

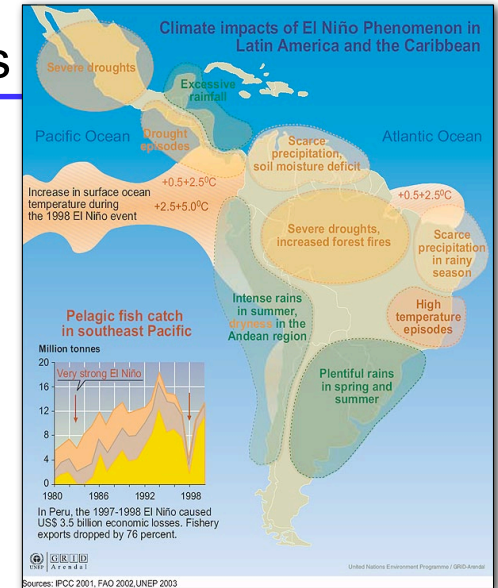
Pacific Ocean Monitoring



- Why all this effort to monitor conditions in the equatorial Pacific?
 - El Niño
- “The (male) Child”
 - Name originates from coastal Peru
 - Refers to Jesus Christ
 - Typically observed in December every 3–7 years
 - Humid, wet cloudy weather instead of dry
 - Ocean turns warm
 - Fishing collapses
 - Torrential rains & mudslides

Niño Impacts

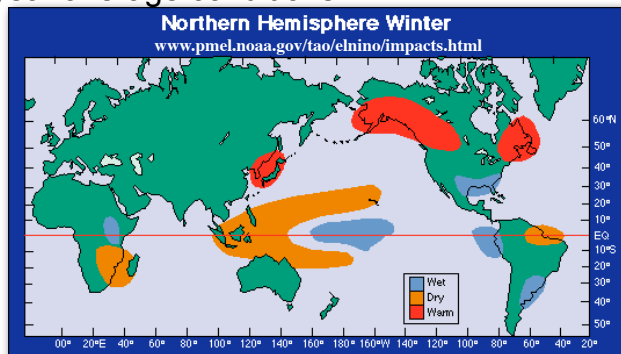
- Global climate disruption
 - Floods
 - Drought
 - Erosion
 - Famine
 - Wildfires
 - Fisheries
 - Coral reef mortality



Niño Global Weather Impacts



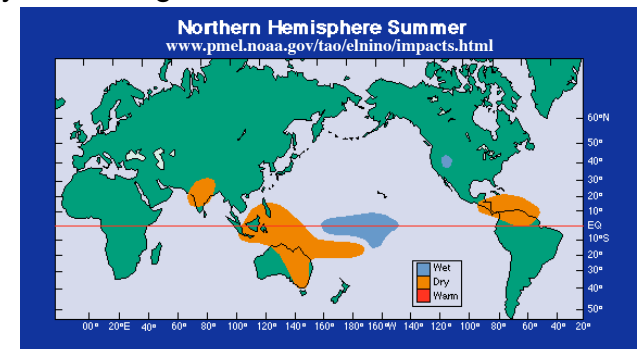
- Niño impacts propagate globally
 - “Teleconnections”
 - Multi-year average conditions



Niño Global Weather Impacts



- Consistent drought in W. Pacific
 - Monsoon failure in India
 - Multi-year average conditions



Niño Global Weather Impacts

- Floods & mudslides in Peru & Ecuador
 - Reversal of pressure & precipitation pattern
- Coastal erosion California
 - Diversion of storm track



5 www.cnn.com/SPECIALS/el.nino/

www.ucsc.edu/currents/00-01/01-08/coastal.html

Niño Global Weather Impacts

- Monsoon failure drought in India
 - Reversal of normal atmospheric pressure & precipitation pattern
- Wildfires in Indonesia

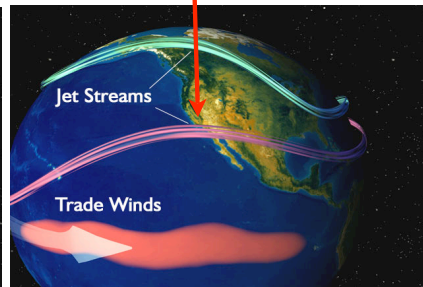


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www.cnn.com/SPECIALS/el.nino/

Niño Global Weather Impacts

- Displaces jet stream and storm tracks at higher latitudes
 - Consistent storm track through California & southern US



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www.nasa.gov/vision/earth/lookingatearth/el_nino_split.html

Niño US Weather Impacts

- California coast erosion
- Flooding in southern tier states



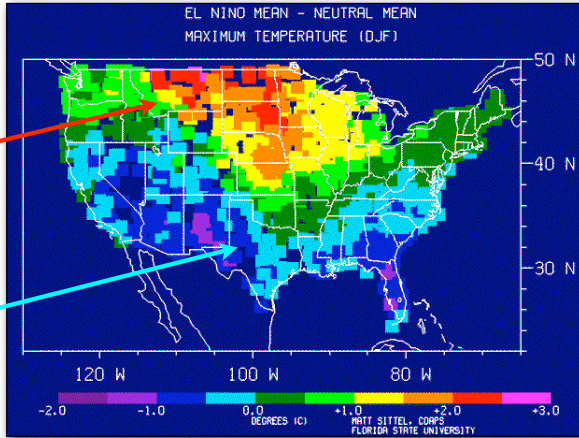
8

www.weatherstock.com/el_nino_cat3.html

Niño Impacts on US Winter



- Warmer in NW, NE & especially northern plains
- Cooler along southern tier states

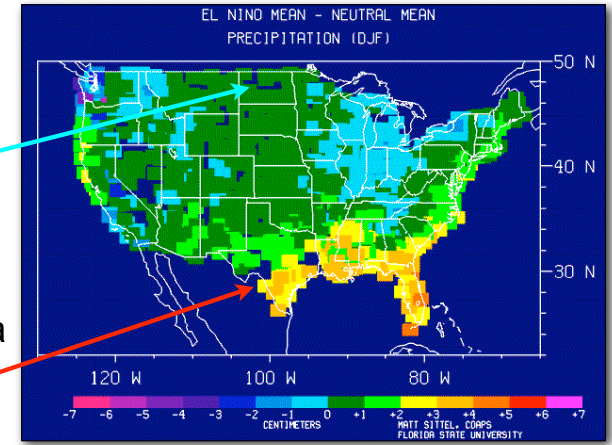


<http://www.pmel.noaa.gov/tao/elnino/impacts.html>

Niño Impacts on US Winter



- Near-average precipitation in northern states
- Wet in N. California & along Gulf Coast

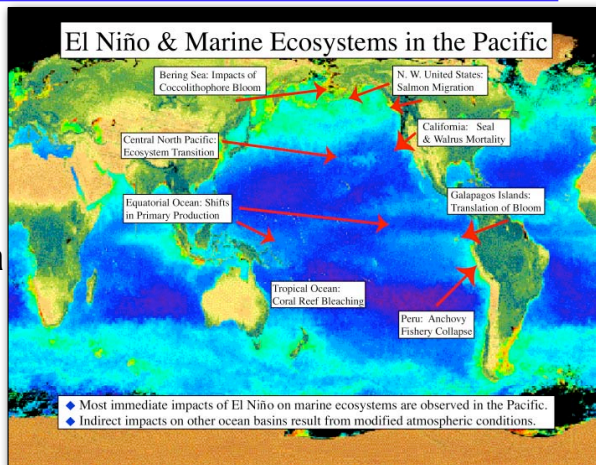


<http://www.pmel.noaa.gov/tao/elnino/impacts.html>

Niño Biological Impacts



- NW poor salmon returns
- Diverted migration
- California marine mammal die-offs
- Peru fish crash

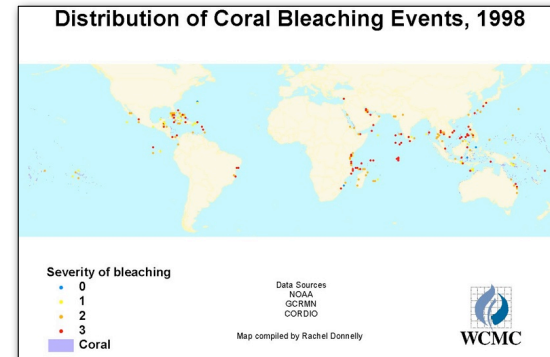


oceancolor.gsfc.nasa.gov/SeaWiFS/BACKGROUND/Gallery/index.html#p5

Niño Biological Impacts



- Coral reef bleaching caused by high temperatures



www.toptotop.org/climate/coralreef.php
www.unep-wcmc.org/climate/activities.htm

Niño Impacts



- Last “Super-Niño” 1997–98
 - Estimated global cost \$32 billion & 23,000 deaths
 - Despite accurate predictions
- Previous strong Niño 1982–83
 - \$8+ billion global impact
 - Was not forecast, no early warning
 - Prompted creation of equatorial buoy array
 - Also satellite monitoring & computer modeling

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www.uswaternewss.com/archives/areglobal/9scirep3.html

El Niño



- A shift in the asymmetrical pattern that produces eastern & western boundary currents in the ocean basins
 - Originates in equatorial Pacific
 - Named for effects on Peru coast at Christmas
- Closely related to changes in atmospheric pressure, winds, and precipitation
 - Global weather effects
 - Lasts 6-18 months

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El Niño – La Niña Cycle



- El Niño (the boy) is actually one half of a cyclical pattern
 - Counterpart is “La Niña” (the girl)
 - La Niña was once considered “normal” and El Niño anomalous
 - Before the cyclic pattern was evident
- “ENSO” = El Niño – Southern Oscillation
 - Oscillation refers to cyclical pattern in change of atmospheric pressure in equatorial Pacific

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La Niña (“Normal”) Conditions



- Strong upwelling off the Peruvian coast in southern hemisphere summer
 - Sea level is low, surface water is cold
 - High atmospheric pressure, dry conditions
 - Strong easterly trade winds (high toward low pressure)
- Opposite conditions in W. Pacific (Indonesia)
 - Sea level is high, surface water is warm
 - Low atmospheric pressure, wet conditions
 - Weak upwelling
 - Strong easterly trade winds

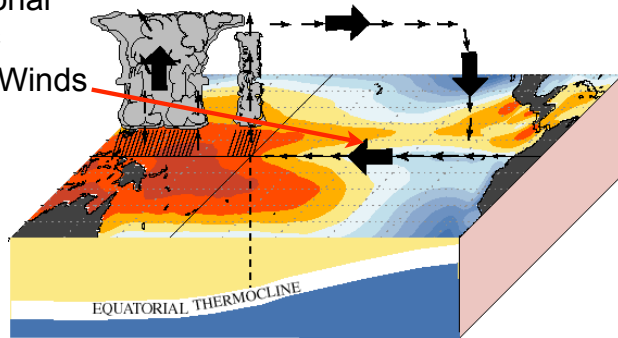
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“Normal” Pacific Equator



- “Normal” sea surface temperature, convection & precipitation **December - February Normal Conditions**

- Equatorial Pacific
- Trade Winds



El Niño Conditions



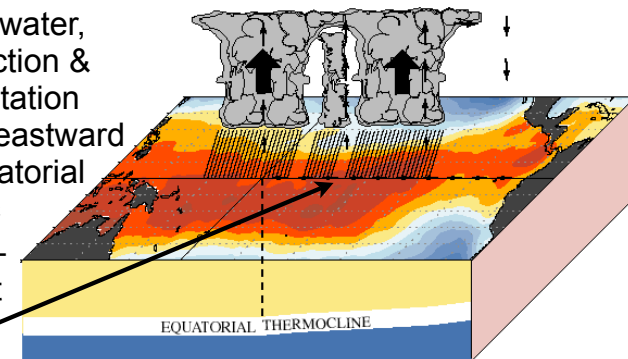
- Niña atmospheric pattern shifts eastward
 - Complex mechanism is not fully understood
 - Irregular intervals ranging from 2–7 years
- Atmospheric pressure pattern does reverse
 - Low off Peru and high over Indonesia
 - Drought in W. Pacific & floods in E. Pacific.

Convection & Rain Change



- “Niño” sea surface temperature, convection & precipitation **December - February El Niño Conditions**

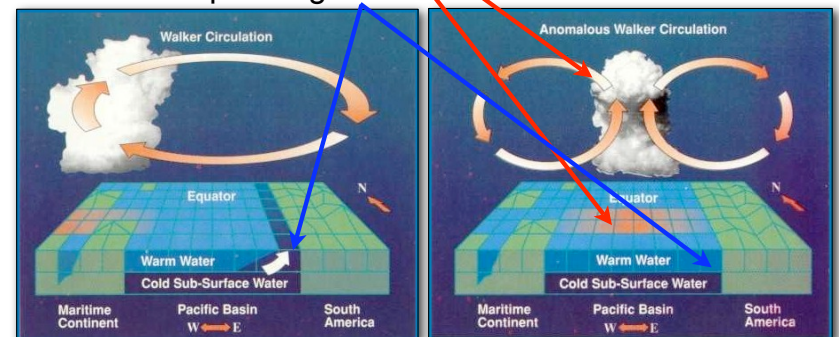
- Warm water, convection & precipitation move eastward in Equatorial Pacific
- Weak - absent Trade Winds



“Normal” vs. Niño Convection

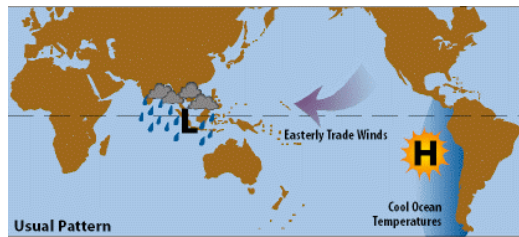


- Convection & warm pool shift to central Pacific
 - Peru upwelling weakens

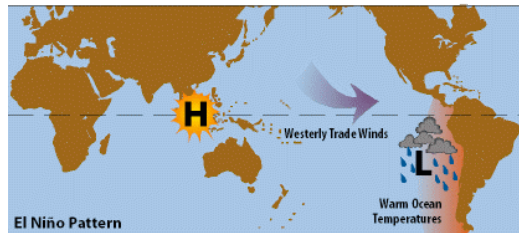


“Normal” vs. Niño Atmosphere

- “Normal” = La Niña



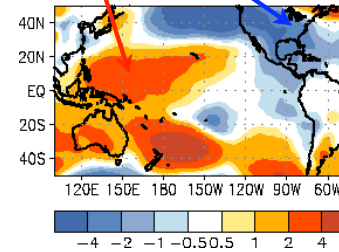
- El Niño



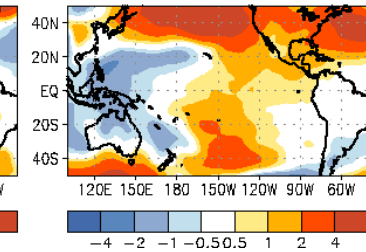
Atmospheric Pressure Change

- Red = High pressure anomaly
- Blue = Low pressure anomaly

PRESSURE DEPARTURES (mb)
EL NIÑO
 Jan-Mar 1998

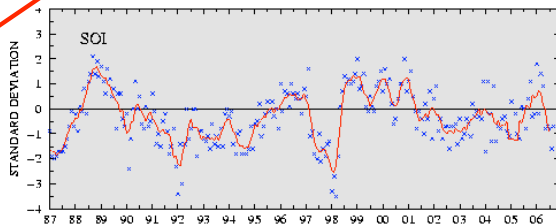
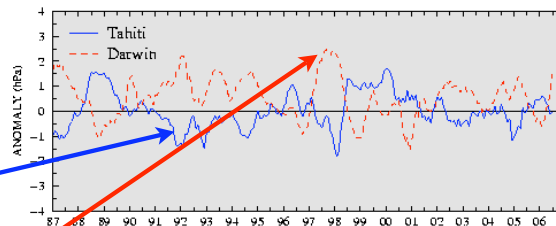


LA NIÑA
 Jan-Mar 1989



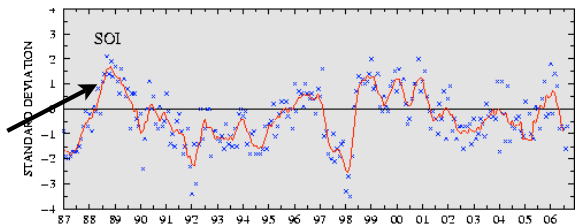
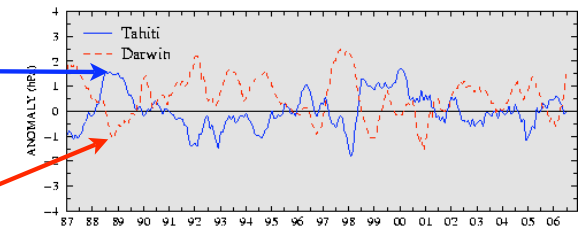
Southern Oscillation Index

- Atmos pressure difference between Tahiti (central Pacific) & Darwin (W. Pacific)



Southern Oscillation Index

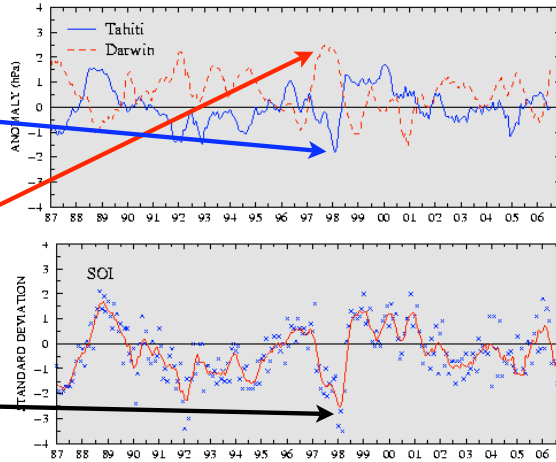
- “Normal” Tahiti = high pressure & Darwin = low pressure
- Positive SOI = Niña



Southern Oscillation Index



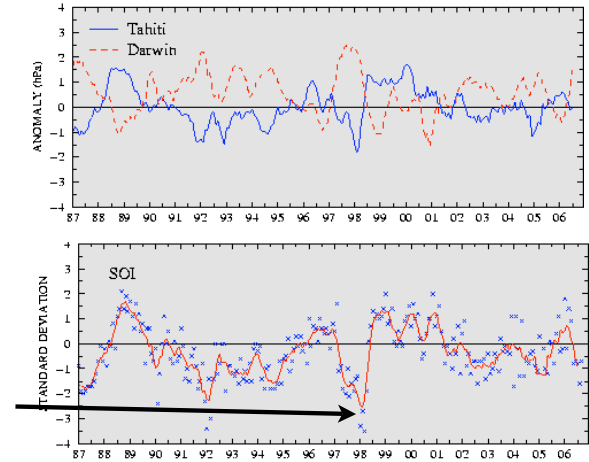
- Niño conditions:
 Tahiti pressure = low,
 Darwin pressure = high
- Negative SOI = Niño



Average ≠ Normal



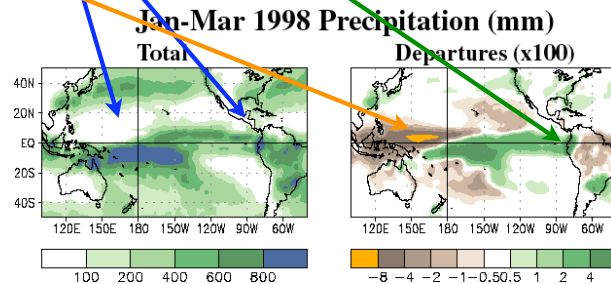
- Notice that Tahiti & Darwin pressure & SOI are almost never average
- “Normal” = variability



Niño Precipitation Change



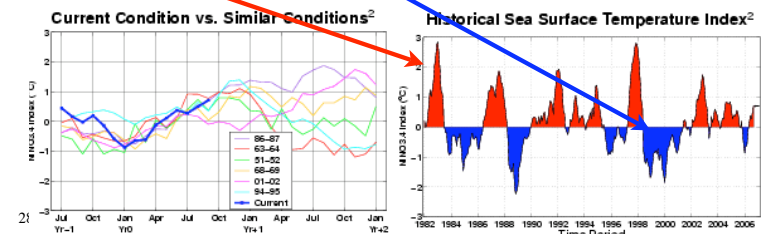
- Absolute precipitation
 - Blue = Wet, White = Dry
- Precip. anomaly (departure from average)
 - Gold/brown = dry, Green = wet



Niño Shifts in Ocean



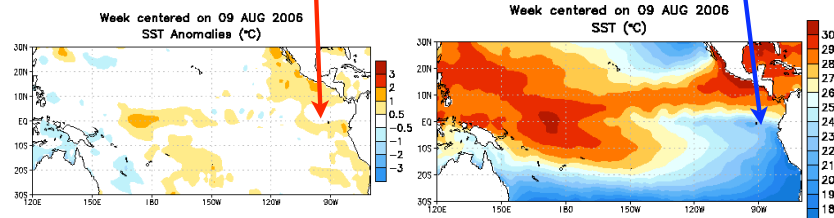
- Sea surface temperature (SST)
 - Warmer off Peru (weaker upwelling)
 - Cooler in W. Pacific
 - Weaker trade winds & transport of warm water
 - “Anomalies” = departure from long-term average
 - Red = Niño, Blue = Niña



Not a Total Oceanic Reversal



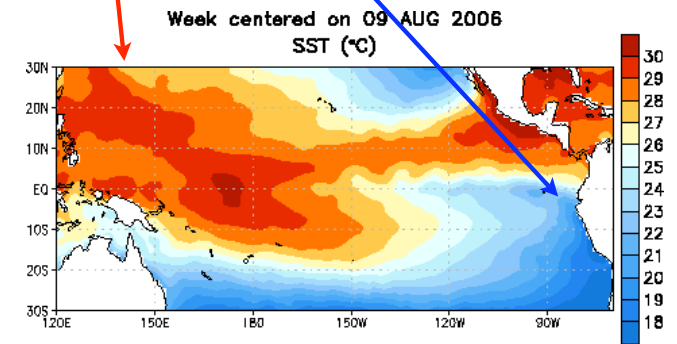
- Only E-W atmospheric pressure & precipitation patterns actually reverse
 - E. Pacific sea surface still cooler than W. Pacific
 - Just not as much cooler as average
 - Warm anomalies = departure from average



Niño Shifts in Ocean



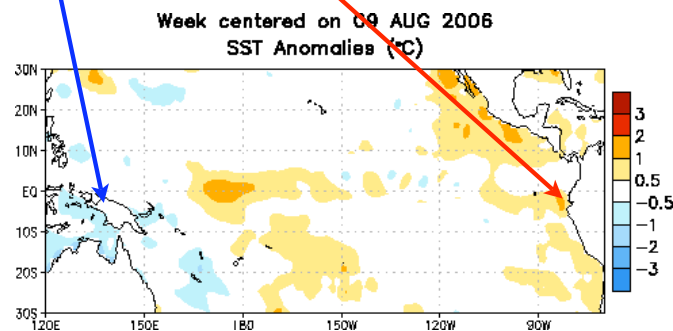
- Sea surface temperature (SST) animation
 - Actual temperatures
 - Still higher to W, lower to E



Niño Shifts in Ocean



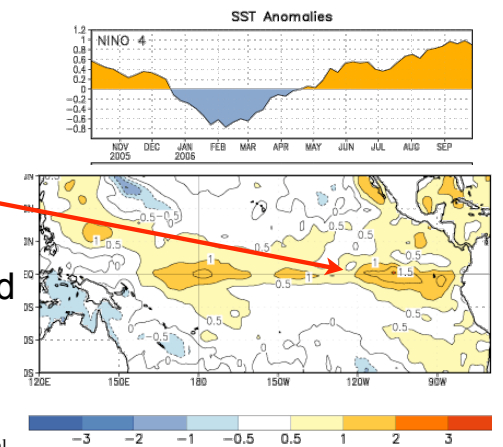
- Sea surface temperature (SST) *anomaly*
 - Departure from long-term average temperatures
 - Negative to W, positive to E



Current Conditions



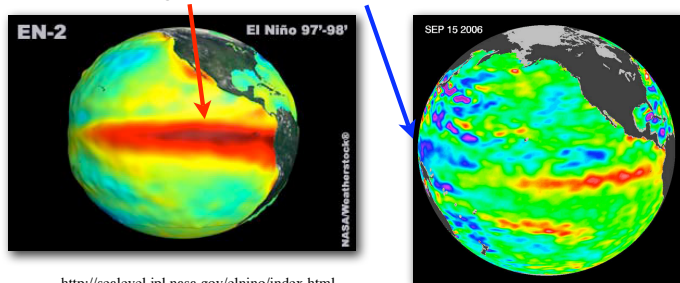
- Equatorial Pacific sea surface temperature anomaly
 - +0.5 - 1.5°C
- Weak trade wind
- Negative SOI



Niño Shifts in Ocean



- Sea level *anomaly*
 - Rises along Peru, falls in W. Pacific
 - Trade winds & Peruvian upwelling weaken
 - Warm water “hill” “sloshes” back eastward
 - Red = high sea level, blue = low



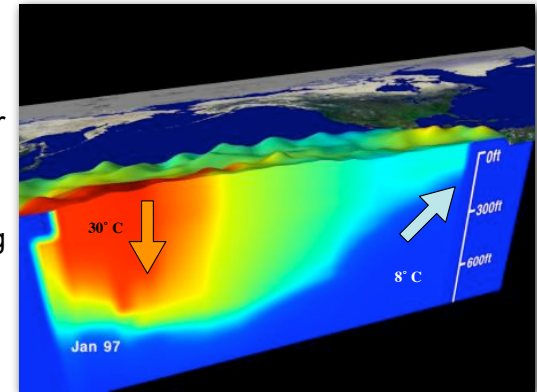
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http://sealevel.jpl.nasa.gov/el_nino/index.html

Sea level & Temperature



- “Normal” = Niña conditions
 - Deep “warm pool” in W. Pacific
 - ~0.3 m higher sea level in W. Pacific
 - Downwelling
 - Shallow cool surface layer in E. Pacific
 - Upwelling



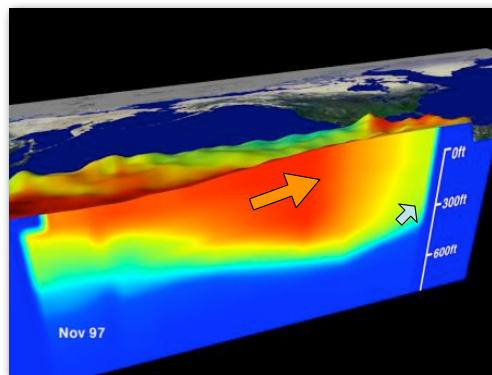
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www.pmel.noaa.gov/tao/el_nino/nino_profiles.html

Sea level & Temperature



- Niño onset conditions
 - Deep “warm pool” moves eastward
 - Sea level in W. Pacific drops
 - Downwelling eases
 - Sea level rises in E. Pacific
 - Upwelling suppressed



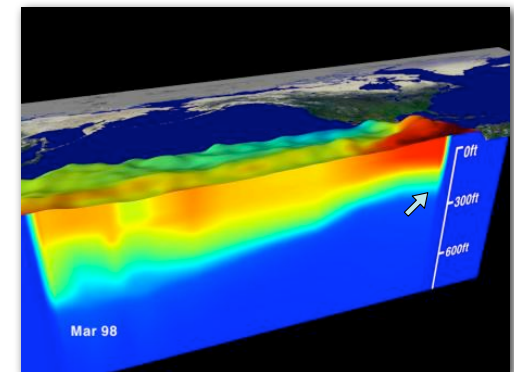
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www.pmel.noaa.gov/tao/el_nino/nino_profiles.html

Sea level & Temperature



- Mature Niño conditions
 - “Warm pool” completely crossed Pacific
 - Higher sea level in E. Pacific
 - Upwelling suppressed



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www.pmel.noaa.gov/tao/el_nino/nino_profiles.html