby/Rosbyintro.html>

The arrival of the Rossby waves near the Asian and Australian continents is marked by a reflection of a second burst of Kelvin waves. The arrival of these waves allows cold water to be upwelled, easterly winds are re-established signaling and end in the El Niño cycle. SST anomalies decrease and by the following spring, the system is back to normal.

1982 was one of the most severe ENSO's. Disastrous floods struck the Pacific coast of the Americas, droughts in Australia and the Sahel ravaged millions, and numerous hurricanes struck French Polynesia. This ENSO event was not truly canonical. See [http://www.cdc.noaa.gov/map/clim/sst\\_olr/old\\_sst/sst\\_8283\\_anim.shtml](http://www.cdc.noaa.gov/map/clim/sst_olr/old_sst/sst_8283_anim.shtml) and notice that warm waters occurred more in the central Pacific first rather than along the South

American coast as in another significant event as shown in this animation:

[http://www.cdc.noaa.gov/map/clim/sst\\_olr/old\\_sst/sst\\_9798\\_anim.shtml](http://www.cdc.noaa.gov/map/clim/sst_olr/old_sst/sst_9798_anim.shtml) .

Because of the shift of heavy rains to the eastern Pacific, large amounts of latent heat released in thunderstorms should warm the upper troposphere. An upper-level equatorial wind generated through the Hadley cell will transport warm air toward the mid-latitudes. This increase in heat will transfer energy to the jet stream.

Infrared satellite can be used to identify effects of ENSO events in terms of precipitation patterns. Negative anomalies in the OLR (outgoing longwave radiation) indicate enhanced convective precipitation. See [http://www.cdc.noaa.gov/map/clim/sst\\_olr/sst\\_olr\\_anim.shtml](http://www.cdc.noaa.gov/map/clim/sst_olr/sst_olr_anim.shtml)

In some areas of the globe such as Indonesia and Australia there is a great deal of relationship between ENSO events and sensible weather. In other areas, such as the United States, there are weaker discernible correlations between the ENSO event itself and actual climate changes.

There is *no direct* correlation between an ENSO event and any specific weather event, despite what you may hear on popular media. To look at apparent correlations between warm and cold episodes and observed temperature and precipitation in the US, see

<http://www.cpc.ncep.noaa.gov/products/predictions/threats2/ens0/elniño/index.shtml>.

During an El Niño, a much stronger than normal sub-tropical jet extends across the Pacific Ocean and across the southern continental US (CONUS). This subtropical jet initiates weather systems across the southern tier of states bringing with it tropical moisture. As a result rainfall is more plentiful in southern California, especially when the El Niño is very strong (*i.e.* high SST anomalies). Wetter than normal conditions also are likely across the Gulf Coast into Florida. Increased west winds associated with the subtropical jet inhibit the development of tropical storms in the Atlantic Ocean typical by enhancing shear profiles in that region of the tropics. Tropical storms that do form tend to curve to the north before reaching the mainland.

The polar jet is also stronger than normal resulting from a warm mid-troposphere in the central to eastern Pacific. The latent heating causes positive height anomalies in the Pacific (ridge) which teleconnects to somewhat persistent troughing further to the east. The extent of the troughiness across the CONUS is less well-correlated due to factors in the northern Atlantic. If the ridge extends to the Pacific Northwest, drier conditions may result. Across the rest of the U.S., the jet stream is stronger than normal, but generally zonal (west-to-east) and often variable.

The strong zonal polar jet keeps the coldest air in place over Canada most of the time which may result in temperatures across the northern Plains and the Great Lakes to be warmer than normal. These warm conditions often extend into the Northeast, although not always (as in the winter of 2003). Cold air which remains in Canada often builds, becoming even colder than usual. If this air is brought southward in transitory waves, cold outbreaks can still be significant in the CONUS. The strong polar jet usually contains frequent storms but relatively weak. The strong subtropical jet prevents a northward surge of the warmest and most moist air in place across the Gulf Coast states. However, a few times during the winter the two strong jets merge (or phase). This typically results in the development of major winter storms. This all means that El Niño winters can still produce significant winter weather events just like non-El Niño winters.