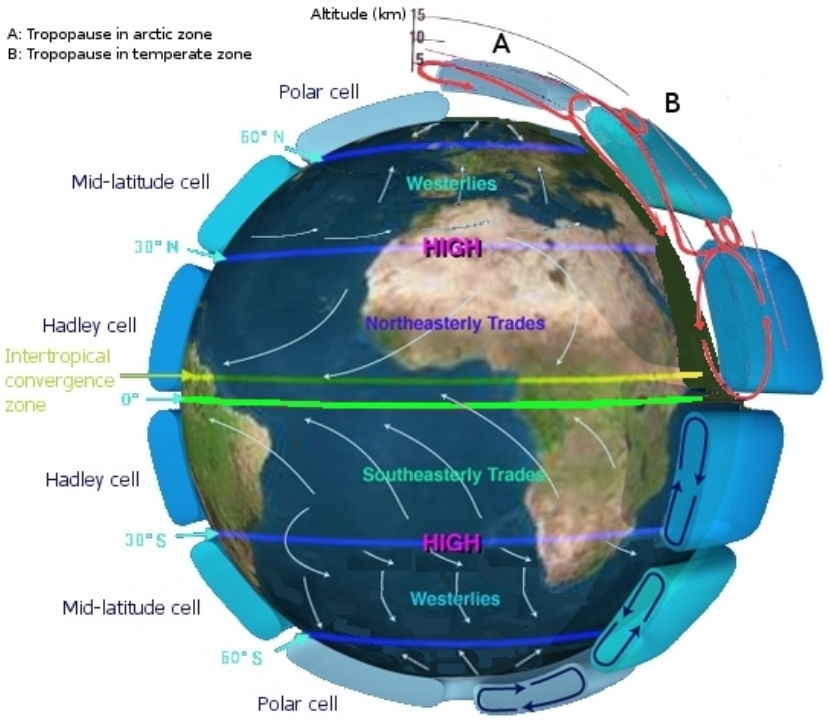
Atmospheric Circulation

http://en.wikipedia.org/wiki/Atmospheric_circulation

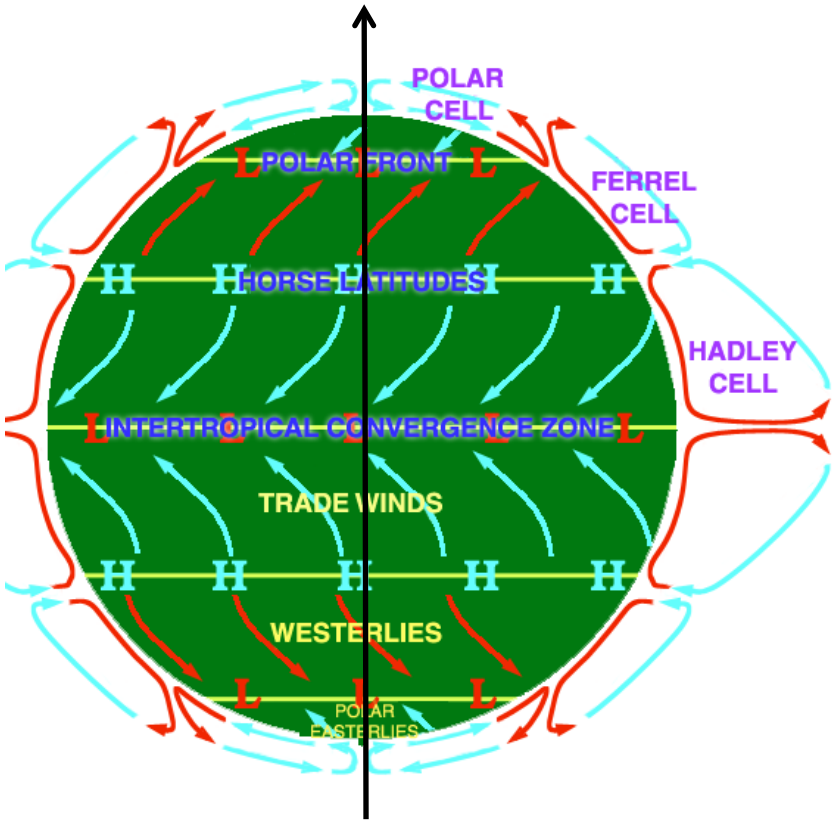
- “Atmospheric circulation is the large-scale movement of air, and the means (together with the smaller ocean circulation) by which thermal energy is distributed on the surface of the Earth.
- The large-scale structure of the atmospheric circulation varies from year to year, but the basic climatological structure remains fairly constant.
- Individual weather systems – mid-latitude depressions, or tropical convective cells – occur "randomly", and it is accepted that weather cannot be predicted beyond a fairly short limit: perhaps a month in theory, or (currently) about ten days in practice (see Chaos theory and Butterfly effect).
- Nonetheless, as the climate is the average of these systems and patterns – where and when they tend to occur again and again – it is stable over longer periods of time.
- As a rule, the "cells" of Earth's atmosphere shift polewards in warmer climates (e.g. interglacials compared to glacials), but remain largely constant even due to continental drift
- They are, fundamentally, a property of the Earth's size, rotation rate, heating and atmospheric depth, all of which change little.
- Tectonic uplift can significantly alter major elements of the circulation patterns, i.e., the jet stream.
- Plate tectonics shift ocean currents.
- In the extremely hot climates of the Mesozoic, indications of a third desert belt at the Equator has been found; it was perhaps caused by convection. But even then, the overall latitudinal pattern of Earth's climate was not much different from the one today.”



Hadley Cell

http://en.wikipedia.org/wiki/Atmospheric_circulation

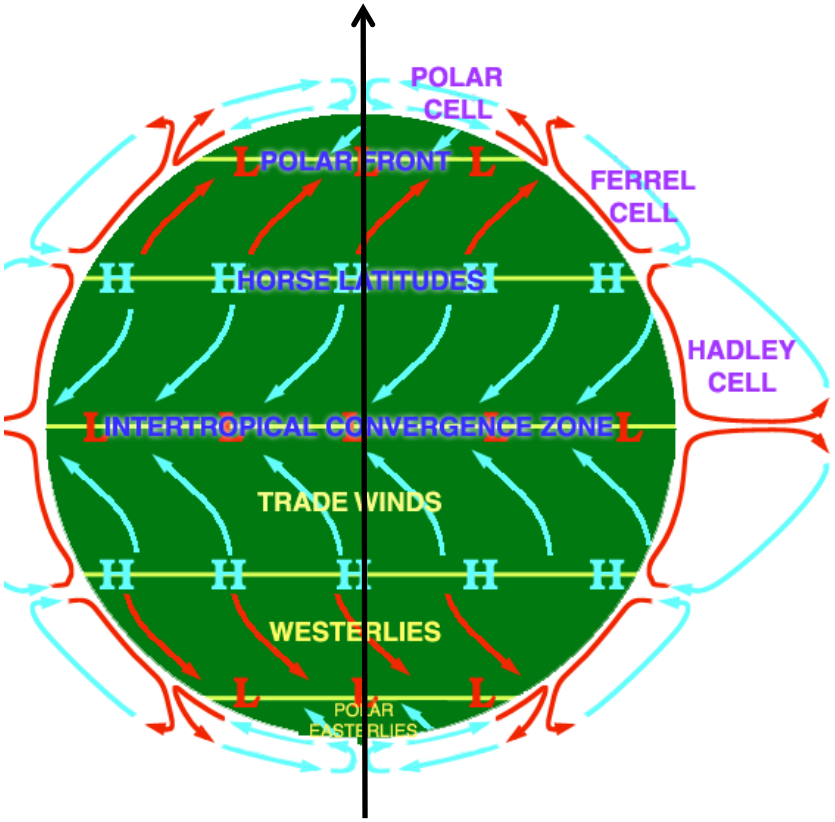
- "The Hadley cell mechanism is well understood.
- The atmospheric circulation pattern that George Hadley described to provide an explanation for the trade winds matches observations very well.
- It is a closed circulation loop, which begins at the equator with warm, moist air lifted aloft in equatorial low pressure areas (the Intertropical Convergence Zone, ITCZ) to the tropopause and carried poleward.
- At about 30°N/S latitude, it descends in a high pressure area. Some of the descending air travels equatorially along the surface, closing the loop of the Hadley cell and creating the Trade Winds.
- Though the Hadley cell is described as lying on the equator, it is more accurate to describe it as following the sun's zenith point, or what is termed the "thermal equator," which undergoes a semiannual north-south migration."



- “The Polar cell is also a simple system.
- Though cool and dry relative to equatorial air, air masses at the 60th parallel are still sufficiently warm and moist to undergo convection and drive a thermal loop.
- Air circulates within the troposphere, limited vertically by the tropopause at about 8 km.
- Warm air rises at lower latitudes and moves poleward through the upper troposphere at both the north and south poles.
- When the air reaches the polar areas, it has cooled considerably, and descends as a cold, dry high pressure area, moving away from the pole along the surface but twisting westward as a result of the Coriolis effect to produce the Polar easterlies.
- The outflow from the cell creates harmonic waves in the atmosphere known as Rossby waves.
- These ultra-long waves play an important role in determining the path of the jet stream, which travels within the transitional zone between the tropopause and the Ferrel cell.
- By acting as a heat sink, the Polar cell also balances the Hadley cell in the Earth’s energy equation.”

Polar Cell

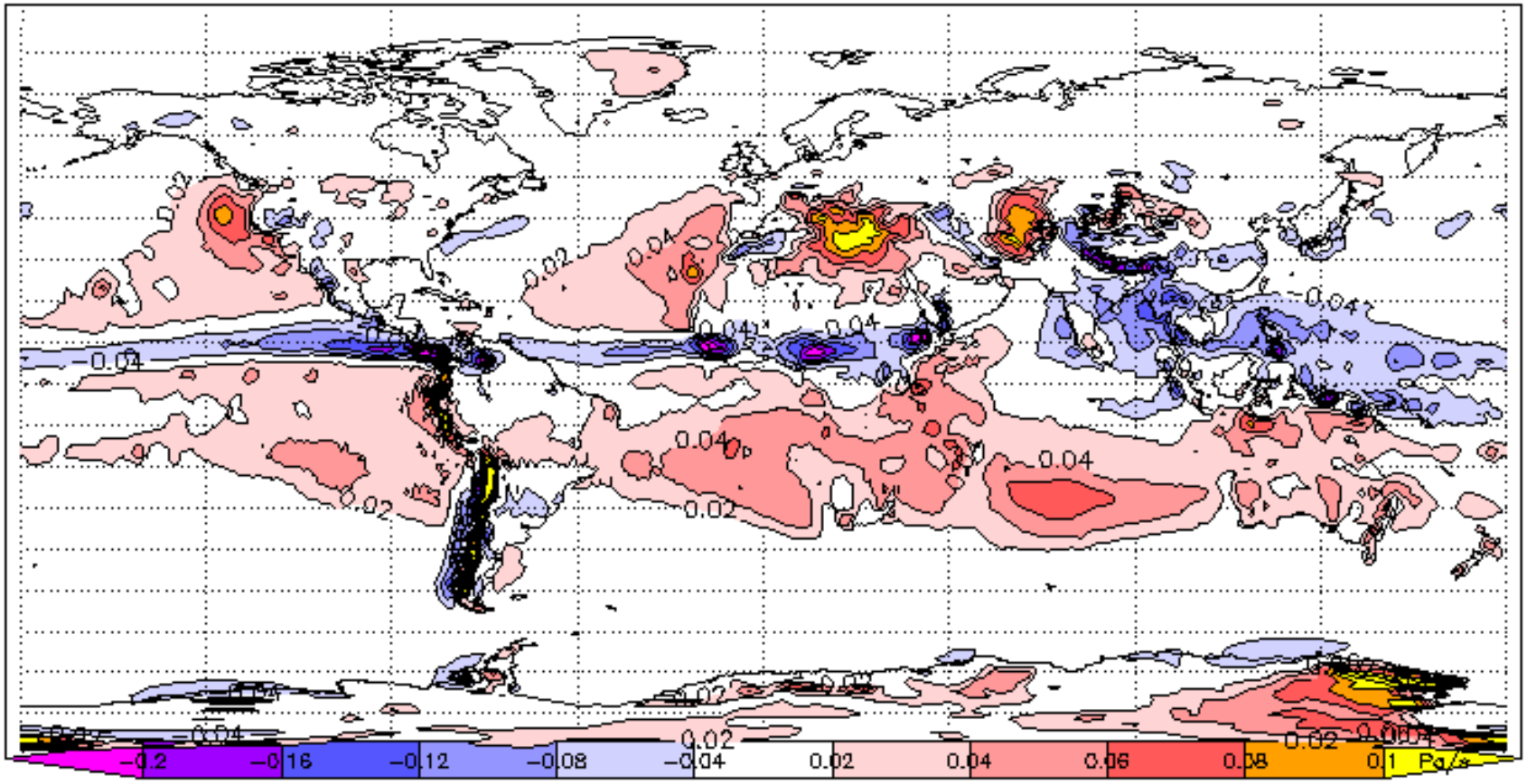
http://en.wikipedia.org/wiki/Atmospheric_circulation



Vertical velocity at 500 hPa, July average

(Sea level pressure is about 1000 hPa)

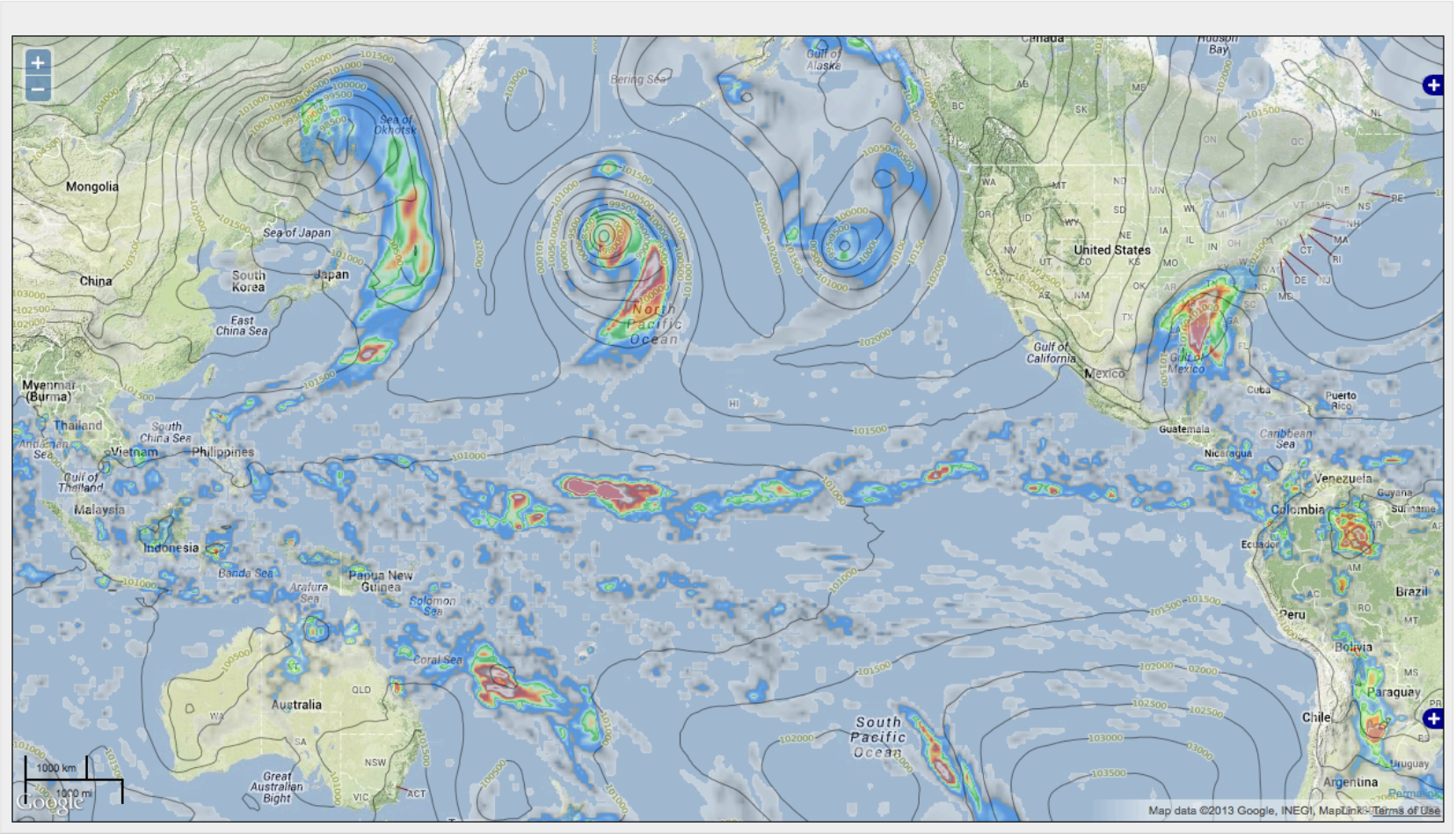
http://en.wikipedia.org/wiki/Atmospheric_circulation



"Ascent (negative values) is concentrated close to the solar equator; descent (positive values) is more diffuse but also occurs mainly in the Hadley cell."

Global Precipitation and Sea Level Isobars
Pacific Basin

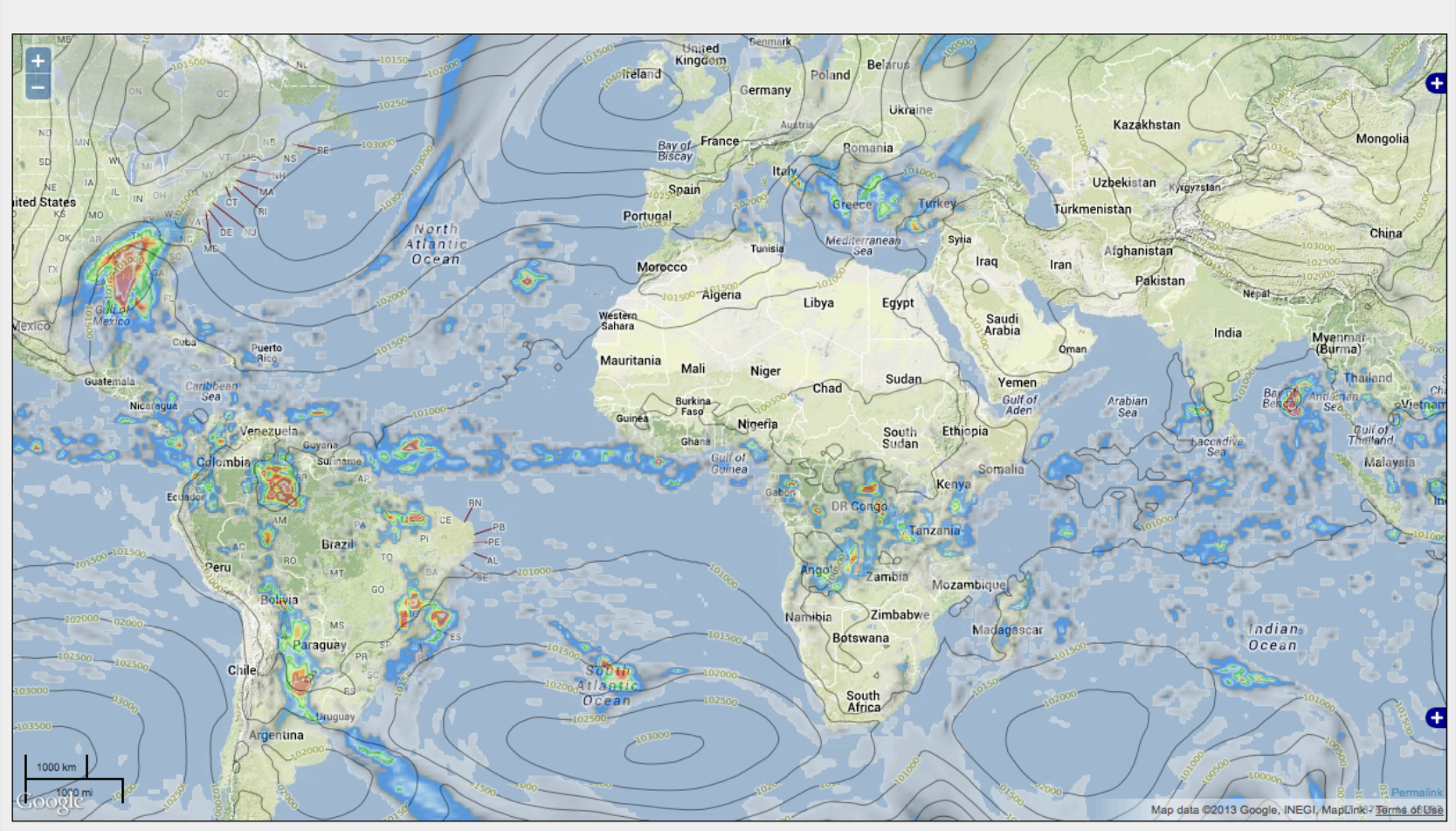
Showing ITCZ: From Open Hazards and Open Weather Map



November 26, 2013, 10:00 am PST: A large storm is moving up the US Eastern seaboard

Global Precipitation and Sea Level Isobars
Atlantic Basin – Indian Ocean

Showing ITCZ: From Open Hazards and Open Weather Map

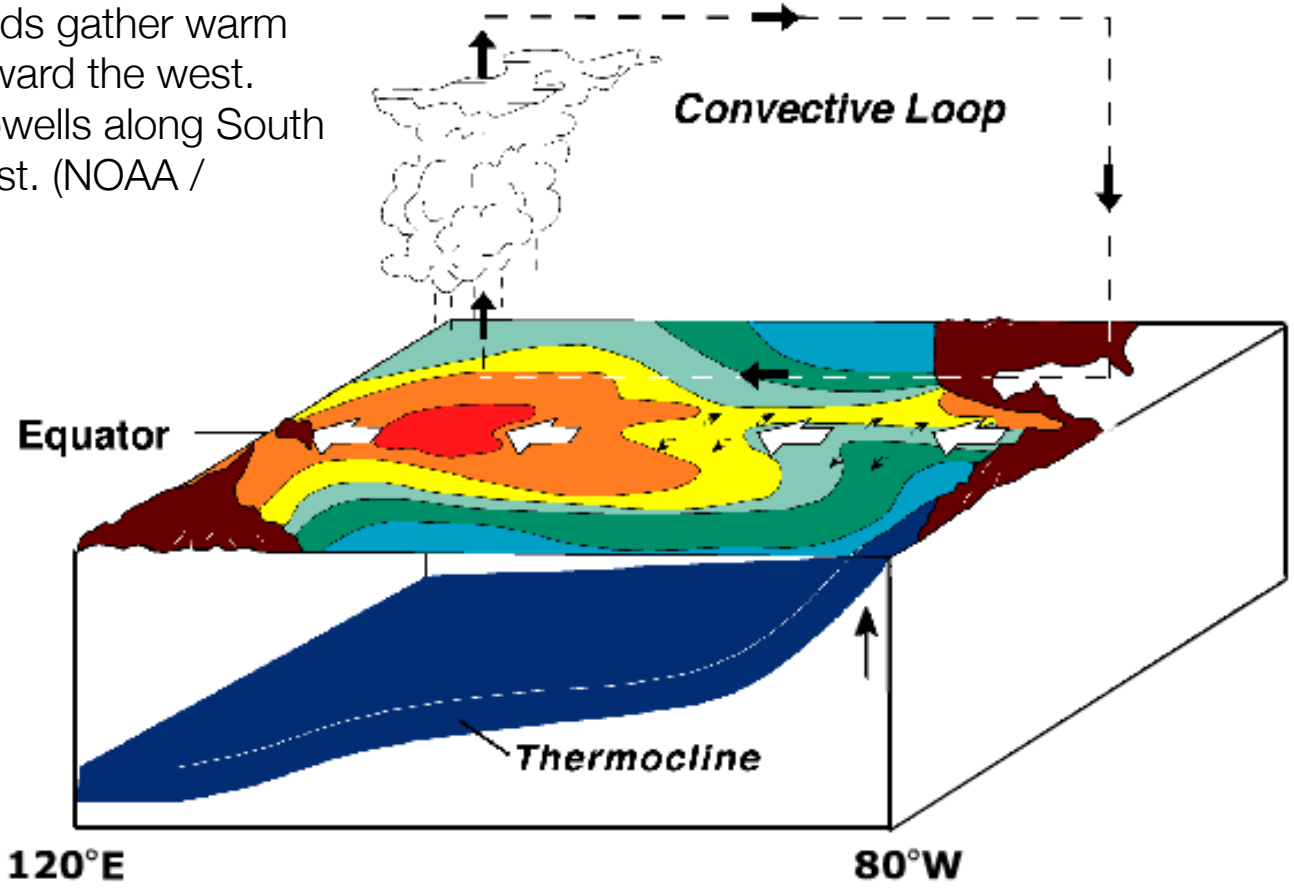


November 26, 2013, 10:00 am PST: A large storm is moving up the US Eastern seaboard
Note that the ICTZ is much better organized in the Atlantic than in the Indian Ocean

Normal Conditions

http://en.wikipedia.org/wiki/El_Nino

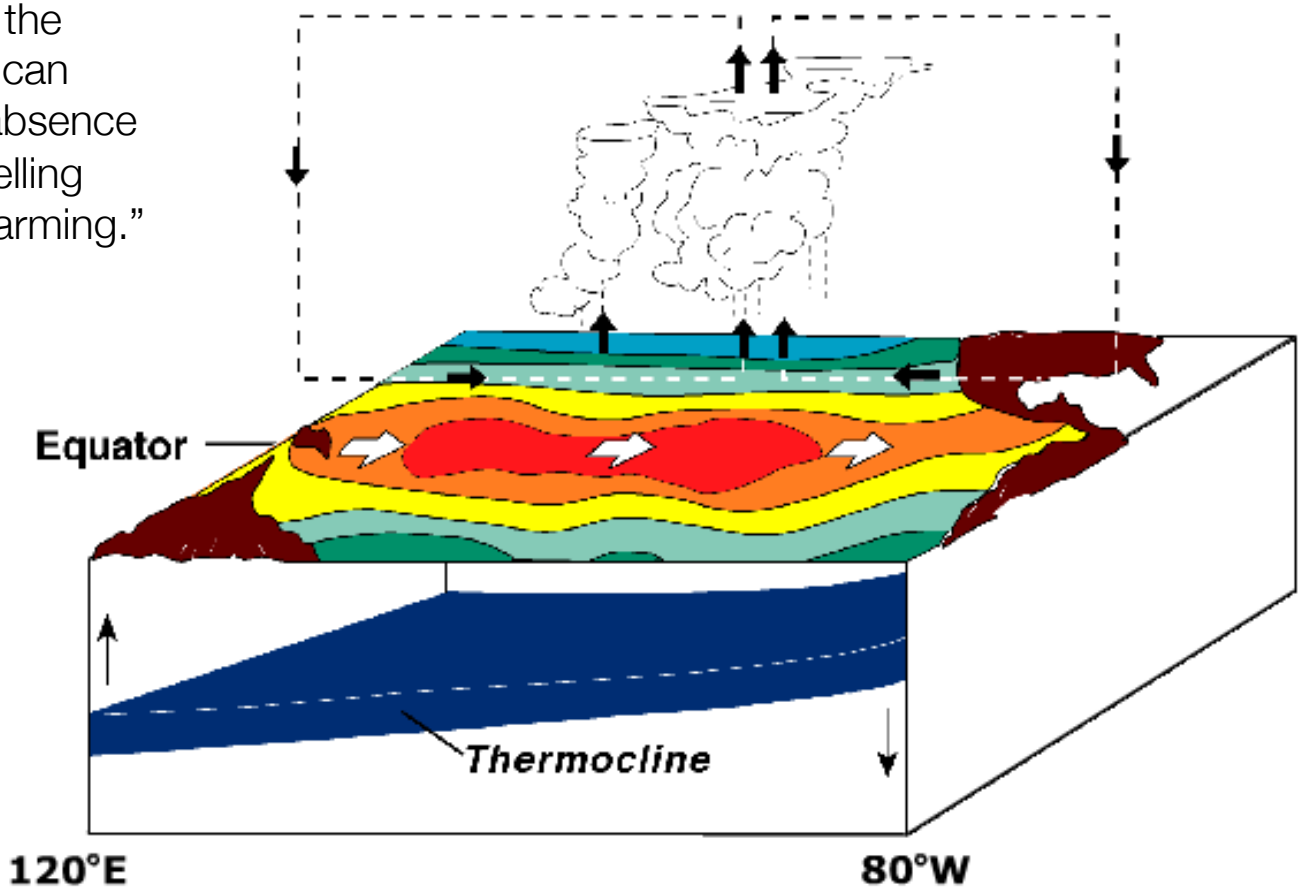
"Normal Pacific pattern: Equatorial winds gather warm water pool toward the west. Cold water upwells along South American coast. (NOAA / PMEL / TAO)"



El Nino Conditions

http://en.wikipedia.org/wiki/El_Nino

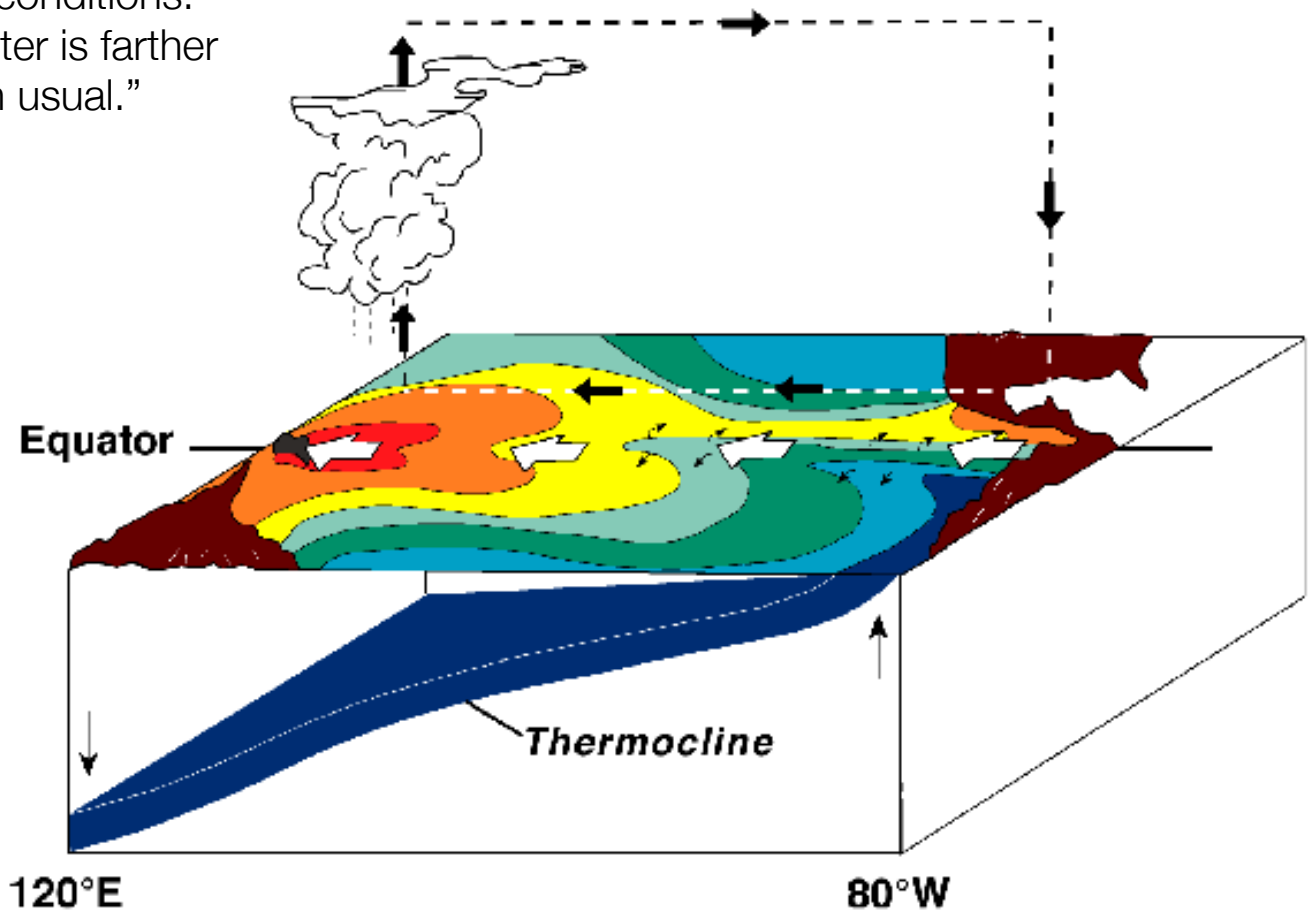
"El Niño conditions: Warm water pool approaches the South American coast. The absence of cold upwelling increases warming."



La Nina Conditions

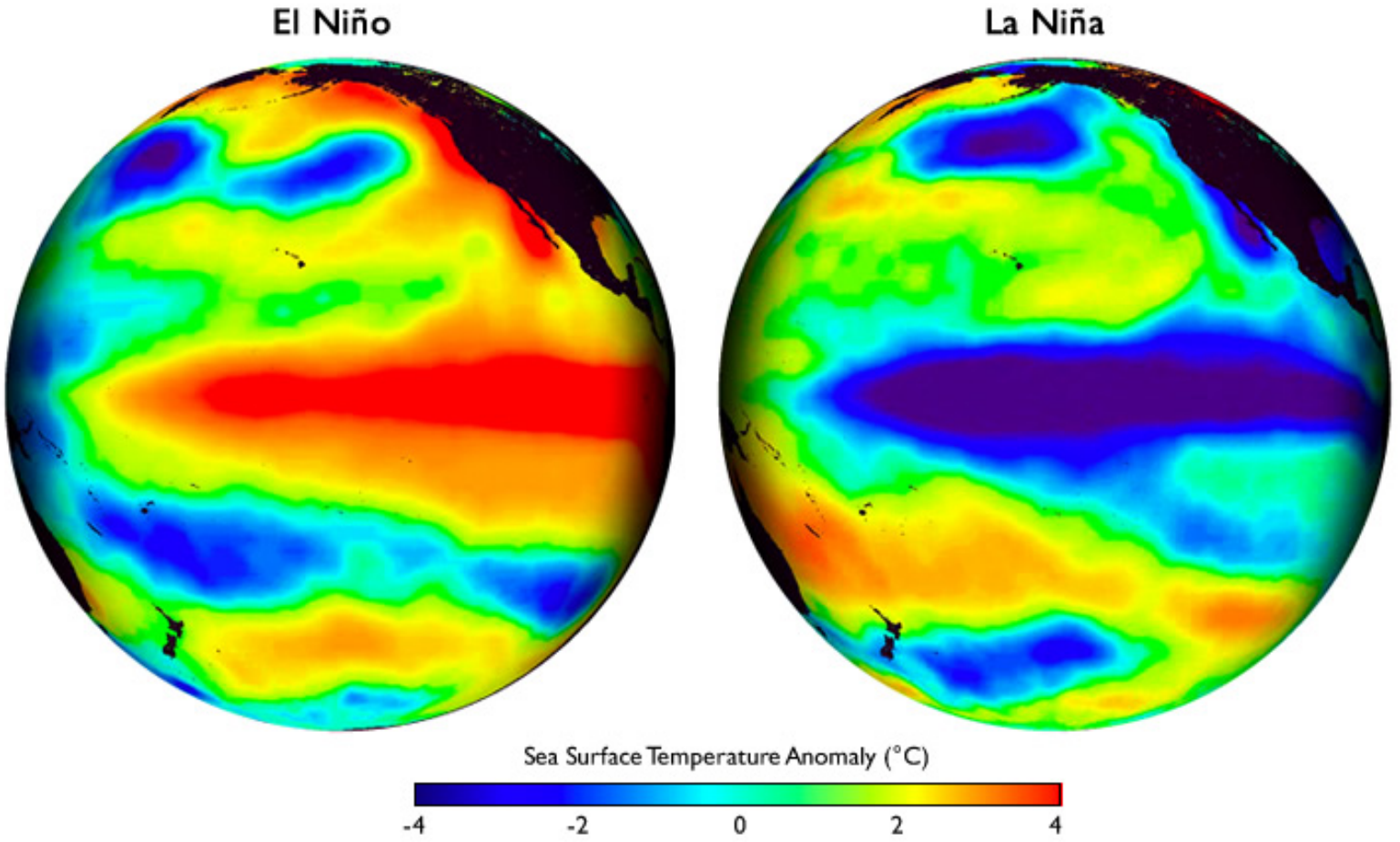
http://en.wikipedia.org/wiki/El_Nino

"La Niña conditions: Warm water is farther west than usual."



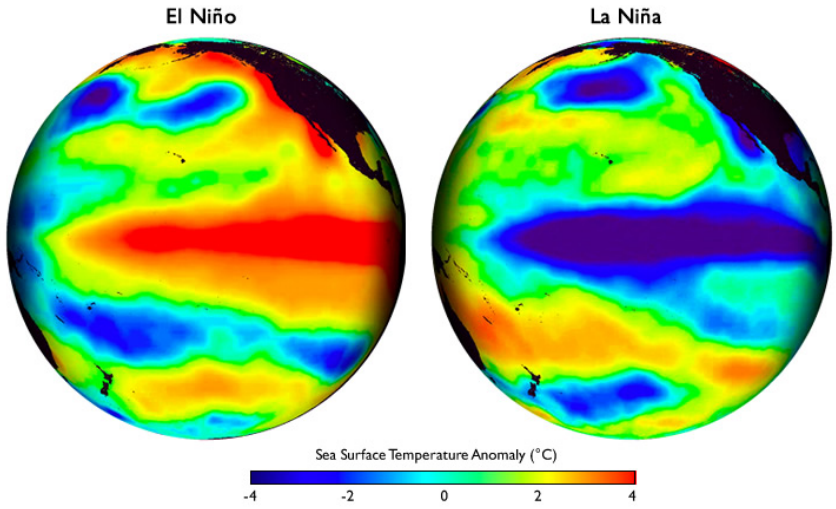
ENSO: El Nino and La Nina

http://www.climate.gov



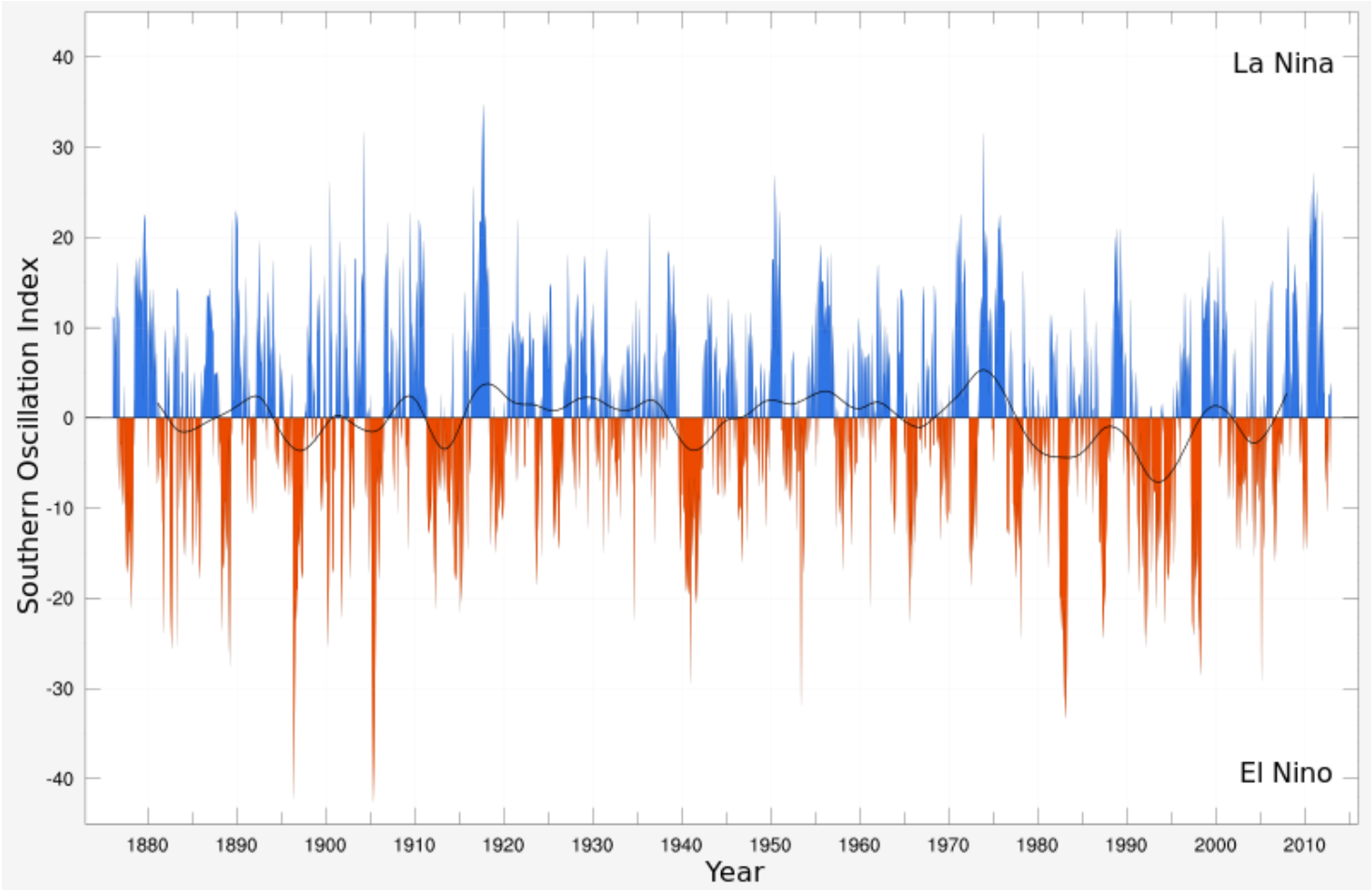
ENSO Characteristics

- “El Niño is defined by prolonged warming in the Pacific Ocean sea surface temperatures when compared with the average value.
- The accepted definition is a warming of at least 0.5°C (0.9°F) averaged over the east-central tropical Pacific Ocean.
- Typically, this anomaly happens at irregular intervals of two to seven years, and lasts nine months to two years.
- The average period length is five years.
- When this warming occurs for only seven to nine months, it is classified as El Niño "conditions”
- When it occurs for more than that period, it is classified as El Niño "episodes”.
- Similarly, La Niña conditions and episodes are defined for cooling.”



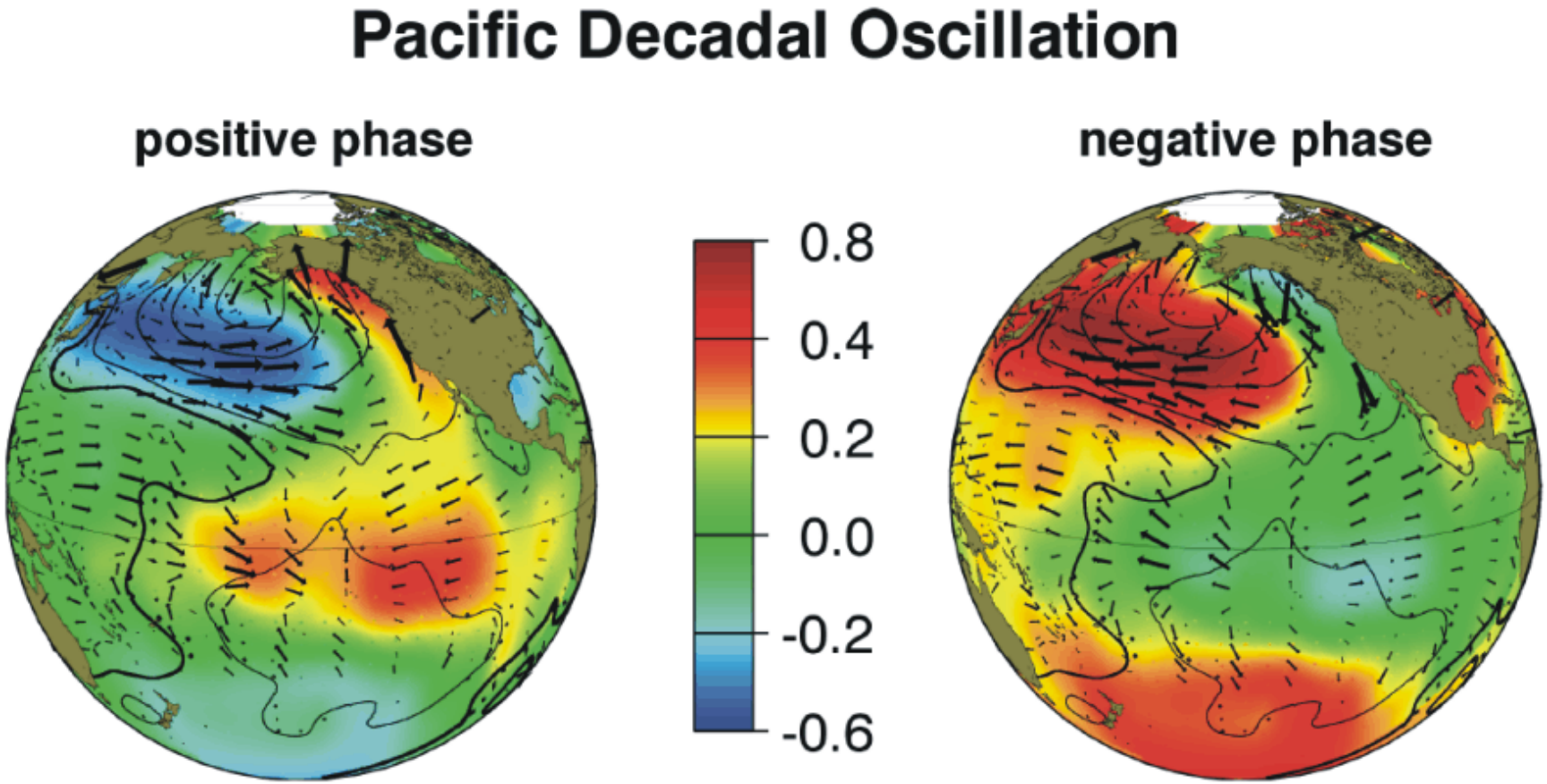
ENSO: Time Series

http://en.wikipedia.org/wiki/El_Nino



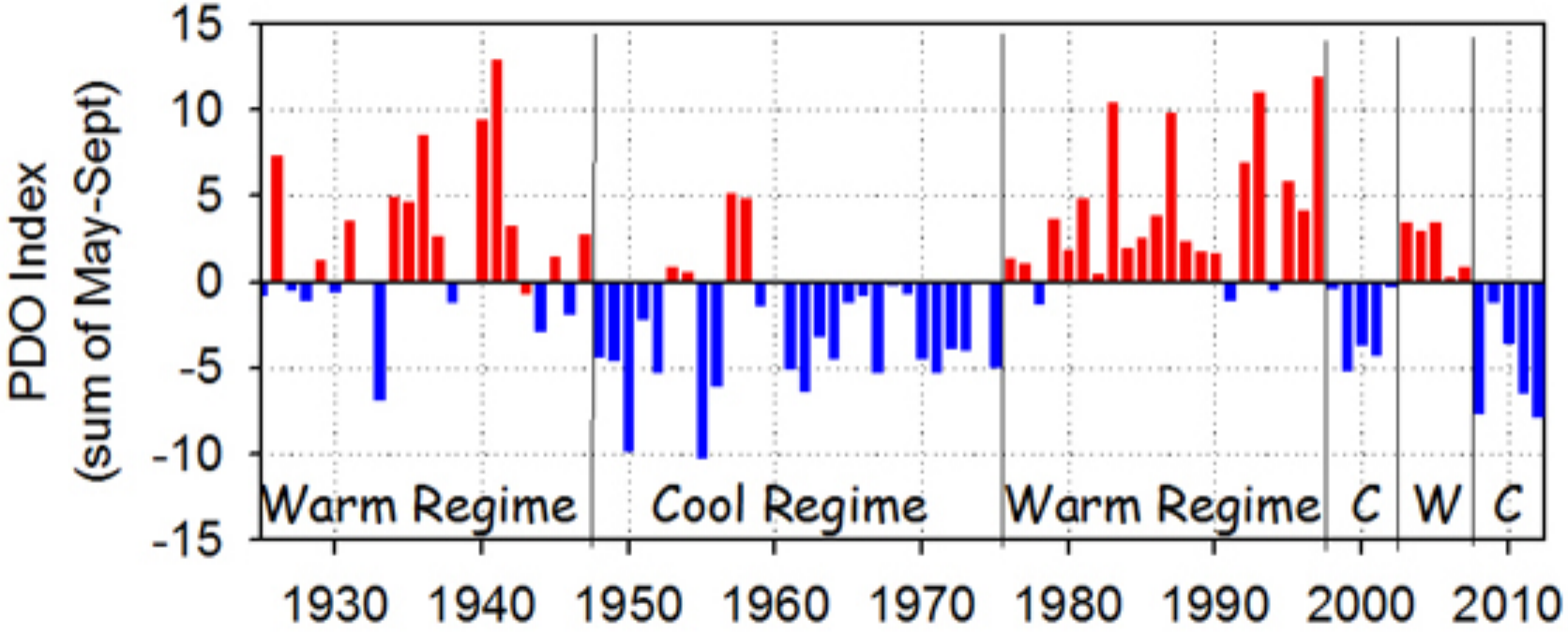
PDO

http://cses.washington.edu



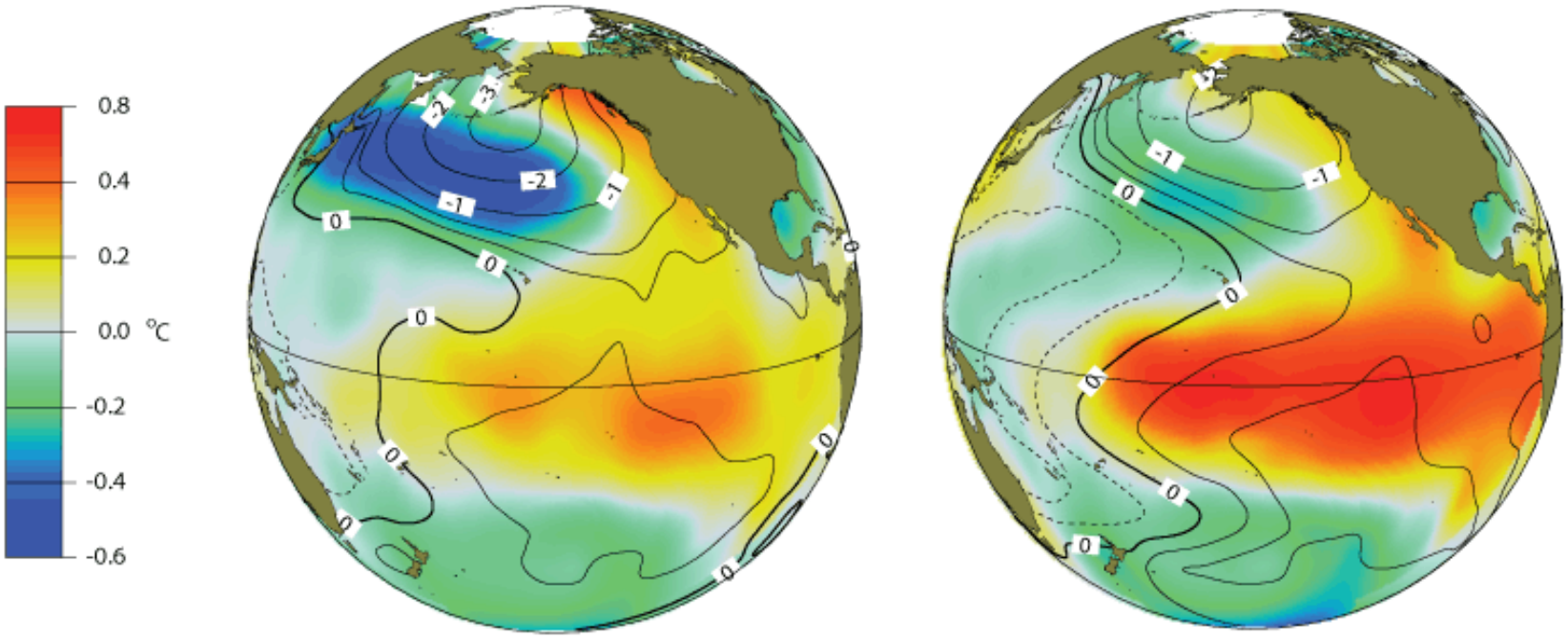
PDO Time Series

http://www.nwfsc.noaa.gov



Comparison of ENSO with PDO

http://cses.washington.edu



Warm Phase PDO

Warm Phase ENSO

Source: Climate Impacts Group, University of Washington

Other Comparisons

http://cses.washington.edu