Workshop 13.

Climate Patterns - El Niño

Introduction: many atmospheric circulation patterns repeat at regular intervals from months to decades, creating precipitation and temperature anomalies on regional to global scales (UCAR). [http://www.ucar.edu/news/backgrounders/patterns.shtml](http://www.ucar.edu/news/backgrounders/patterns.shtml) One of the strongest and longest-studied of these repeating patterns is the Niño / La Niña phenomenon, also called the "Southern Oscillation" or "ENSO" phenomenon. It strongly impacts the fishing and farming economies of Pacific-coastal South America, but it impacts climate worldwide and is associated with droughts and forest fire frequency in the SW United States.

A list of repeating atmospheric circulation patterns: El Niño SO PDO PNA AO AAO AMO MJO NAO

Key Concepts:

- El Niño & La Niña effect global climate
- El Niño & La Niña years can be identified from Sea Surface Anomalies
- Niño & La Niña years are associated drought and forest fires in the Southwest
- Forest fires in the Southwest may be associated with climate change

The Niño - Southern Oscillation (ENSO)

When atmospheric and oceanic conditions are "normal", high atmospheric pressure exists over the eastern Pacific Ocean, near Peru, and low pressure over the western Pacific, near Australia. This pressure gradient creates strong easterly (east to west) winds which "push" warm ocean surface waters westward. Cold waters from the depths of the eastern Pacific rise, or upwell, to fill in the space where the warm waters were. See the equator-ward bulges of cold water (blue) in the eastern Pacific in the upper images of the figure below. This is most pronounced during La Niña events (upper right panel of the figure below).

During an Niño event, the atmospheric pressure decreases over the eastern Pacific, which causes the easterly winds to weaken. The warm surface water is no longer "pushed" westward, and the upwelling of cold waters off the South American coast decreases. As a result, the surface waters in the eastern equatorial Pacific are warmer than normal. This is shown by the large red and orange area in the lower left panel of the figure below.

Niño events are usually followed by La Niña events, in which the opposite occurs. The atmospheric pressure gradient over the equatorial Pacific is greater than usual, and more cold water upwells from the depths of the ocean near the coast of South America near Peru. This is shown by the dark blue area along the equator in the lower right panel of the figure below.

The variation of the atmospheric pressure gradient over the equatorial Pacific Ocean is known as the Southern Oscillation. Because the southern oscillation is the driving force of an Niño (or La Niña) event, the phenomenon is often referred to as ENSO (Niño - Southern Oscillation).

Global climate can be affected during an ENSO event (either Niño or La Niña). However, weather patterns for the equatorial regions in and around the Pacific are the most strongly influenced. During normal years, the western Pacific near Indonesia (where the warmest waters usually sit) receives heavy rainfall. During Niño years, the rains migrate eastward, following the warmest waters. This situation can cause droughts in Indonesia, Australia, eastern Africa, and floods in Ecuador and Peru. Niño and La Niña also influence the weather patterns in the United States, though to a lesser extent.
1998 (El Niño) and 1989 (La Niña) Pacific Ocean temperatures and departures.
http://www.pitt.edu/~mabbott1/climate/mark/Images/sst_nino_nina.gif

In the figure above, the largest temperature differences between El Niño and La Niña (1988 & 1989) events (lower 2 panels) are in the equatorial Pacific between 150W and 120W (4°C). Look closely at the temperature departures (lower 2 panels). What are the sea surface temperature contrasts in five places (El Niño minus La Niña): Japan (W shore), Hawaii (W shore), Baja California, Cuba (W shore), New Zealand (W shore)? For example, the western coast of Japan is about 1 degree warmer in an El Niño than a La Niña year.
2.

Sea surface temperatures (SST) are routinely measured by buoys and satellites across the equatorial Pacific in order to observe conditions and to try to predict ENSO events. Above is a graph of sea surface temperature anomalies (SSTA) of the equatorial Pacific Ocean near the South American coast. Positive numbers mean the water is warmer than usual; negative numbers mean the water is colder than usual. Does warm water in the equatorial Pacific indicate El Niño or La Niña conditions? (see previous question)

Fire data source: Hughes, 2000 (unpublished)
Drought data source: Cook, E.R. et al., 1999

3.

The Palmer Drought Severity Index (PDSI) uses local temperature and rainfall information to determine dryness. Numbers are calculated to represent long term drought conditions. Negative numbers are considered drought conditions, positive numbers are considered excessive rainfall conditions, and zero is normal. So -4 means severe drought, -2 means moderate drought, 2 means moderate rainfall, 4 means heavy rainfall. Above is a graph of PDSI values and hectares burned by forest fire for the SW United States.

Compare the figure above with the one in the previous figure, what is the relationship between El Niño and La Niña climate and forest fires?
4.

What is the trend in the and the number of acres burned from 1980 - 1995? This is at least partly due to a build-up of fire fuel (dead and dry wood, leaves, and other plant material). During the twentieth century, fire management policy was to quickly extinguish forest fires. This led to less land area being burned, and the build-up of fuel in the unburned areas. In about 1980, forest scientists concluded that naturally occurring forest fires had, in the past, benefited ecosystems by clearing out the old to make room for the new. Fire management policies then changed from extinguishing forest fires, to letting them burn naturally as long as property and lives were not threatened. Describe how this change in policy is reflected on the graph.
5.

What has been the trend in world temperature 1980 - 2005 (figure above)? Compare that trend with the trend in the PDSI in the previous question. Remember that the PDSI includes both temperature and moisture in its calculations. How may global warming have affected the PDSI? How might global climate change have affected wildfires in the Southwest?

Compare these two hypothesis. What is the best explanation for the increased fire frequency from 1980 - 1995?