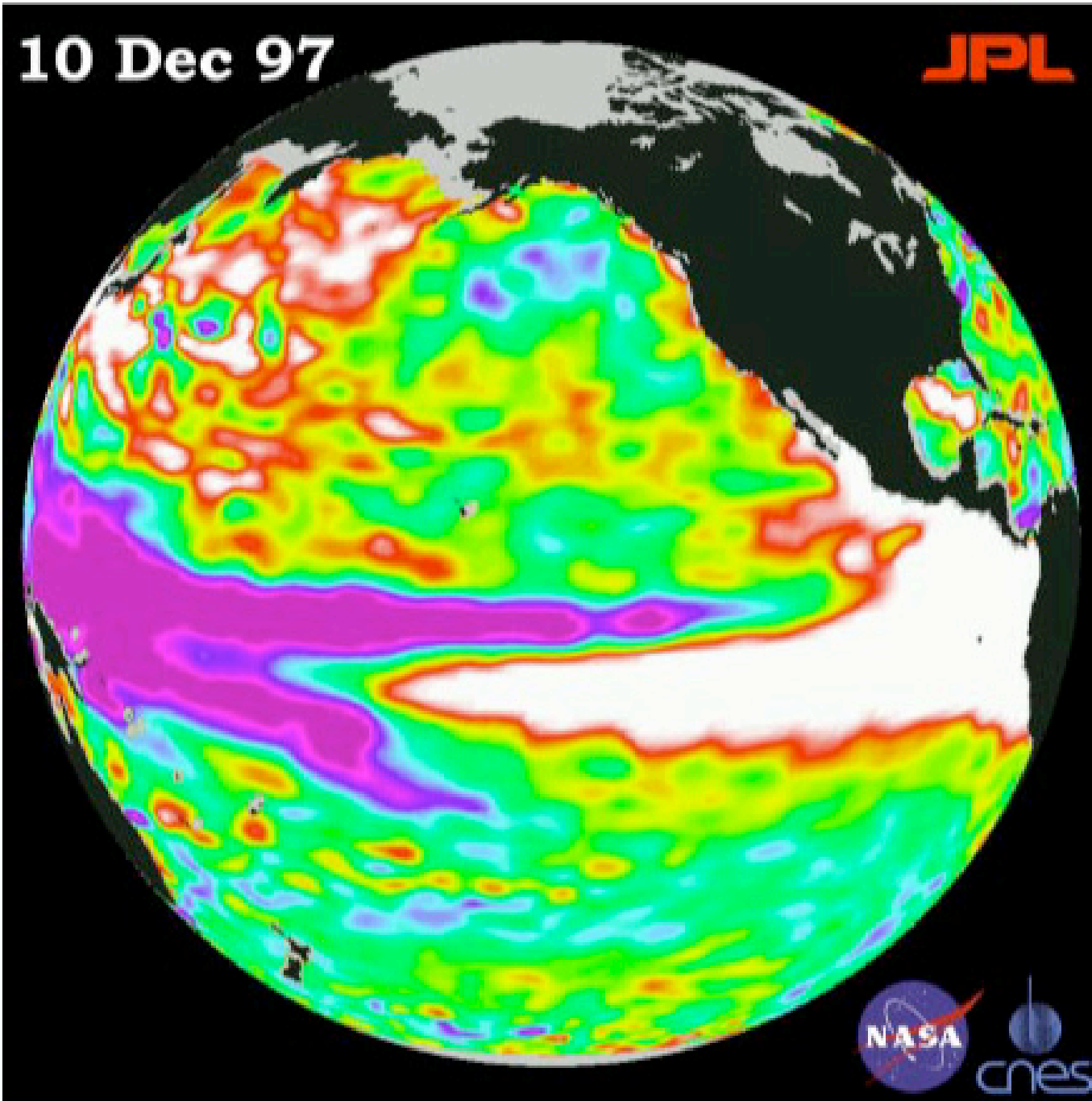


10 Dec 97

JPL



lecture 9

## ENSO and Climate Variability

# **Internal Climate Variability**

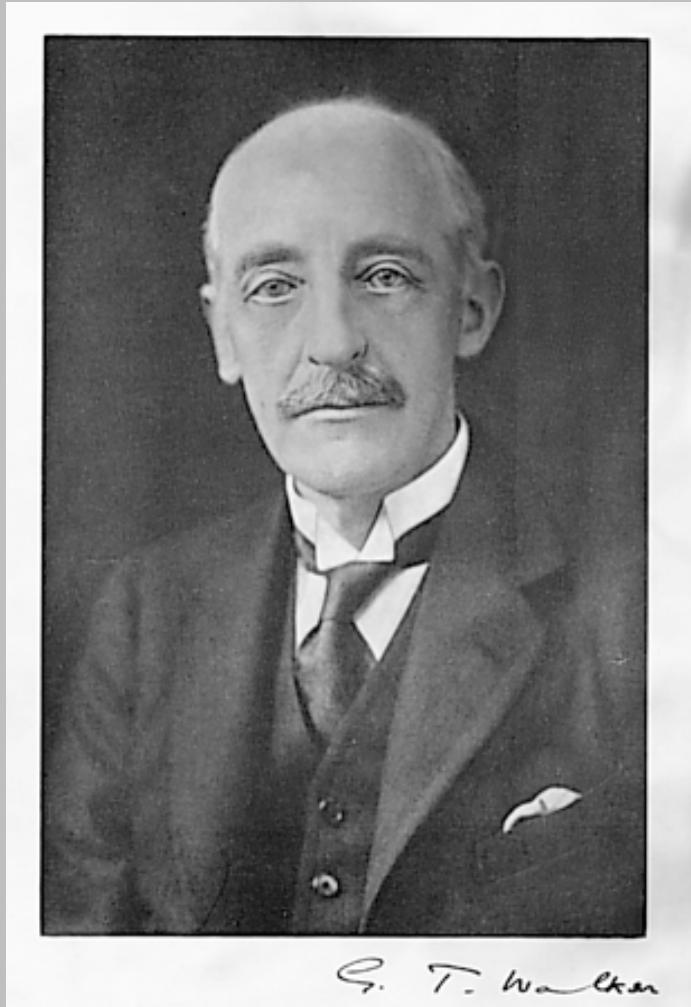
## **Some key concepts to review:**

**Recall that high pressure is associated with cold temperatures and sinking motion. The sinking motion occurs because surface air moves away from the high pressure center under the influence of gravity, and draws down air from above.**

**Conversely, low pressure is associated with warm temperatures and rising motion. The rising motion occurs because surface air converges on an area of low pressure under the influence of gravity, forcing rising motion over the low.**

**What kind of hydrologic conditions are associated with a high and low?**

**Recall also that the predominant wind direction at the equator is...**

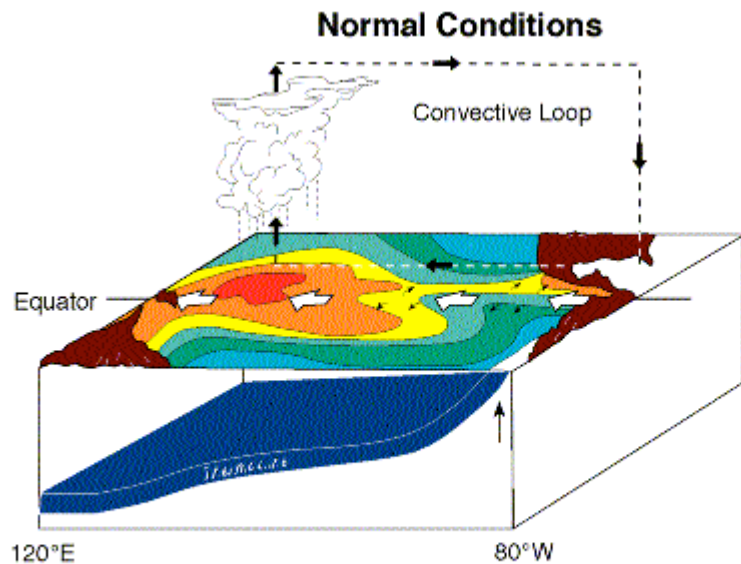


In 1899, the Indian monsoon failed, leading to drought and famine in India. This led **Gilbert Walker**, the head of the Indian Meteorological Service, to search for a way to predict the Indian monsoon. By the early 20th century, he had identified a peculiar see-saw relationship between pressure over the maritime continent and India and the Pacific near South America. When pressure is high over the eastern Pacific, it is low over the maritime continent, and vice versa. He called this relationship the **Southern Oscillation**.

**Since the 1800s, Peruvian fisherman noticed that their harvest completely failed every few years. This periodic event was associated with unusually warm waters off the coast of Peru. These warm waters resulted from a shutdown of the upwelling circulation normally found along the equator. Since upwelling supplies nutrients to the surface waters, this resulted in mass starvation of plant and animal life in the eastern equatorial Pacific. Since the periodic warming almost always occurred around December, the fisherman named it El Niño, in reference to the Christ child.**

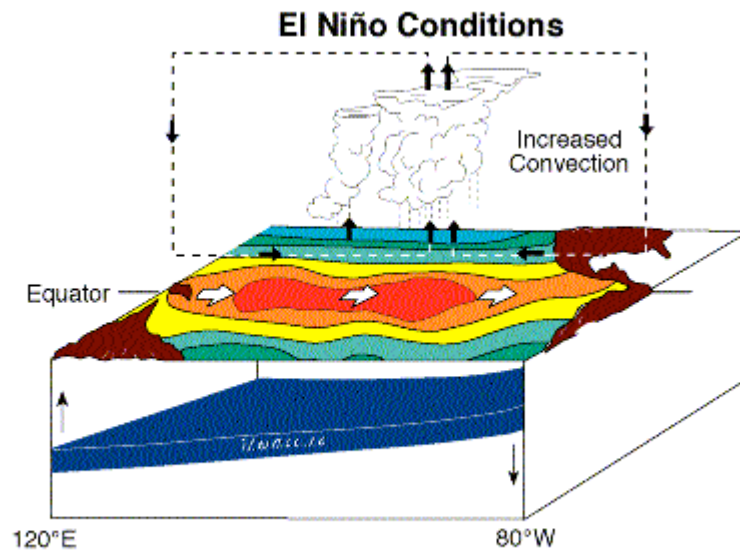


In 1969, **UCLA professor Jacob Bjerknes** was the first to recognize that El Niño and the Southern Oscillation are actually manifestations of the same physical phenomenon and that it results from an unstable interaction between the atmosphere and the ocean. This resulted in the term **ENSO** to refer to this phenomenon.



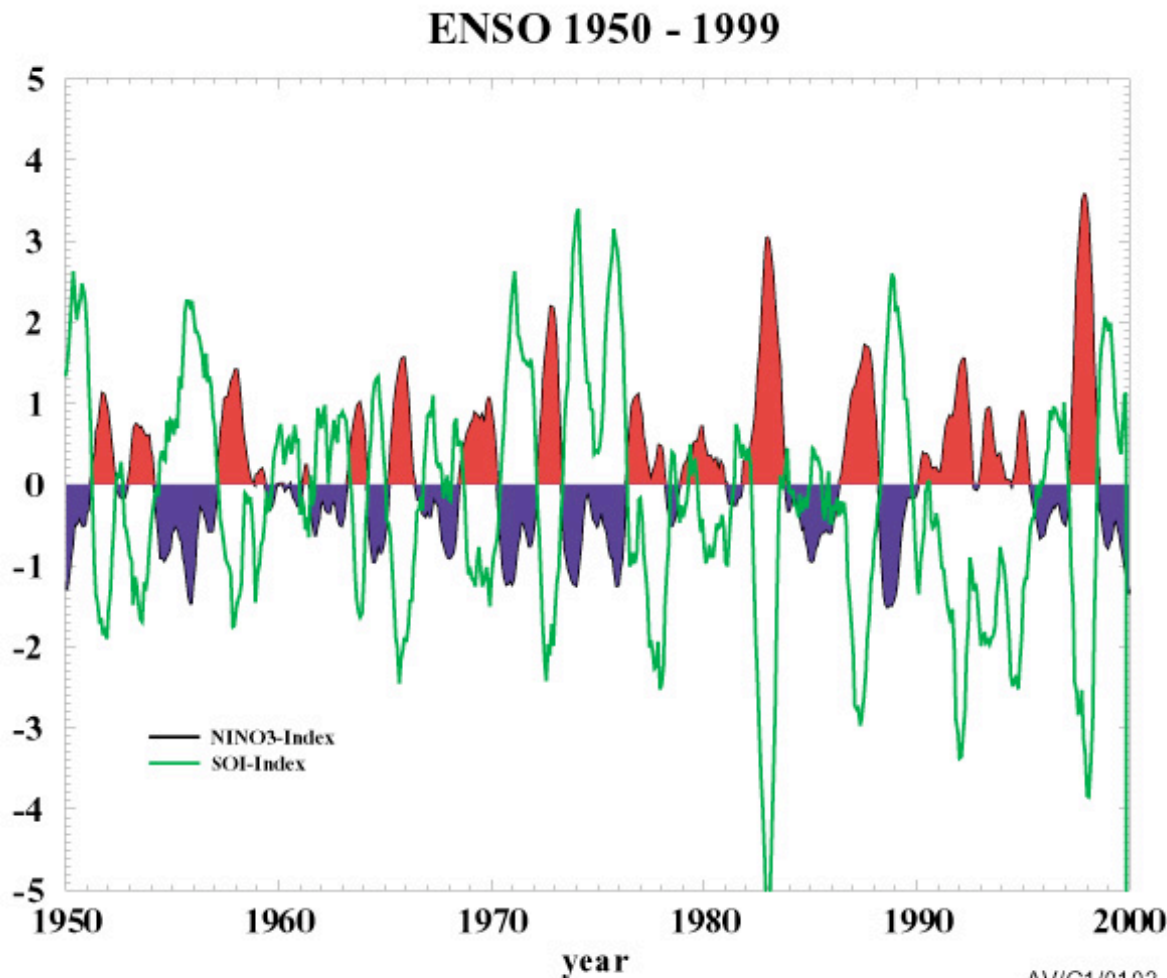
## How are atmosphere and oceanic conditions related during an El Niño?

Under “normal” conditions, often referred to by the term La Niña, the easterly trade winds blow across the Pacific, generating upwelling along the equator across most the Pacific, and piling up warm water in the west. The east-west contrast in sea surface temperature sets up low pressure and rising motion in the west, and high pressure and sinking motion in the east.



When an El Niño occurs, the trade winds collapse, upwelling of cold water ceases along the equator, and sea surface temperatures rise in the central and eastern equatorial Pacific. Pressure decreases in these regions, and rising motion leads to precipitation.

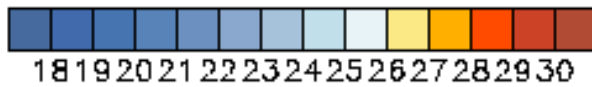
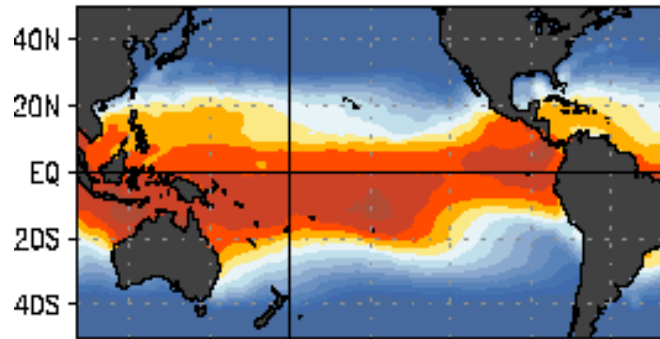
If you look at sea surface temperature in the central equatorial Pacific and the difference in pressure between Tahiti and Darwin, you see a very clear anti-correlation. Both of these are indices for the ENSO phenomenon. The red portions are El Niño years, while the blue portions are La Niña years.



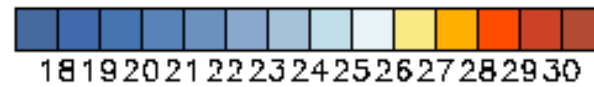
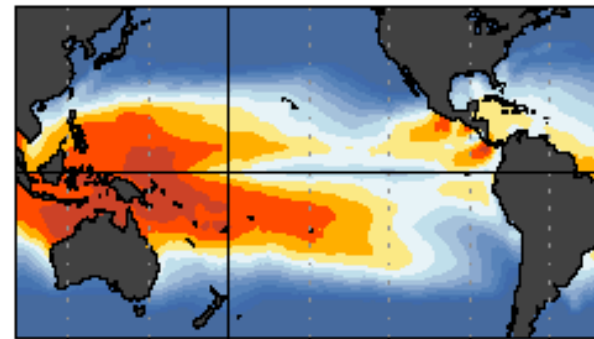
Note the typical time scale of the ENSO phenomenon.

# OCEAN TEMPERATURES (°C)

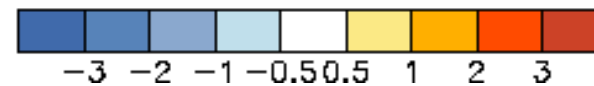
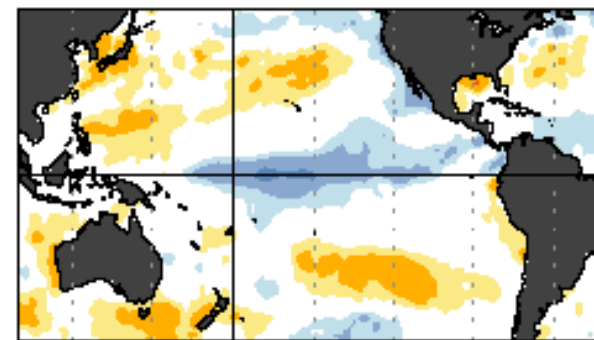
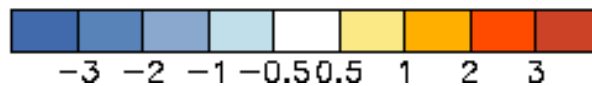
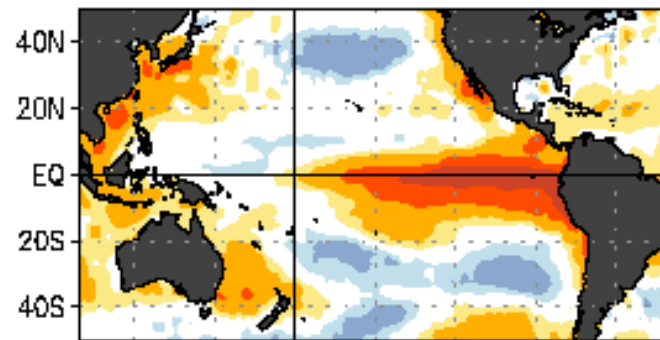
## EL NIÑO Jan-Mar 1998



## LA NIÑA Jan-Mar 1989



# OCEAN TEMPERATURE DEPARTURES (°C)

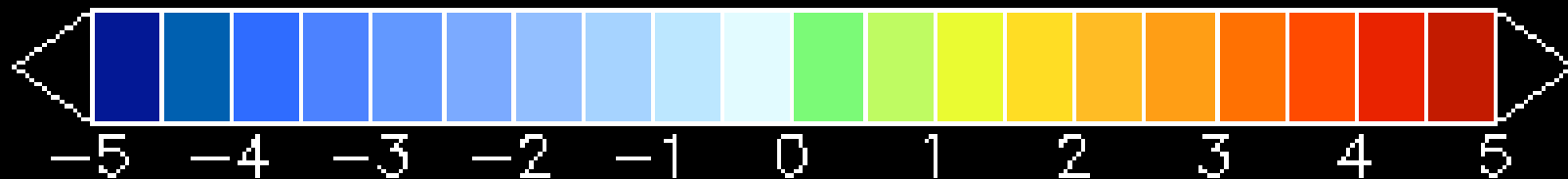
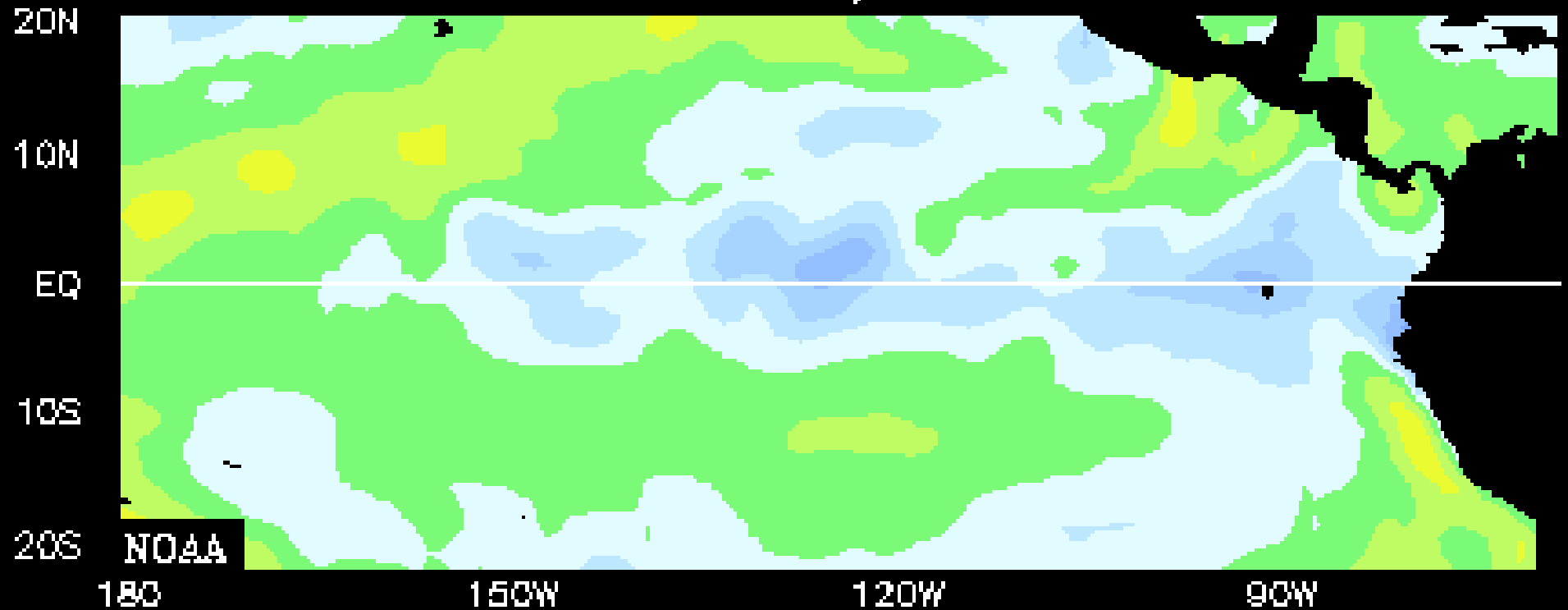




# Animation of the 1997-98 ENSO event

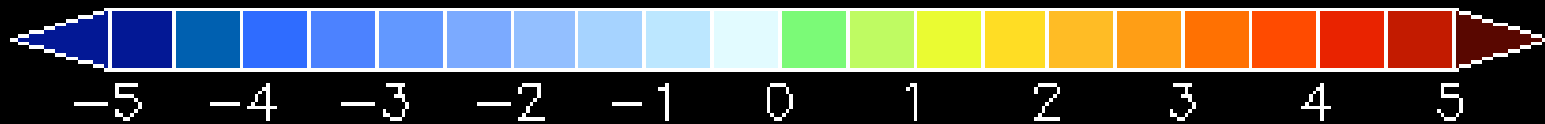
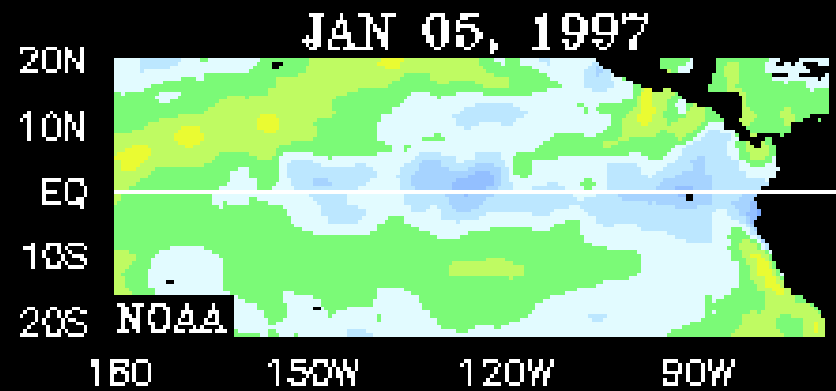
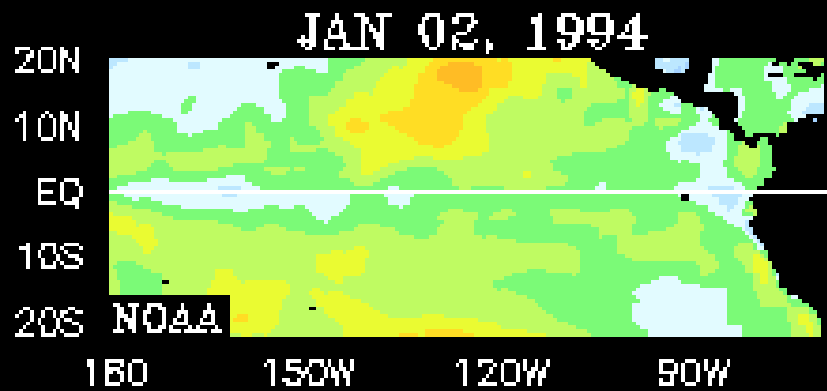
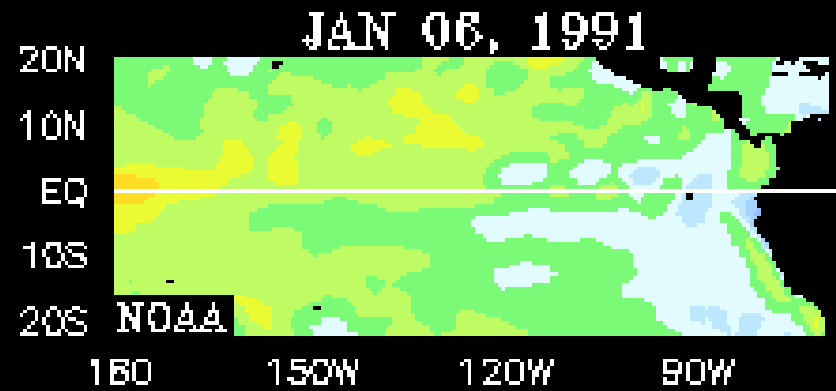
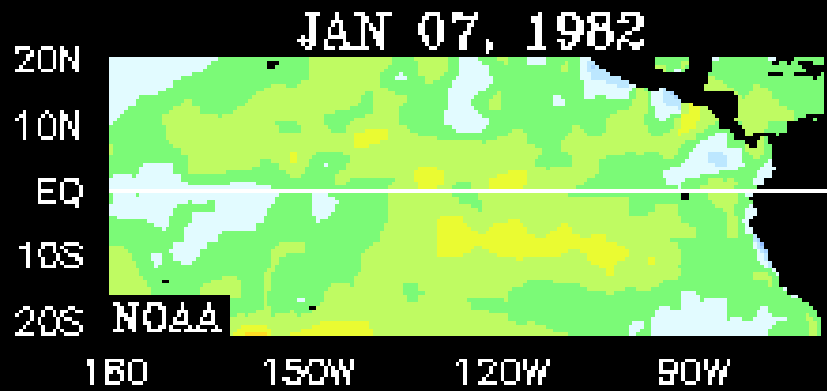
SST ANOMALIES °C

JAN 05, 1997



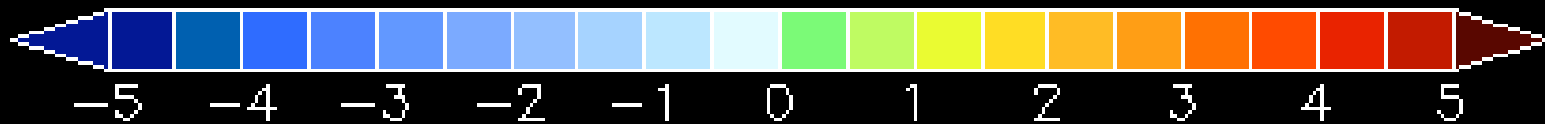
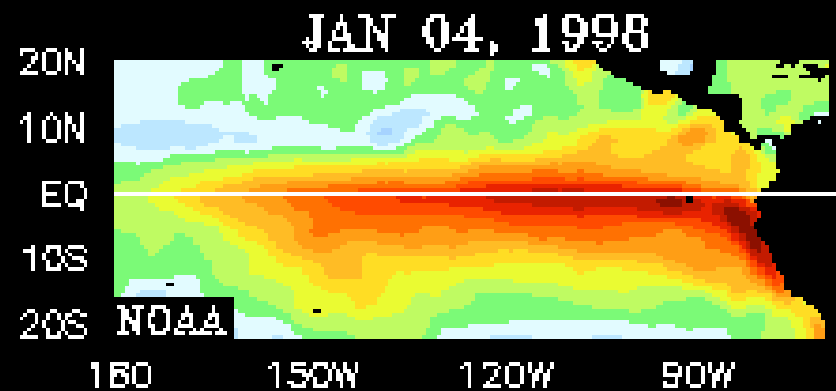
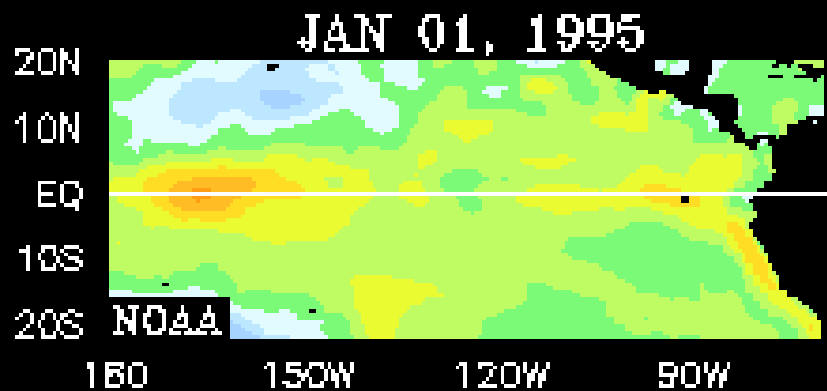
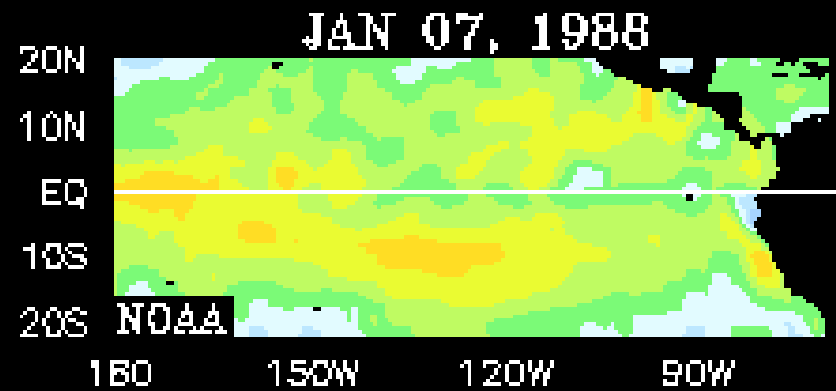
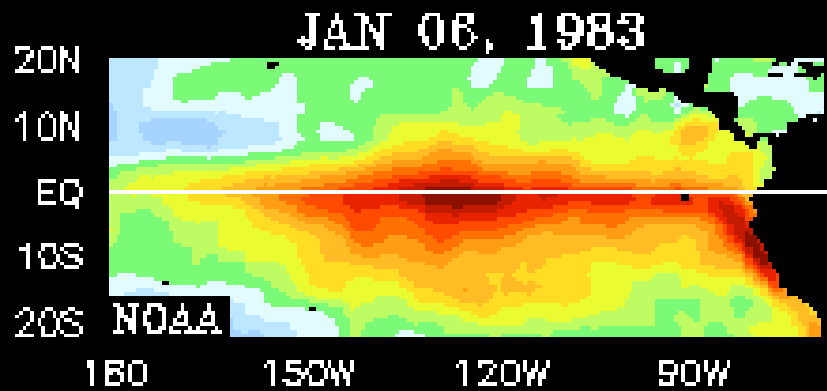
# Animation of 4 El Niño events

SST ANOMALIES °C



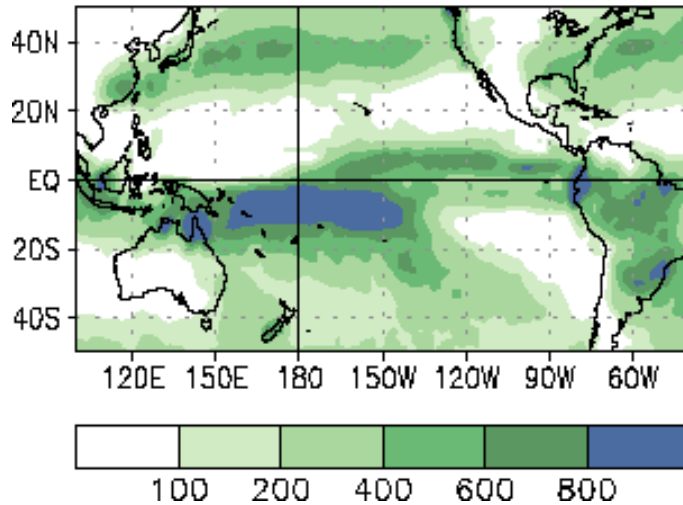
# Animation of 4 La Niña events

SST ANOMALIES °C

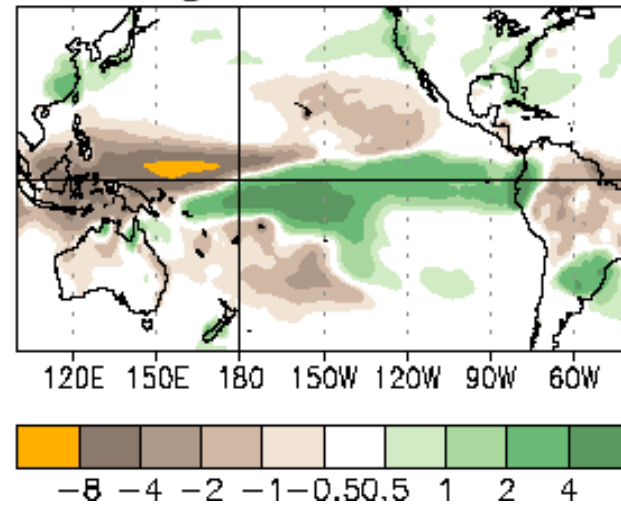


# Jan-Mar 1998 Precipitation (mm)

## Total

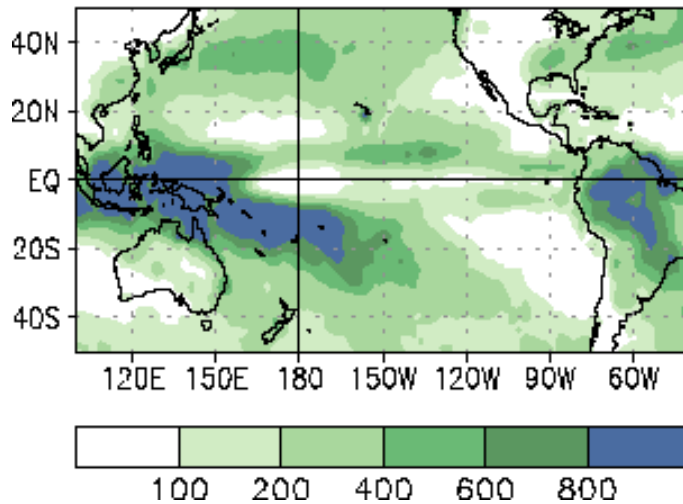


## Departures (x100)

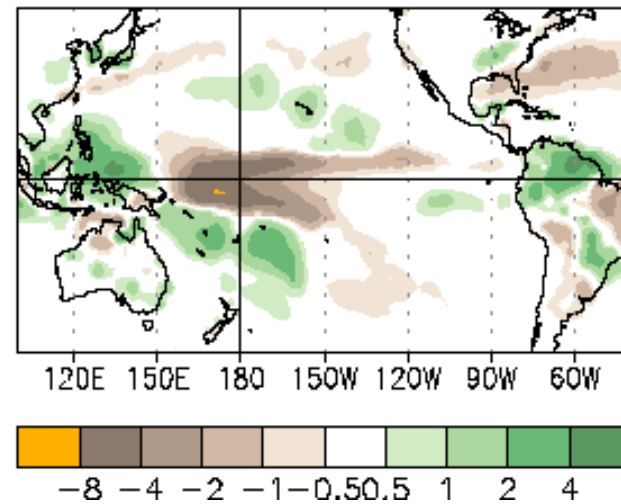


# Jan-Mar 1989 Precipitation (mm)

## Total



## Departures (x100)

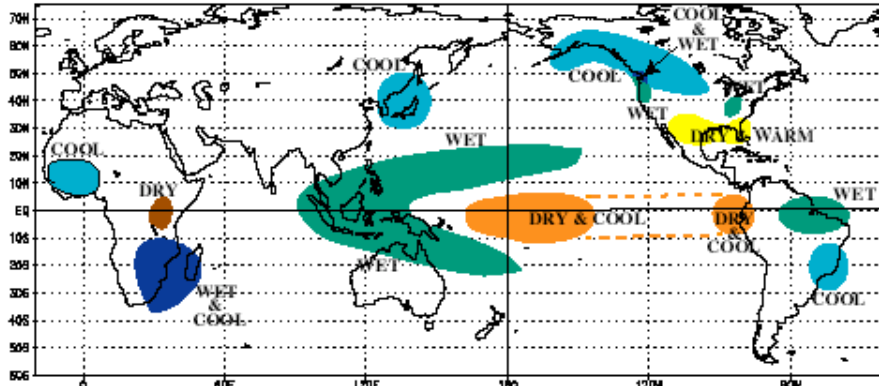


**ENSO generates such a huge climate anomaly over such a large area, that it affects climate in many other parts of the world.**

**It does this by altering the pattern of atmospheric disturbances that typically propagate from one region to another, though these mechanisms are not completely understood.**

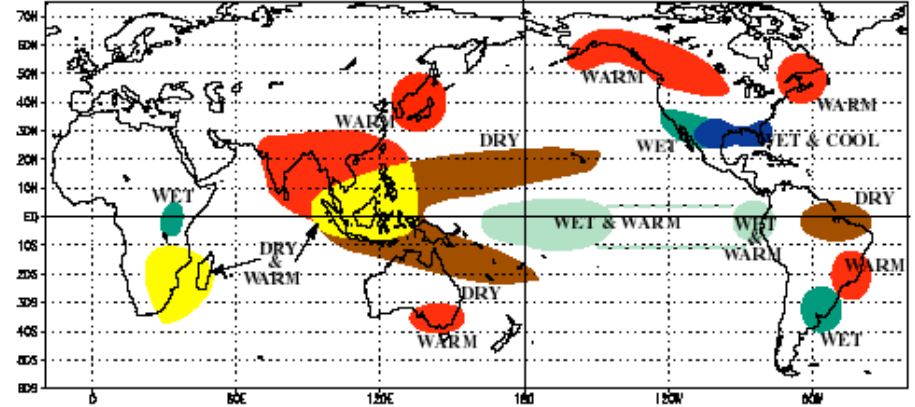
# La Niña

COLD EPISODE RELATIONSHIPS DECEMBER - FEBRUARY

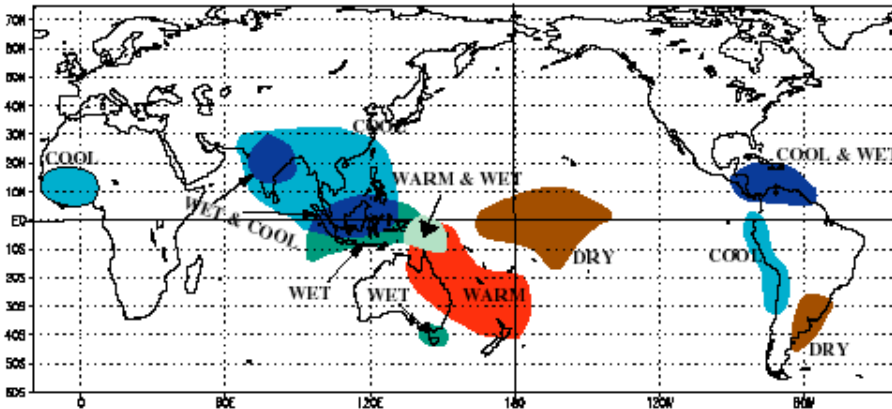


# El Niño

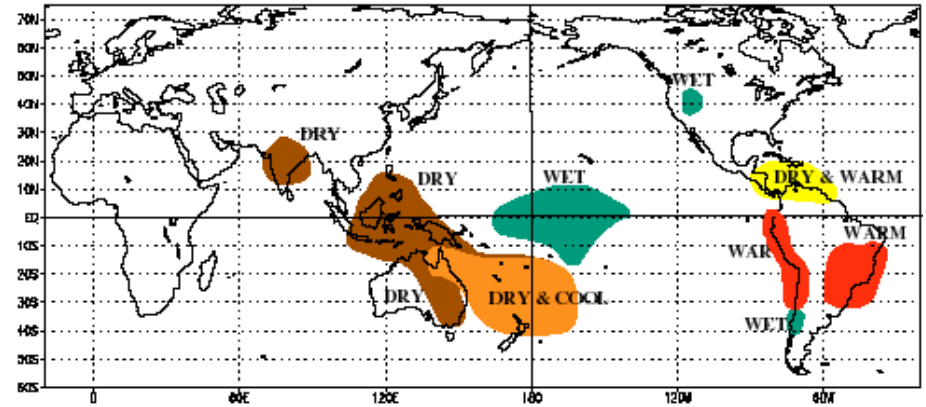
WARM EPISODE RELATIONSHIPS DECEMBER - FEBRUARY



COLD EPISODE RELATIONSHIPS JUNE - AUGUST



WARM EPISODE RELATIONSHIPS JUNE - AUGUST

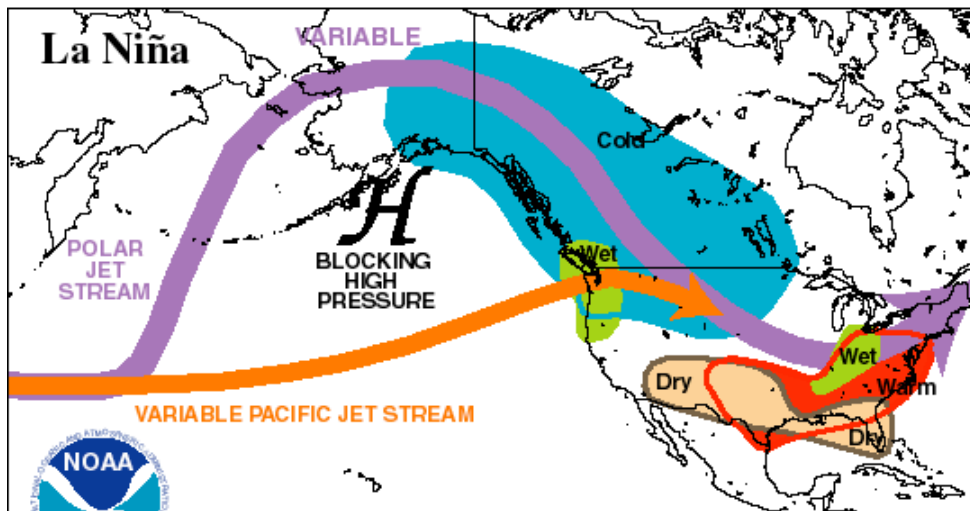
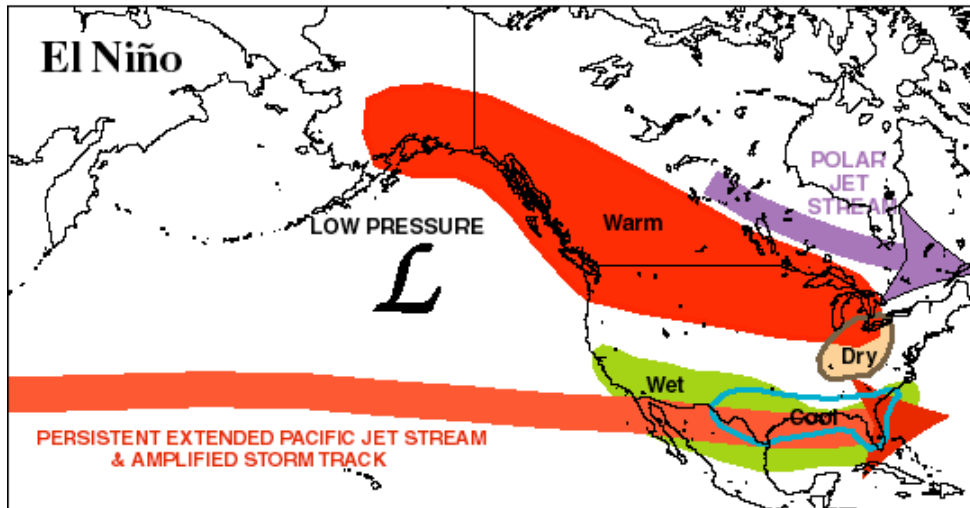


Climate Prediction Center  
NCEP



Climate Prediction Center  
NCEP

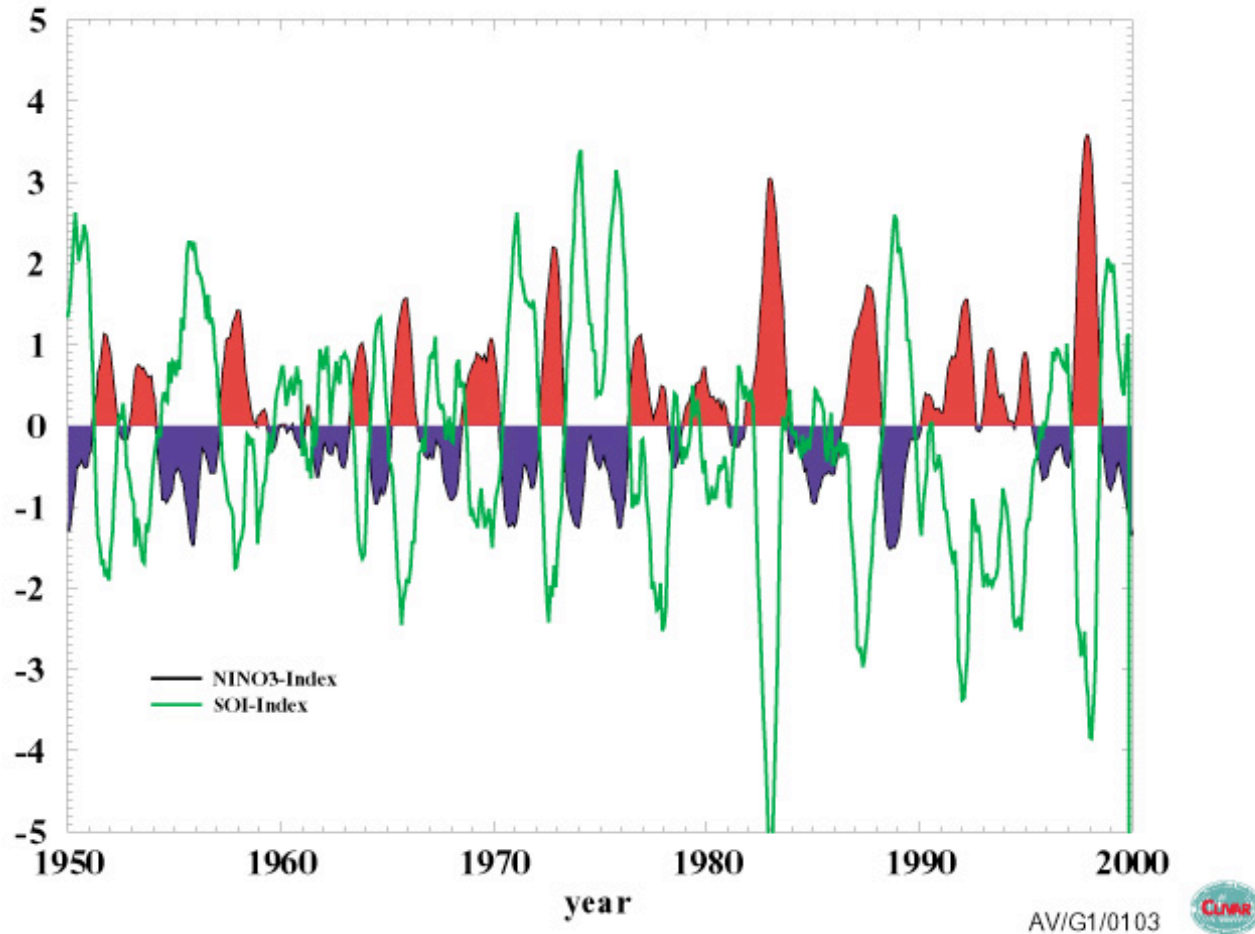
**TYPICAL JANUARY-MARCH WEATHER ANOMALIES  
AND ATMOSPHERIC CIRCULATION  
DURING MODERATE TO STRONG  
EL NIÑO & LA NIÑA**



Climate Prediction Center/NCEP/NWS

**ENSO has a strong impact on the position of the jet stream over the Pacific. During La Niña, the jet stream is pushed far to the north of California. During El Niño, the jet stream tends to be located at about the same latitude as Southern California. Thus the storm activity associated with the jet stream is also located at the same latitude as Southern California.**

## ENSO 1950 - 1999



**Note the large 1997-98 El Niño event and the prolonged La Niña during 1974-75.**



## **What happened in California during the 97-98 El Niño?**

**“On February 2nd and 3rd, just as doubt was beginning to surface in southern California about the reality of El Nino's consequences, the first of a month-long succession of dramatic and impressive storms paid a visit, with high winds, intense rain, heavy mountain snows, and high surf. Embedded in the fast flow, storms followed closely and quickly on each other's heels, for most of the remainder of the month, leaving little time for recovery. Almost no part of the state escaped unaffected. Although storms cannot be individually ascribed to its presence, El Nino certainly played a prominent role in setting the stage as an "enabling factor" for the unfolding sequence of events.”**

**“Many locations from the San Francisco Bay area southward set February and/or any-month precipitation records, including: UCLA (20.51", wettest month ever), Bakersfield (5.36" wettest Feb), Mojave (6.70", wettest Feb, 615 percent of average), Edwards Air Force Base (5.88", wettest month, 42 years), UC Riverside (9.49", wettest month), Santa Maria 11.59" (wettest month), Los Angeles Civic Center (13.79", wettest Feb), Oxnard 17.80" (wettest month), Ventura Downtown (18.91", wettest month, 132 years), Santa Barbara (21.74", wettest month, 132 years), Lompoc (12.86", wettest month), San Francisco (14.88", wettest Feb, 148 years of records, 508 % of average, old record 12.52" in 1878), and Lake Lagunitas (second to 1891, record starts 1879). Monthly totals reached 36.37" at Cazadero in Sonoma County, with automated mountain gages north of Los Angeles reporting February totals up to 43 inches (likely to be slightly underestimates). In Santa Clara County, Ben Lomond recorded 19.7" in the first 8 days of the month, and by February 20, many locations had already set monthly records. Major episodes included the 3rd-6th, 8th-11th, 17th-19th, and 23rd-24th.”**

**Dr. Kelly Redmond,  
Western Regional Climate Center  
in a report to the Federal Emergency Management Agency**



**1974-1975 La Nina**

**CLIMATE PREDICTION?**