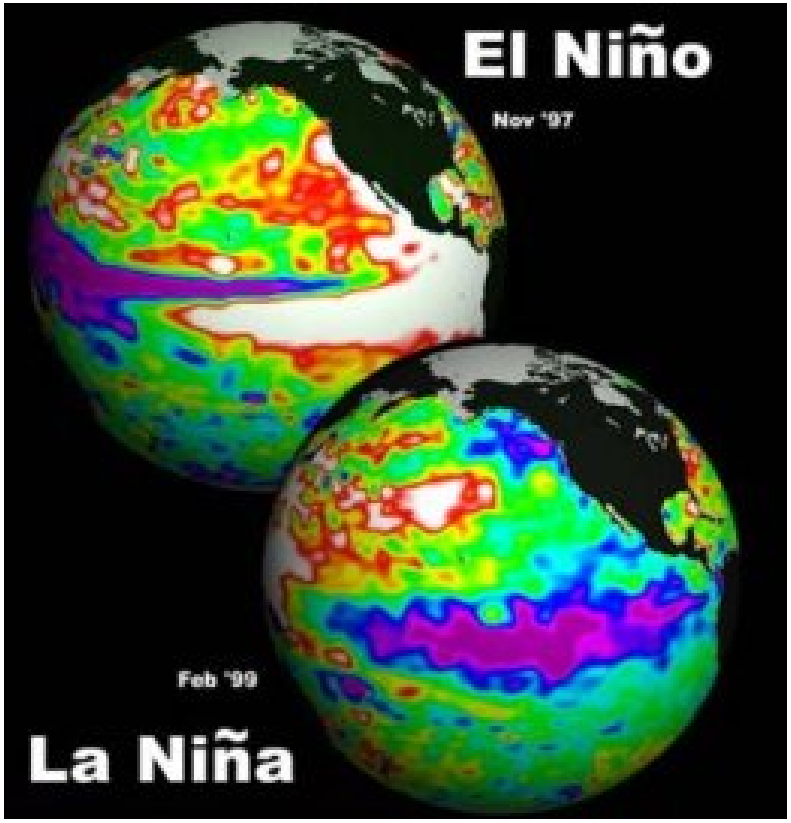
Equatorial Circulations and the ENSO

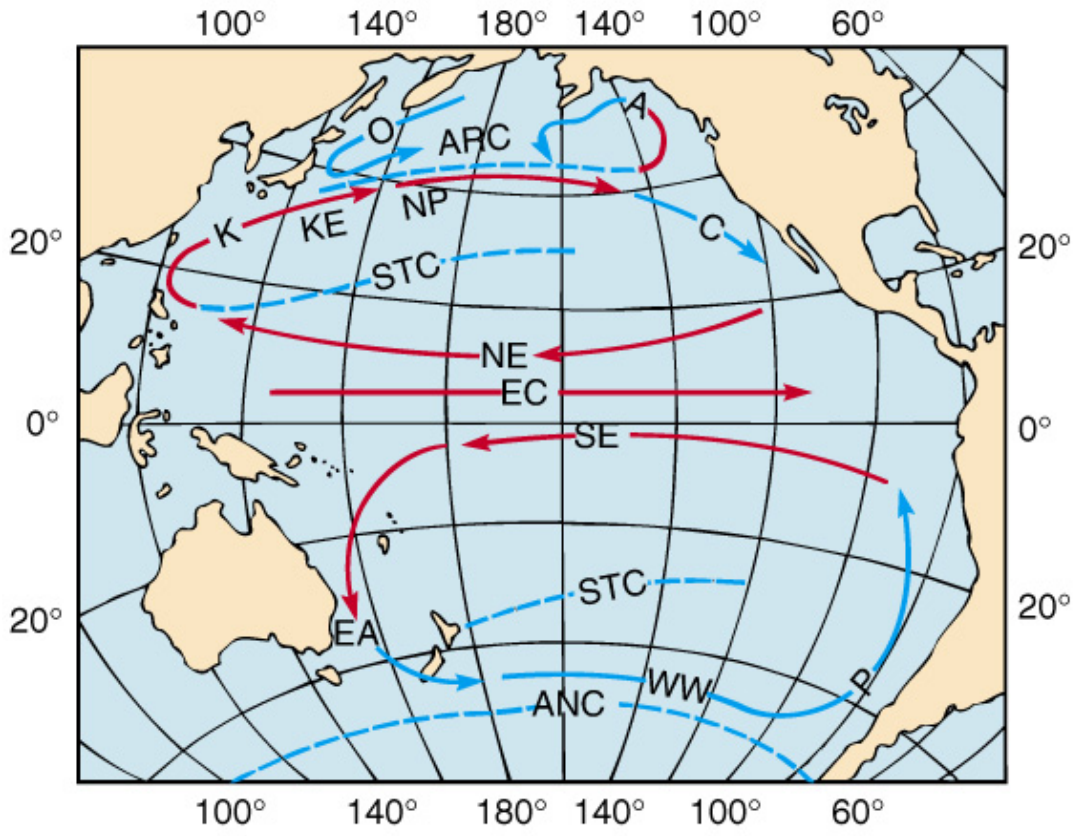
AdOc 4060/5060 Spring 2013

Chris Jenkins



Sea surface height

Pacific Ocean surface currents



CONVERGENCES

ARC–Arctic
STC–Subtropical
ANC–Antarctic

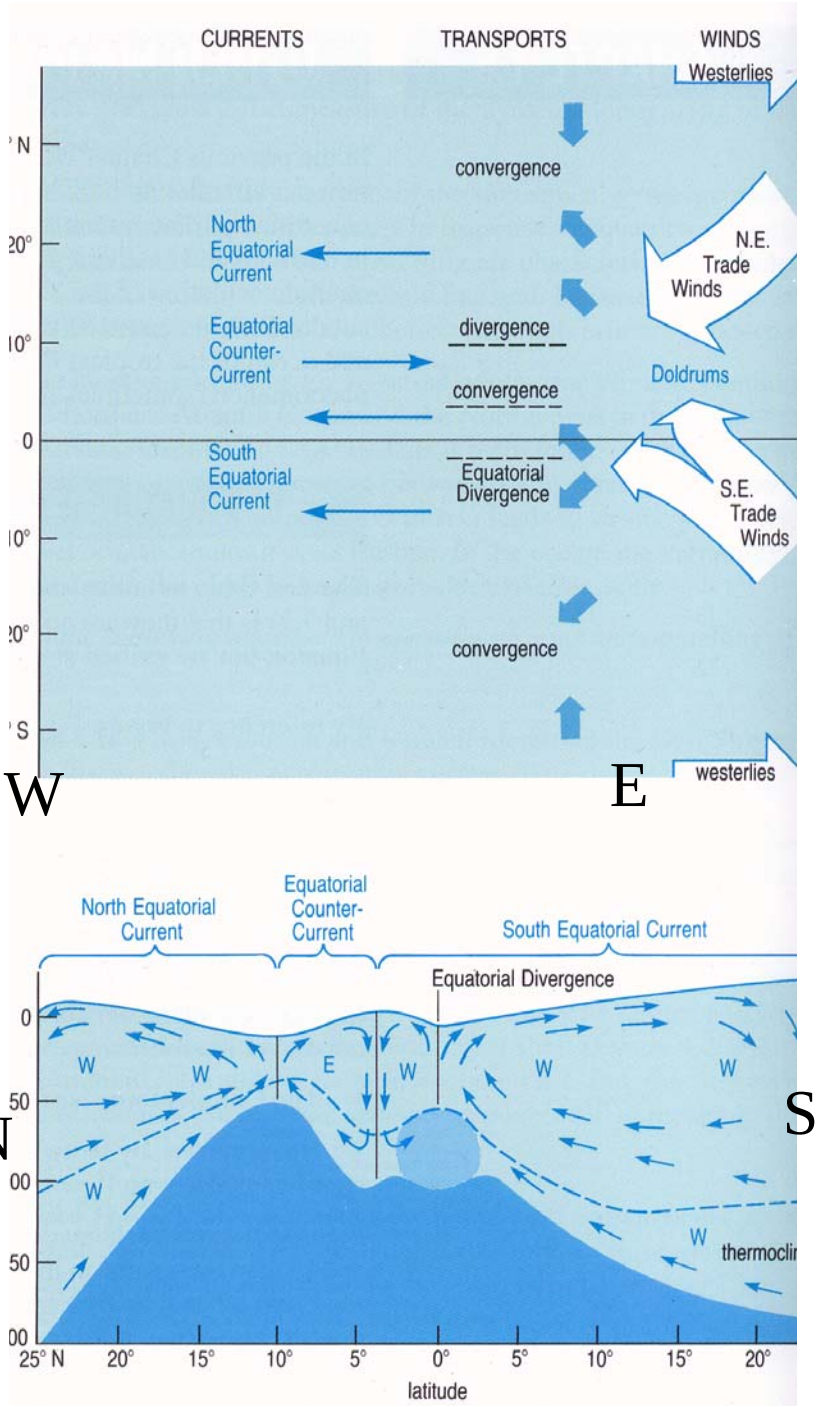
TEMPERATURE

warm
cold

CURRENTS

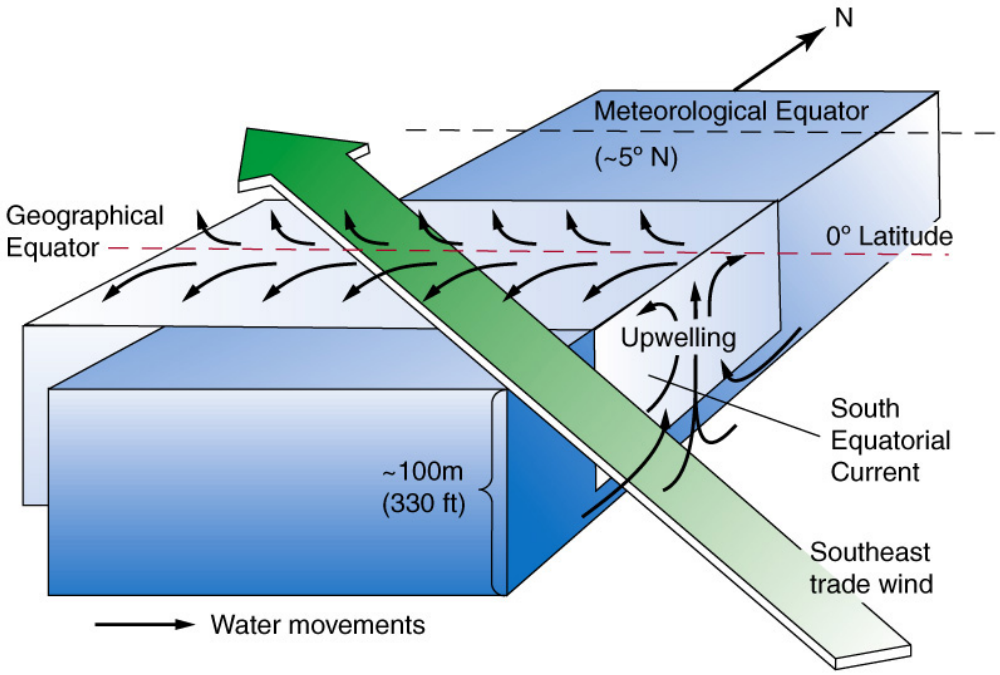
A–Alaskan
C–California
EA–East Australian
EC–Equatorial Counter
K–Kuroshio
KE–Kuroshio Extension
NE–North Equatorial
NP–North Pacific
O–Oyashio
P–Peru
SE–South Equatorial
WW–West Wind Drift

Transverse Currents: - power derived from trade winds flowing into the ITCZ (both E to W and W to E)
-called N and S Equatorial currents
-are moderately shallow and broad; transport about 30 sv



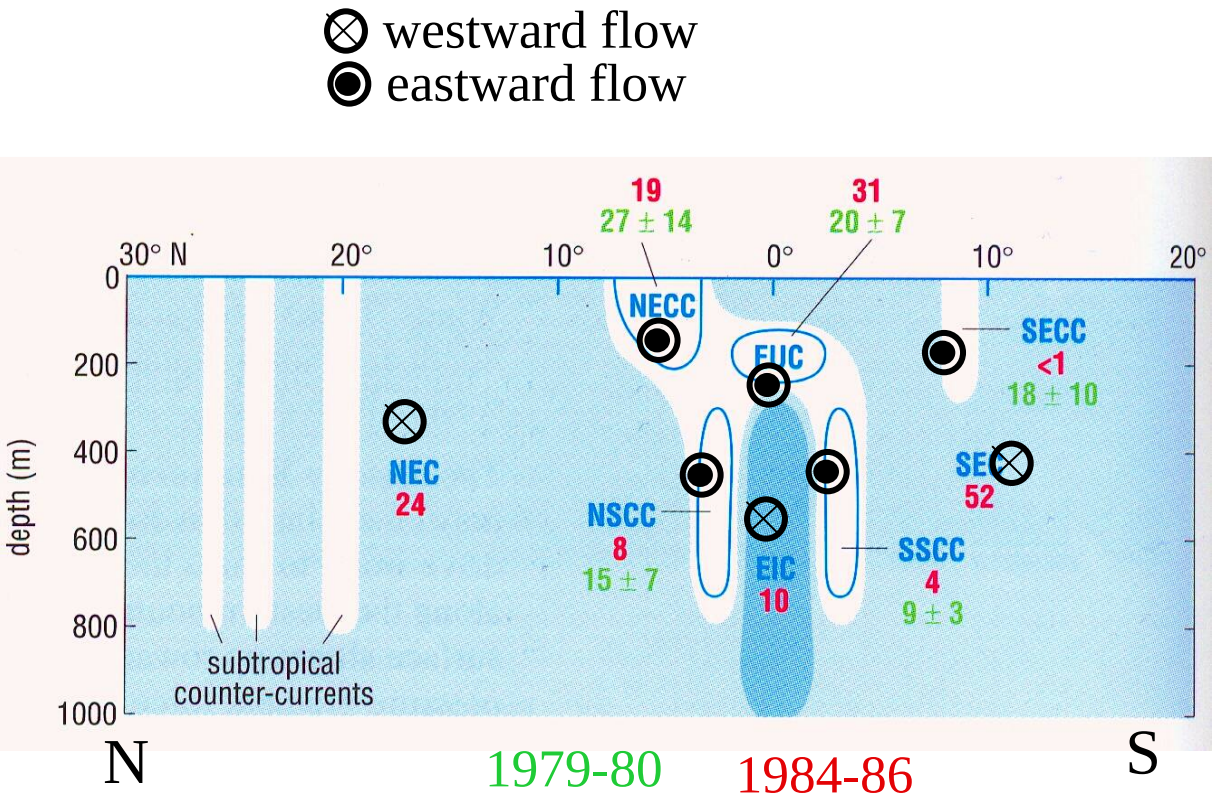
Plan view (From Collings ++, 'Circulation')

Equatorial upwelling



Section view (From Collings ++, 'Circulation')

Figure 5.2 Schematic diagram to show the structure of the equatorial current system in the central Pacific, at 170° W, down to a depth of 1000 m (i.e. much deeper than in Figure 5.1(b)). Westward flow in the North and South Equatorial Currents (NEC and SEC) is shaded pale blue; strong westward flow (the Equatorial Intermediate Current, EIC) is darker blue. Eastward flow (including the South Equatorial Counter-Current, SECC) is unshaded; areas of strong eastward flow in the Equatorial Undercurrent (EUC), the North Equatorial Counter-Current (NECC) and the North and South Subsurface Counter-Currents (NSCC and SSCC) are outlined in blue. Note that a banded pattern is also shown for the northern subtropics, where counter-currents have been observed. The numbers are volume transports in sverdrups (10^6 m^3 s^{-1}). Those in red are for 155° W, based on data for April 1979–March 1980, and those in green are for 165° W, based on data for January 1984–June 1986.



Section view (From Collings ++, 'Circulation')

Kelvin Waves

• waves in the ocean or atmosphere that balances the Earth's Coriolis force against some waveguide (e.g., coastline, equator); ducted

• non-dispersive (phase speed equal to the group speed all wavelengths)

• limited locations, scenarios

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

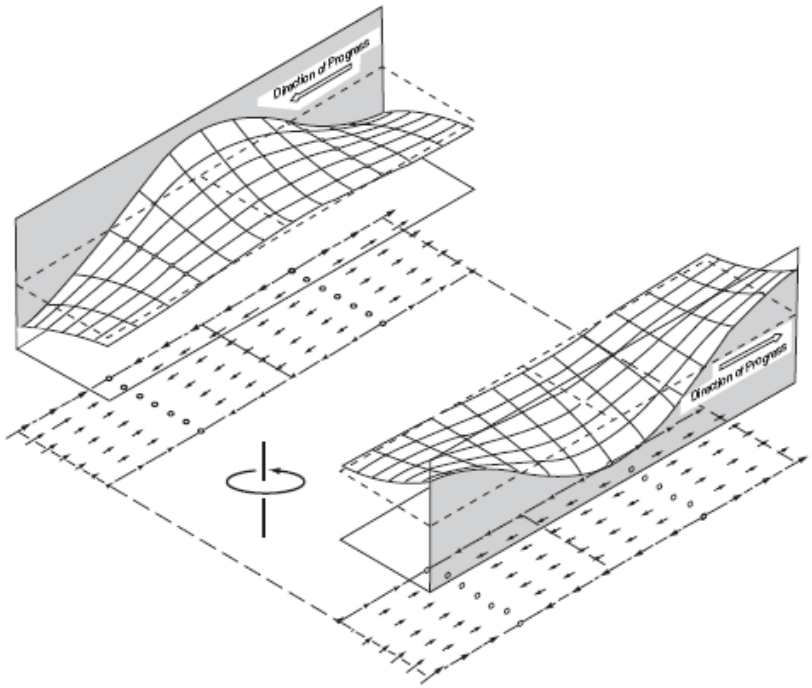
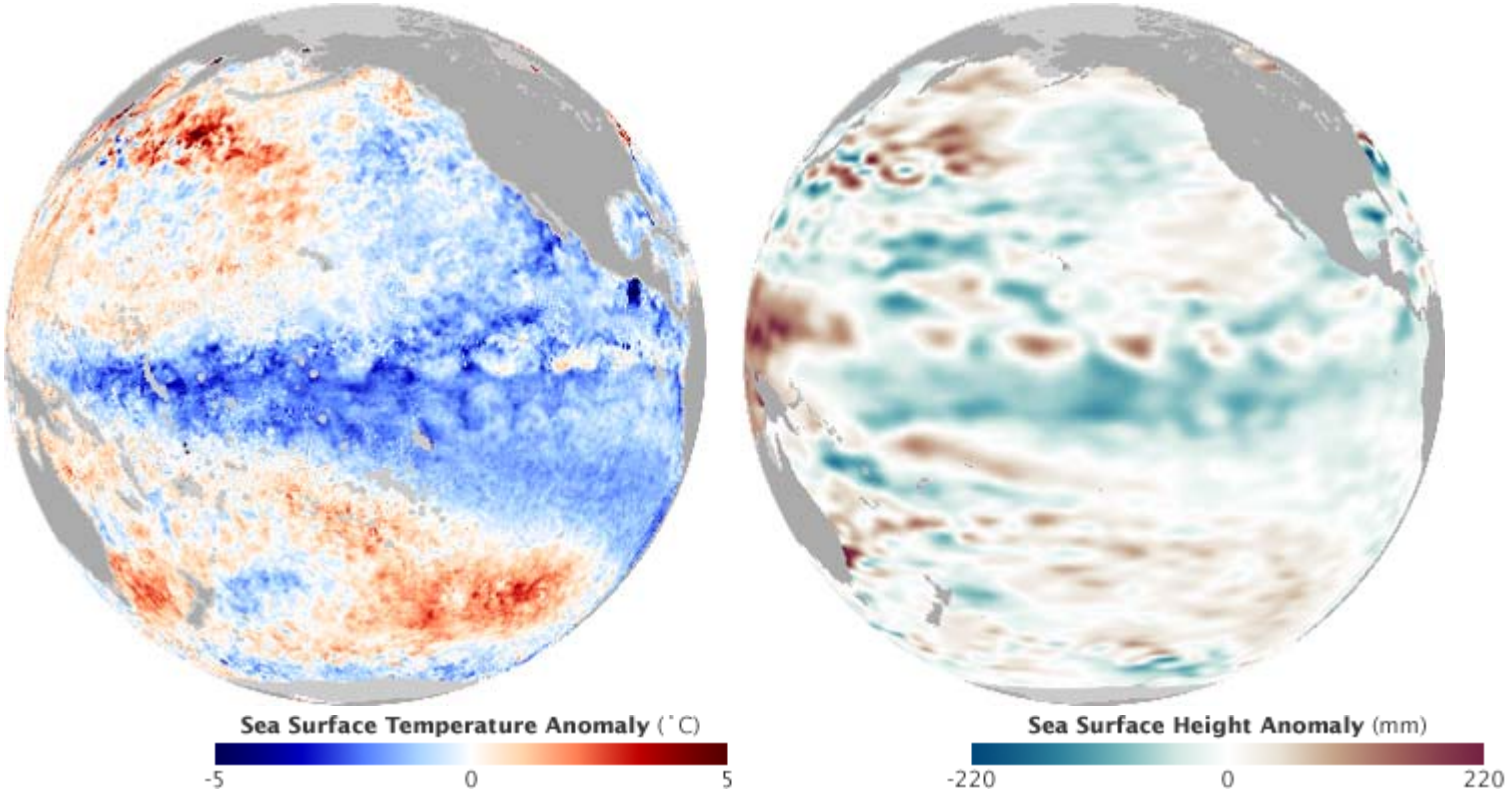


Figure 1 Northern hemisphere Kelvin waves on opposite sides of a channel that is wide compared with the Rossby radius. In each vertical plane parallel to the coast, the currents (shown by arrows) are entirely within the plane and are exactly the same as those for a long gravity wave in a nonrotating channel. However, the surface elevation varies exponentially with distance from the coast in order to give a geostrophic balance. This means Kelvin waves move with the coast on their right in the Northern Hemisphere and on their left in the Southern Hemisphere. (From Mortimer, 1977.)



http://earthobservatory.nasa.gov/IOTD/view.php?id=48141

- Equatorial
- Coastal

http://www.livescience.com/1095-hurricane-created-rare-trapped-wave.html

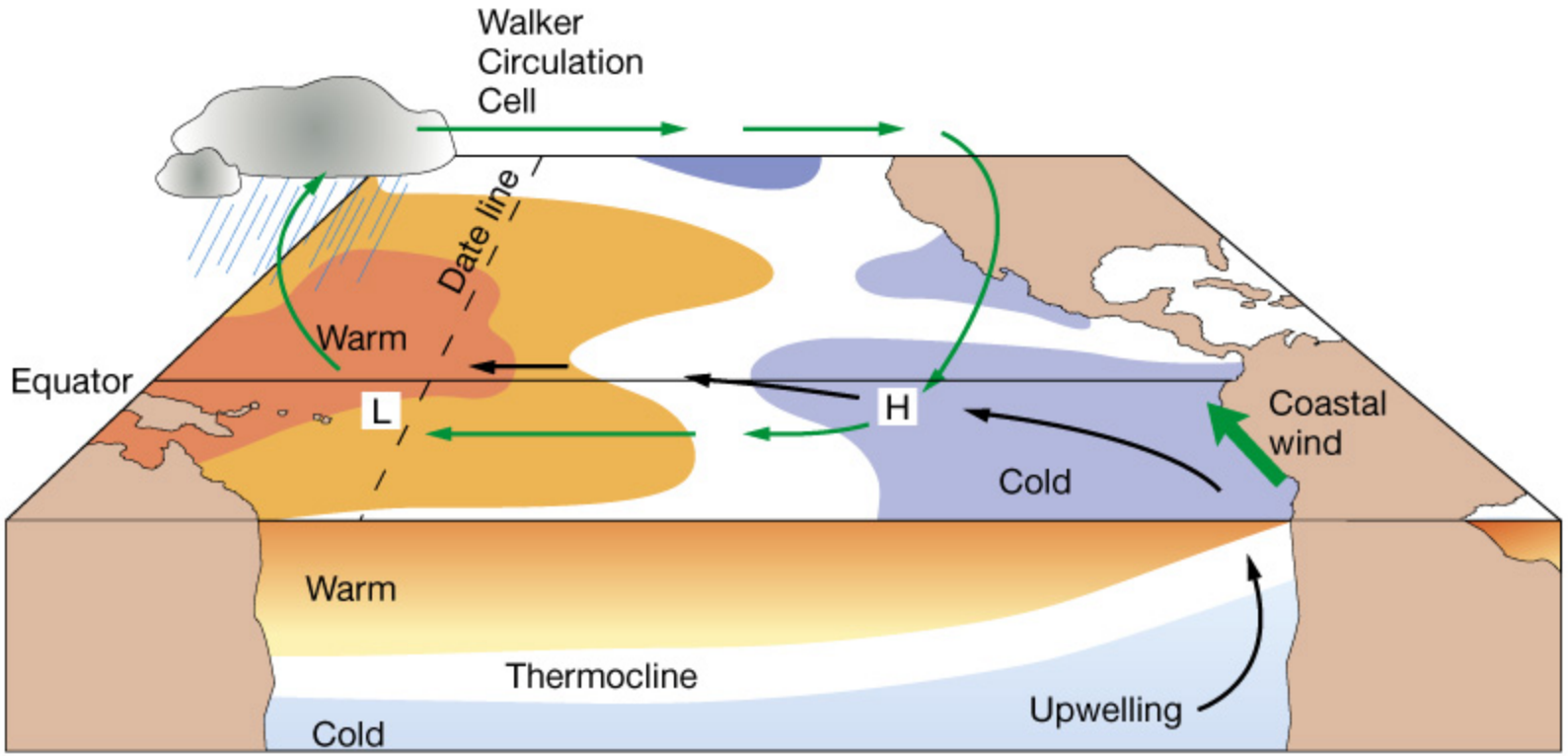
ENSO – El Nino, La Nina

• the *leading source* of natural, interannual variations in weather and climate over large parts of the globe

• driven by changes in atmosphere-ocean circulation over the equatorial Pacific

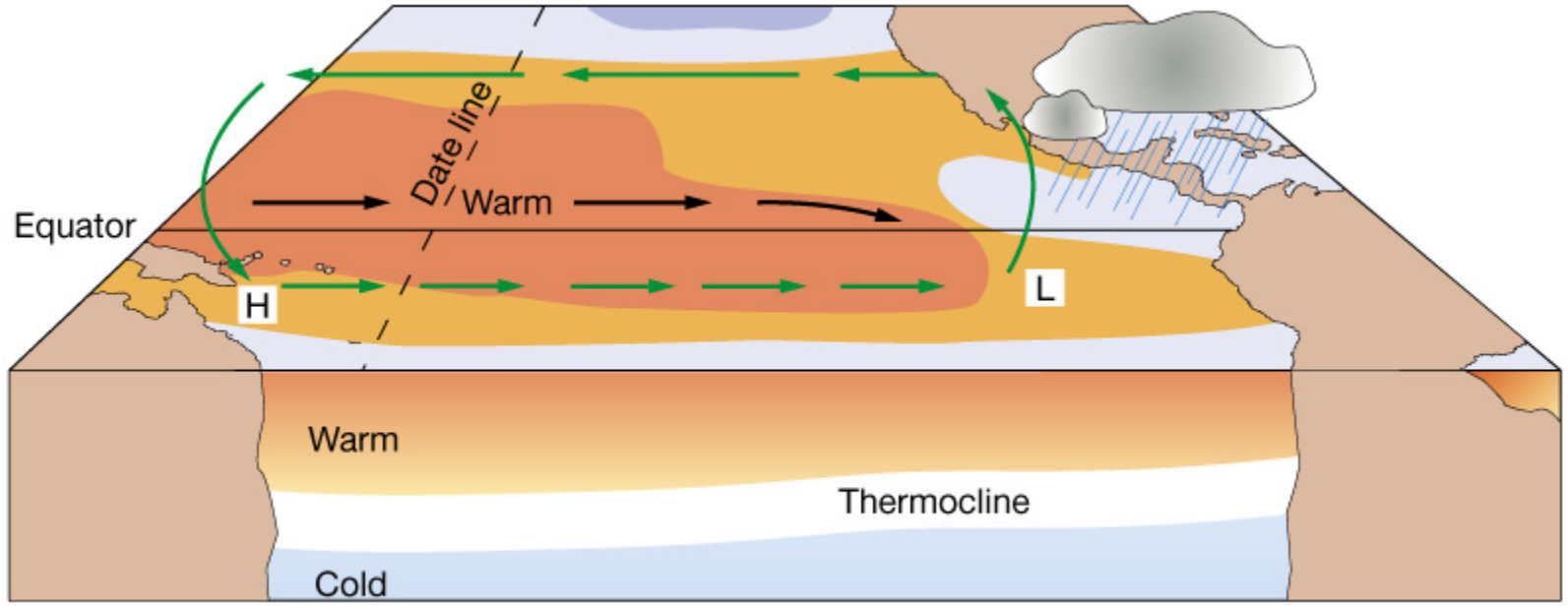
- El Niño = warm surface current in equatorial eastern Pacific that occurs periodically and around Christmastime
- Southern Oscillation = change in atmospheric pressure over Pacific Ocean accompanying El Niño (Darwin / Tahiti)
- ENSO describes a combined oceanic-atmospheric disturbance

Normal conditions in the Pacific Ocean



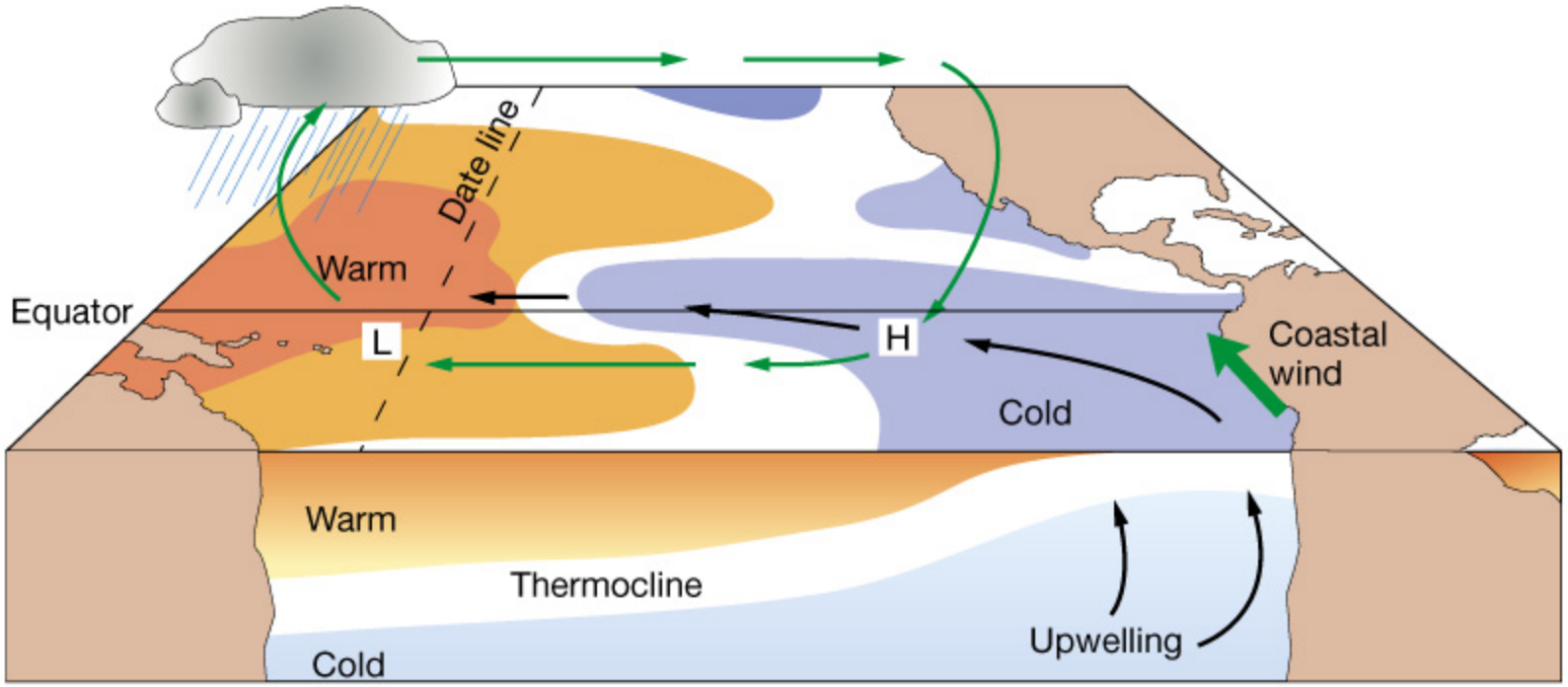
(a) Normal conditions

El Niño conditions (ENSO warm phase)

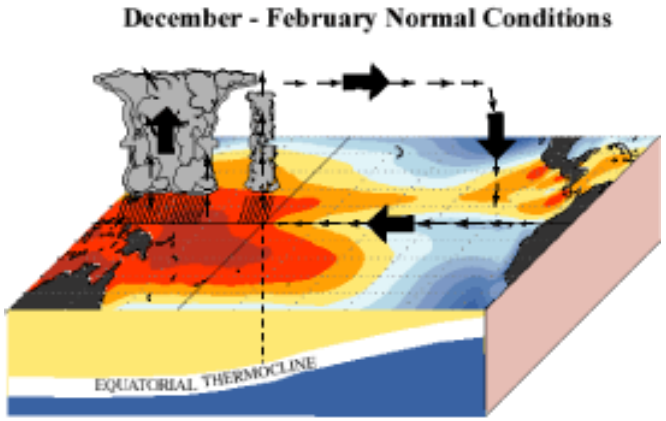


(b) El Niño conditions

La Niña conditions (ENSO cool phase; opposite of El Niño)



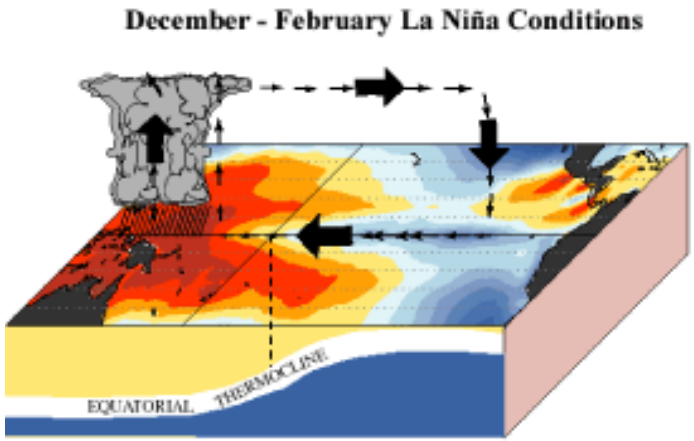
(c) La Niña conditions



ENSO

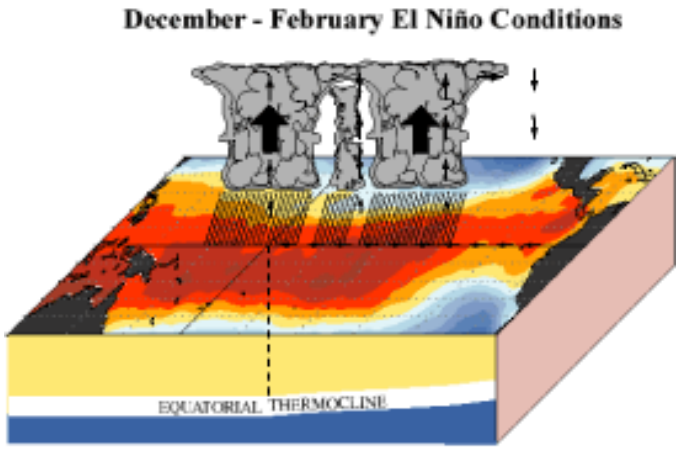
- both states recur every 2-7 yr
- usually reach max Dec-Feb
- last ~9-12 months (or more)

La Niña



Strong easterlies (high SOI)
Strong eastern upwelling (cold SSTs)
Heavy rainfall in western warm pool

El Niño

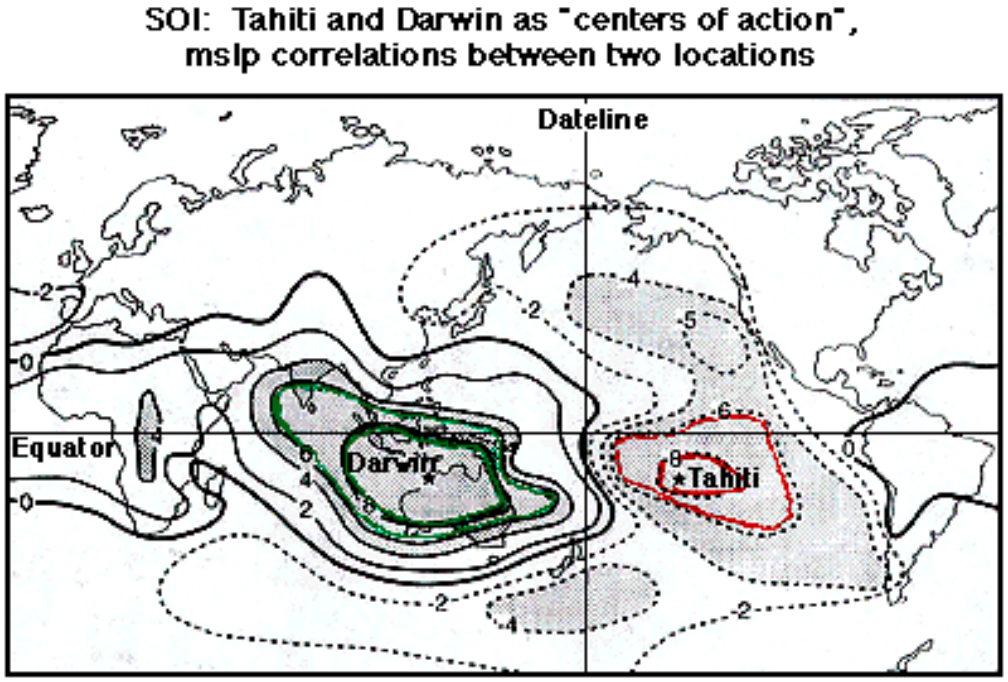


Weak easterlies (low SOI)
Weak eastern upwelling (warm SSTs)
Eastward shift in rainfall

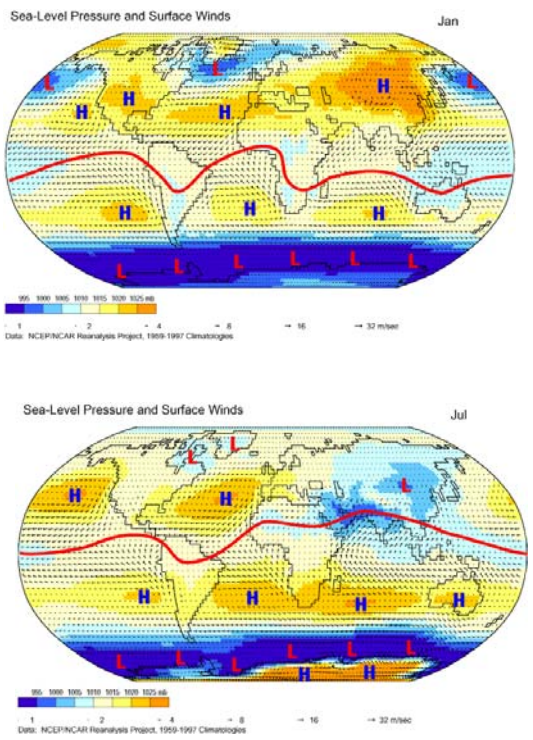
- relative strengths of western L and eastern H vary with time
- implies that something must disrupt the feedback (long waves)
- ‘seesaw’ between strong L/H and weak L/H is called:

Southern Oscillation

- standard measure (SO Index) is simply the sea level pressure difference between Tahiti (H) and Darwin, Australia (L)

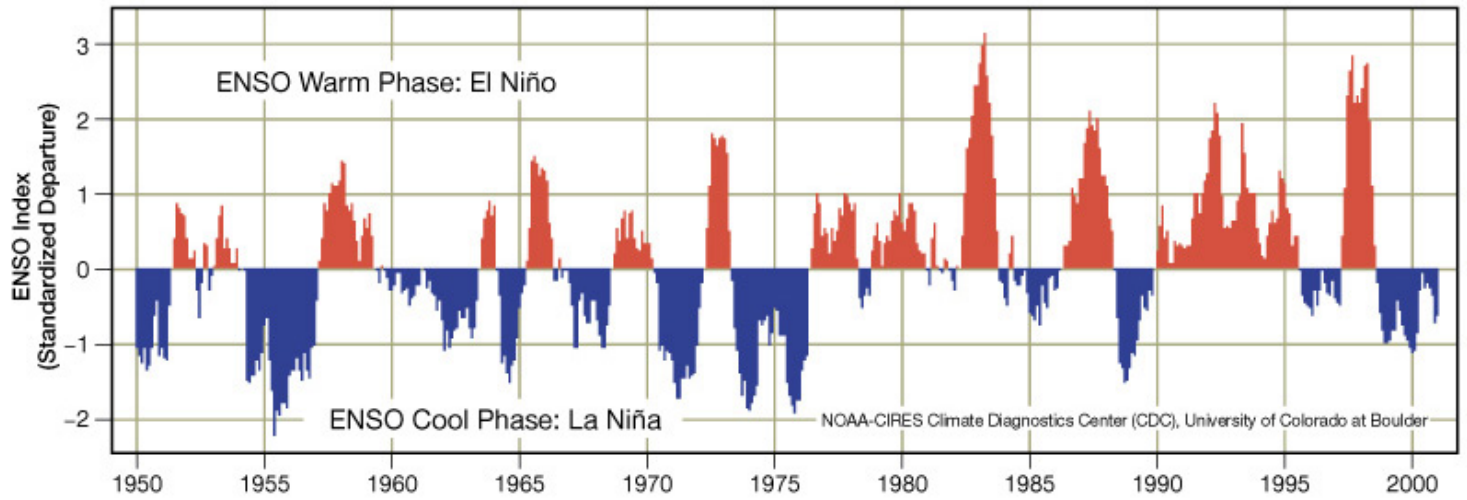


ITCZ Shift



El Niño recurrence interval

- Typical recurrence interval for El Niños = 2-12 years
- Pacific has alternated between El Niño and La Niña events since 1950



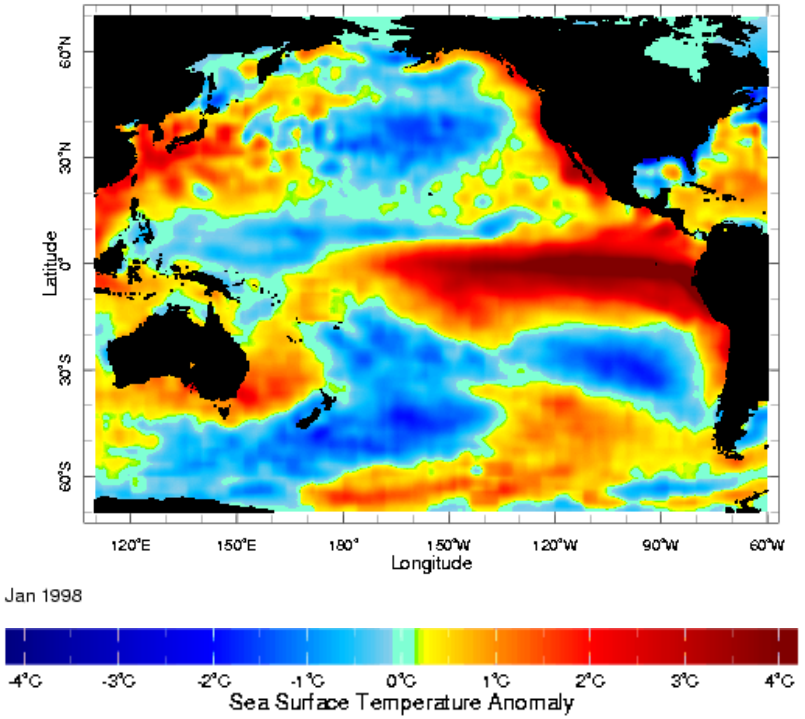
Sea Surface Temperature

http://www.youtube.com/watch?v=vTig9gKegQk

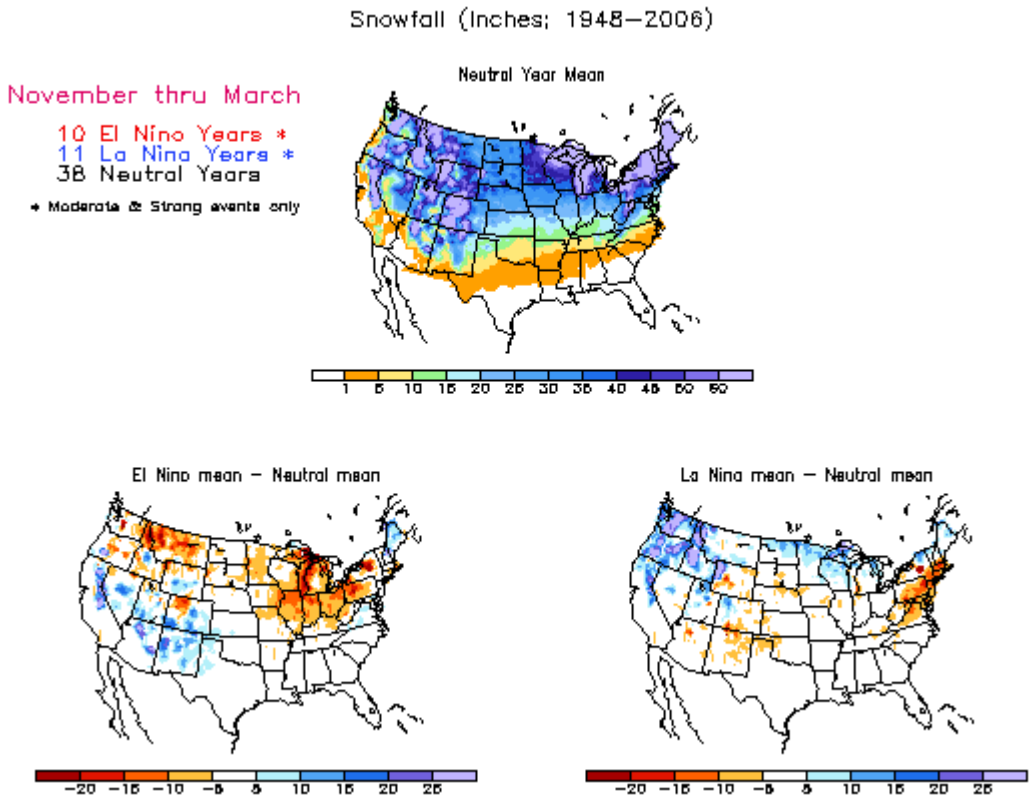
http://www.youtube.com/watch?v=DbNzw1CCKHo&feature=related

The 1997-98 El Niño

Sea surface temperature anomaly map shows warming during severe 1997-98 El Niño



US Climate effects

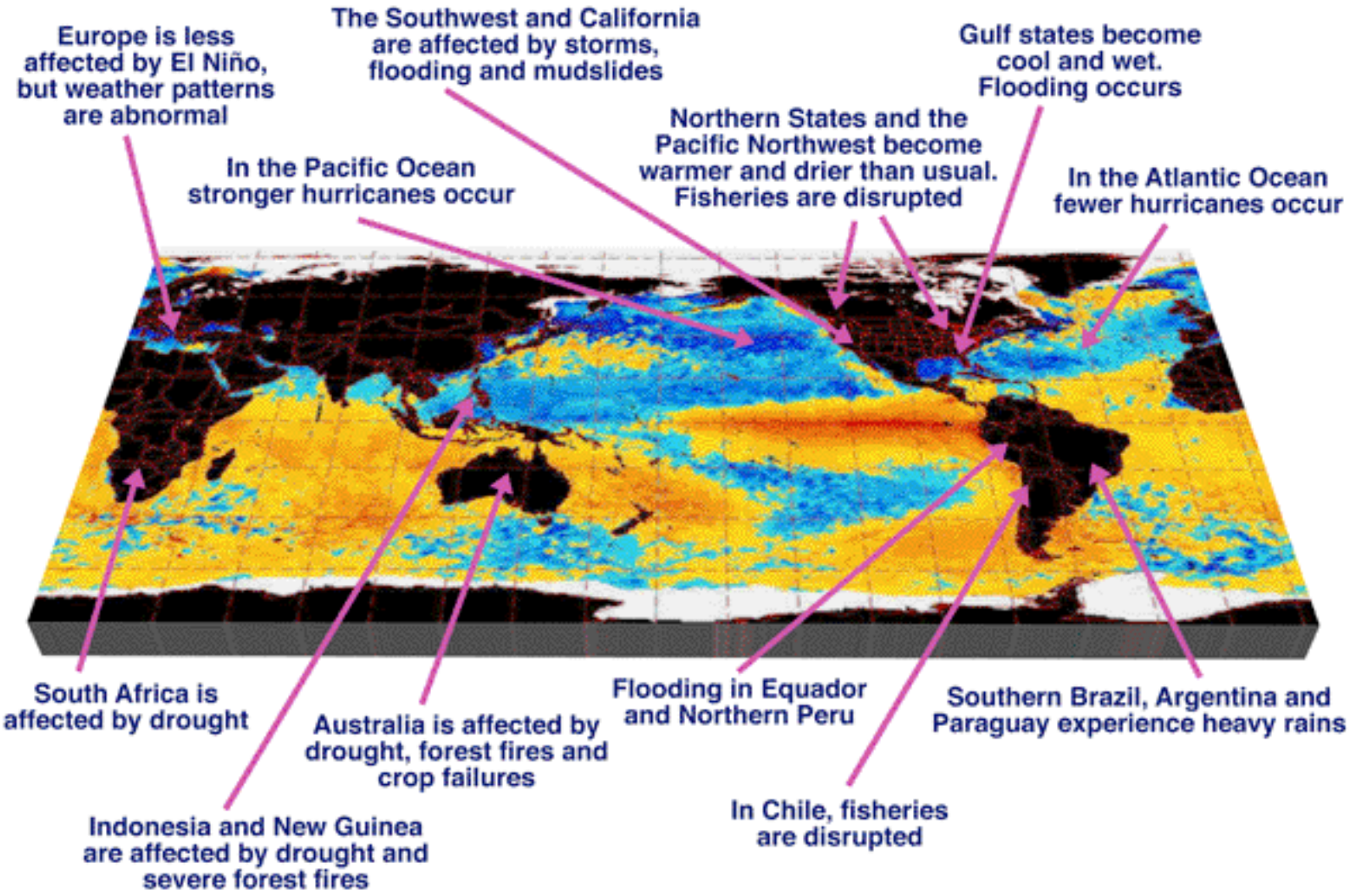


ENSO in Popular Culture

Mean seasonal snowfall (November - March 1948 through 2006) in inches for Neutral years (top). Lower left map is the difference in snowfall between El Niño years and Neutral years. Lower right map is the difference in snowfall between La Niña years and Neutral years. Data are analyzed on a 2.5º latitude x 2.5ºlongitude grid. Note that the Neutral year composite includes weak ENSO years.

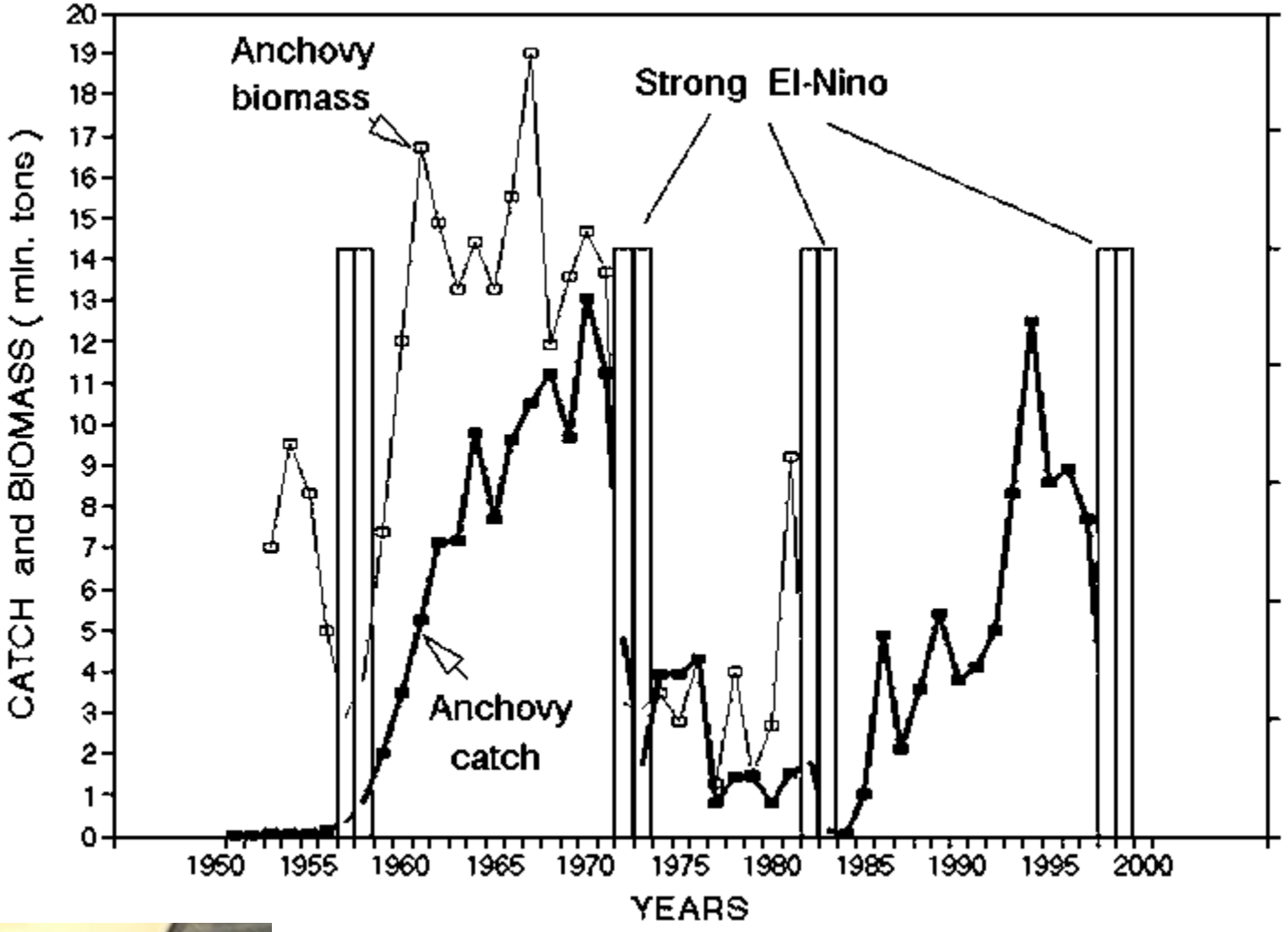
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/us_impacts/ustp_impacts.shtml

The Global Impact of El Niño



http://serc.carleton.edu/eet/pmel/case_study.html

Fisheries Impcts



End