# El Niño/La Niña

A Modern Day Plague

# Introduction

One thing in our daily lives which affects us and can dramatically change our outlook is the weather. Optimistic plans for a day at the beach can turn bad in a matter of thirty minutes as an afternoon thunderstorm rolls in off the Atlantic Ocean. A rainy day can be brightened by breaking clouds and sunshine. These are just small scale weather processes which can happen anytime.

However, when an El Niño occurs the results are much more devastating to the individuals that feel the affects. Hundreds of thousands can loose their lives and billions of dollars are involved.
Flash floods can rip down mountain sides swallowing unsuspecting villages and their residents in a matter of seconds. Malaria outbreaks from mosquitoes congregating around the left over stagnant pools of water can kill innocent infants. Families can parish from starvation and malnutrition because severe droughts have decimated the seasons crops. Category five hurricanes can shred coastal cities like thin paper with 150 mph winds and twenty-five foot storm surges taking peoples homes, cars, boats and lives in the process. Miles of beautiful enchanting coral communities thriving with color and life can be bleached and drained of life by relentless pools of water reaching 90°F.
Persistent physical oceanographic processes which span hundreds of miles along coastal regions, come to an abrupt and almost total halt. Fisherman go home with empty nets and pockets for months because their lone source of income has migrated to find cooler more productive waters.

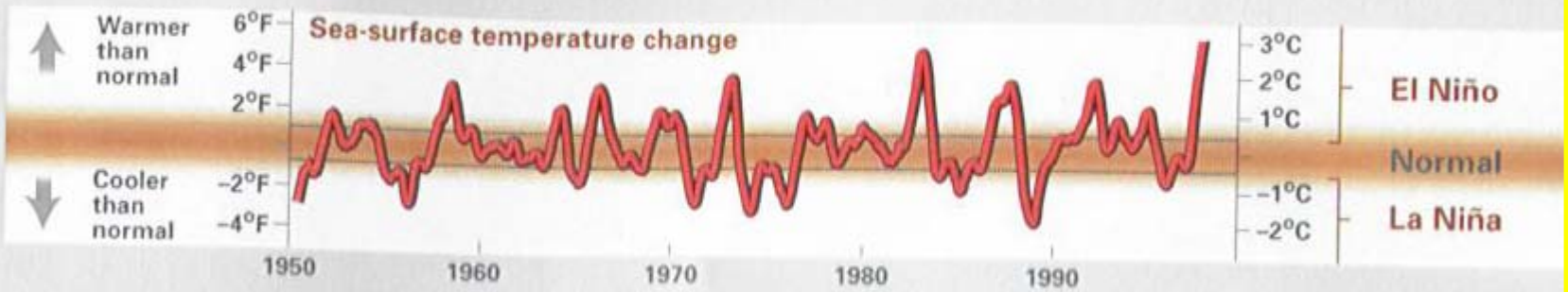
The following presentation is to inform you about the El Niño phenomenon and the effects which accompany this still not understood global event.

# Normal Conditions

Sun heats the ocean surface in western Pacific by Australia & Indonesia, causing hot, moist air to rise creating low pressure on the ocean surface. Moist air rises, cools and falls in the form of precipitation. Parts in this area receive more than 330 inches of rain a year.

The now drier air is pushed east across the Pacific by upper atmosphere winds becoming cooler and more dense. Air eventually sinks creating high pressures off the west coast of the Americas.

Water is then pushed by trade winds back toward Australia & Indonesia, causing hot water to pile up in this area.

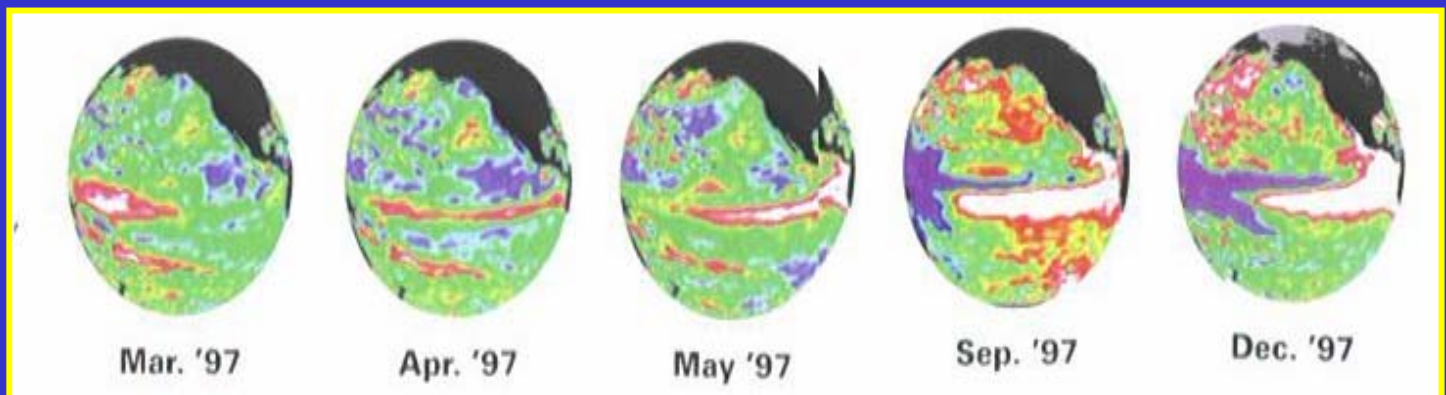



NGM 81

# The El Niño Phenomenon

El Niño is a temporary warming of the eastern Pacific Ocean. For reasons unknown westerly flowing trade winds which cool the Pacific weaken and warm western water creeps east toward South America.

Without the trade winds pushing the water west, surface temperatures in the eastern Pacific increase and the water expands. Eventually deep convection occurs and moist surface air blast into the atmosphere, causing large amounts of rain in the western Americas.



# The effects of El Niño

A severe El Niño causes the displacement of atmospheric pressure cells and affects weather over large areas of the earth. In the 1982-83 El Niño the polar jet stream dropped southward over the Pacific Ocean causing unusually dry conditions to Hawaii and a strong low pressure system to the Gulf of Alaska which resulted in strong winds and lots of rain for the western coast of the United States.

Heavy rains creep in towards Ecuador, Peru and Polynesia due to the convergence of northern and southern trade winds (NGM 99). Draught visited Australia, southeast Africa, southern India and Indonesia due to the cooling of the southwestern Indian Ocean, which strengthens a high pressure area keeping rain fall from the reaching these areas. 600,000 people died in one region of India due to an epic draught in the 1789-93 El Niño (NGM 99).

In the 1982-83 El Niño, the worst on record, ocean temperatures off Peru rose 7° C above normal causing tropical marine species to migrate north as far as the Gulf of Alaska. Also, the number of North Atlantic hurricanes making land fall was drastically reduced because a stronger subtropical jet stream shears off their tops prohibiting a westbound disaster coarse.

The 1991-92 El Niño delivered heavy winter rains o southern California and the U.S. Gulf Coast, and mild, low precipitation winter to the coastal regions of Oregon and Washington. The polar jet steam's southern migration over the northern states also caused heavy snow in New England and Canada. (Duxbury and Duxbury 97)

Coral bleaching was frequent in Australia's Great Barrier Reef because of high sea temperatures. Coral bleaching occurs when the coral tissue expels its zooxanthellae, a symbiotic algae, which lives in the structure of the coral essential to its survival.
http://www.ogp.noaa.gov/misc/coral/coralit.html

# EL NIÑO IMPACTS

## June-September 1997

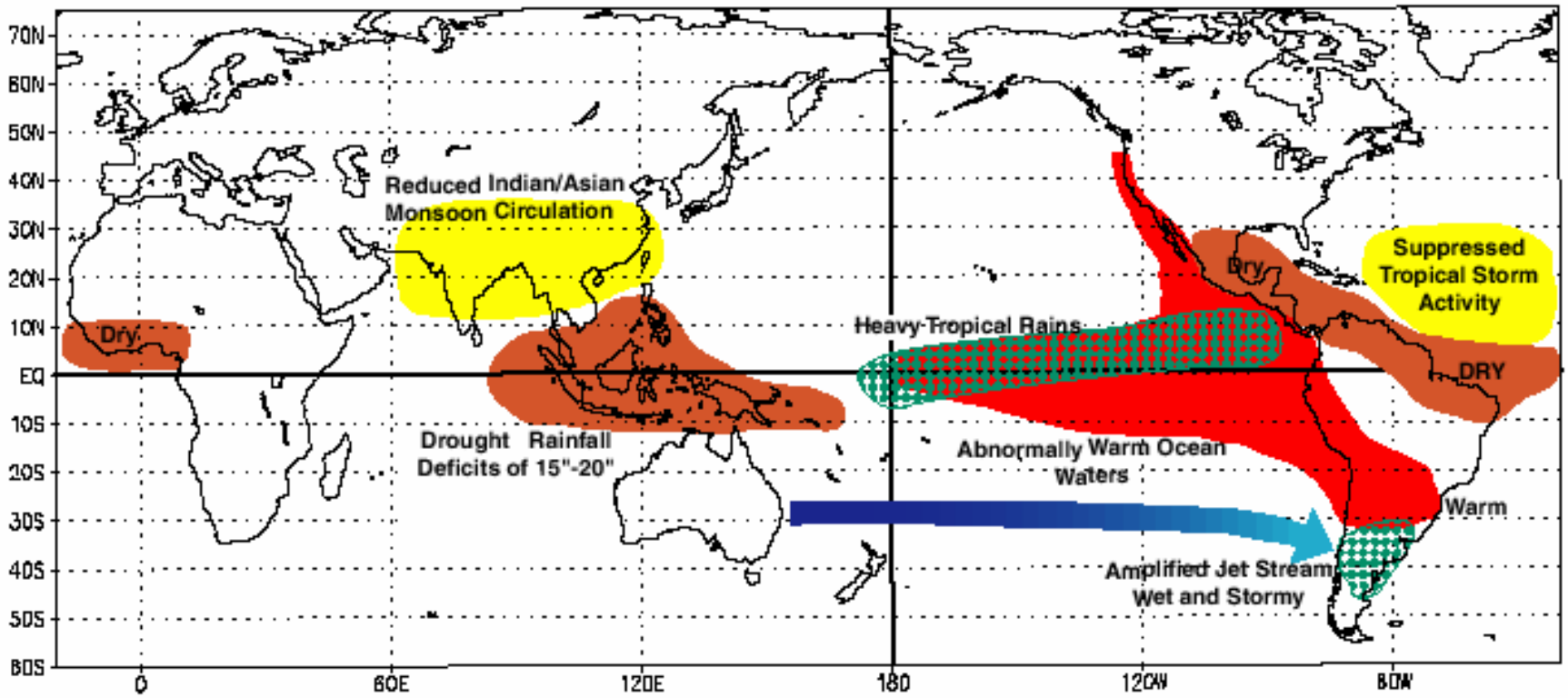


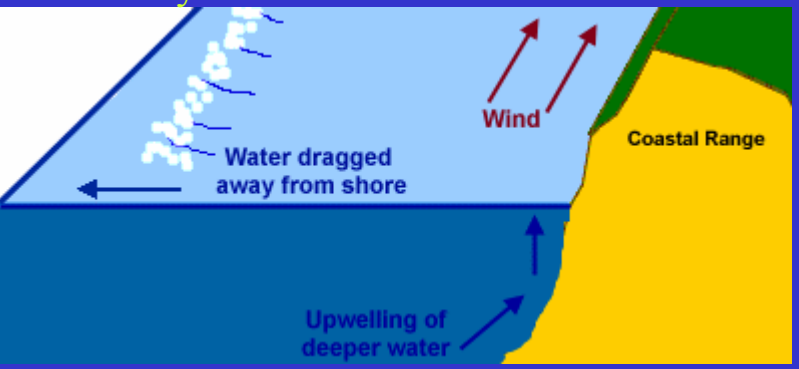

Figure 1. Schematic representation of major El Niño impacts during June-September 1997. The largest impacts thus far have been in the tropics and subtropics, and over the middle latitudes of the South Pacific and South America. The major impacts on the United States are not expected until the winter season.

http://www.nnic.noaa.gov/products/special_summaries/97_3/fig1.gif

# Physical, Biological and Chemical responses to El Niño

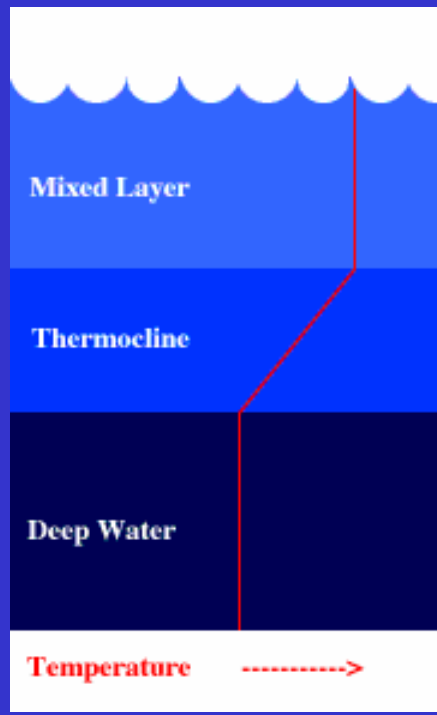
Rain decreases the salinity of the coastal waters, where upwelling has stopped.
Cool nutrient-rich upwelling waters off the coast of Peru are blocked by a 500 ft deep pool of warm water. This causes the anchovy population of Peru to migrate south for better conditions.

http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/eln/upw.rxml
University of Illinois




Ekman transport causes water to be transported
90° to the left of wind in the Southern Hemisphere
and 90° to the right of wind in the Northern Hemisphere

A deeper thermocline often observed during El Niño years limits the amount of nutrients brought to shallower depths by upwelling process, decreases the years fish crop.



# Carbon Dioxide Flux

The surface waters of the central and eastern Equatorial Pacific contain high partial pressure of $CO_2$. The Equatorial upwelling of this area is the atmosphere's largest source of $CO_2$, supplying about 0.7 to 1.5 Pg($10^{15}$). This is four times as much as all the other oceanic regions combined.

El Niño produces large inter-annual effects on ocean-atmosphere $CO_2$ exchange. Non-El Niño years supply a higher flux of carbon out of the ocean than when there is mature El Niño. The high $CO_2$ fluxes in non -El Niño years of 1995-96 were the result of increased surface water $pCO_2$ and higher winds. The Equatorial Undercurrent (EUC) was closer to the surface in 1995-96 and upwelling supplied the higher $pCO_2$ found in the surface waters. During the El Niño years of 1997-98 the winds and EUC were weak and the supply of $pCO_2$ is lower .

In the same equatorial region, data shows that during two separate one year periods in 1995-96 and 1997-98 the release of C as $CO_2$ into the atmosphere was 0.7 Pg ($10^{15}$) less in the El Niño year during 97-98.Fluxes from buoy-measured $\Delta$ $pCO_2$ and winds were also calculated. It showed mature El Niño phase averaged 0.2 mol of C $m^{-2}year^{-1}$ into the ocean and post El Niño phase ranged from 2 to6 mol of C $m^{-2}year^{-1}$ into the ocean (Science 99).

This information suggests that El Niño causes a drastic change in the flux of carbon dioxide in the central eastern equatorial regions. This reduction of carbon dioxide in turn affects the productivity of this area.

**Table 1.** Comparison of physical,chemical, and biological conditions in the central equatorial Pacific for mean, El Niño onset, El Niño mature and La Niña. **( Sience 2128)**

| Condition | Physics | Chemistry | Biology |
|---|---|---|---|
| Mean | Upwelling-favorable trade winds; deep therrmocline in the west, shallow in the east; strong undercurrent | Elevated marconutruients( $NO_3$, $PO_4$, $SiO_4$, and $CO_2$) flux of $CO_2$ out of ocean; iron limitation | Chlorophyll ~ 0.2 to 0.3 μg per liter $^{-1}$; primary production(PP)~ 75 mmol C $m^{-2}$ $day^{-1}$ new production(NP) ~ 15 % of PP |
| El Niño onset | Upwelling favorable trade winds; thermocline deepens in central and eastern Pacific; variable undercurrent | Elevated(but lower than mean) maronutrients; flux of $CO_2$ out of ocean; stronger iron limitation | Chlorophyll < 0.2 μg per liter $^{-1}$ ; PP~ 50 mmol C $m^{-2}$ $day^{-1}$ ; NP ~ 10% of PP |
| El Niño mature | Weak trade winds reducing upwelling; enhanced rainfall; flat thermocline across the basin, recovering in the central and eastern Pacific before SST; weak undercurrent | No enhancement of macronutrients; oligogrophic conditions; flux of $CO_2$ close to zero | Chlorophyll ~ 0.05 μg per liter $^{-1}$; PP~ 35 mmol C $m^{-2}$ $day^{-1}$ ; NP ~ 10% of PP |
| La Niña | Upwelling favorable trade winds; shallow thermocline in central and eastern Pacific; strong undercurrent | Elevated(higher than mean) macronutrients; flux of $CO_2$ out of ocean(stronger than mean); enhanced supply of iron | Chlorophyll < 1 μg per liter $^{-1}$, higher in blooms; PP~ 80 reaching 160 mmol C $m^{-2}$ $day^{-1}$ in blooms; NP ~ 15%of PP, up to 50% in blooms |

# Southern Oscillation

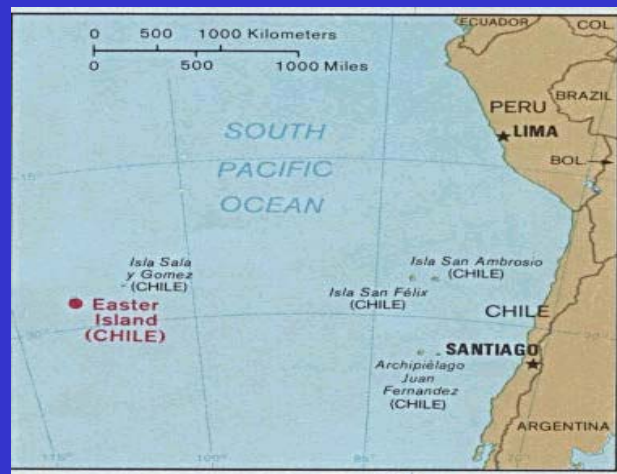
The exact cause of El Niño is still unknown, but the appearance of certain weather processes have been associated with El Niño. One of such processes in Southern Ocean Oscillation (SO). During SO the atmospheric pressure increases on one side of the Pacific and decreases on the other side, and then reverses The pressure centers occuring with this process lie over Easter Island in the eastern Pacific and Indonesia in the western Pacific. Normally there is a high pressure system over Easter Island and a low pressure system over Indonesia. East blowing trade winds are strong and consistent and upwelling occurs off of Peru's coast. When the atmospheric pressure system weakens, the trade winds break down. Westerly winds are formed due to tropical low pressure areas that develop over accumulated warm water near Indonesia. Over a few months, the warm water moves east towards Peru, eventually increasing sea surface temperatures and suppressing upwelling.

The pool of warm surface water carries the overlying low- pressure zone of rising air and precipitation eastward across the Pacific, eventually resulting in heavy rains on the normally dry coastal regions of Peru.

http://www.1000traveltips.org/Indonesia.htm


Indonesia

http://www.netaxs.com/~trance/ra anui.html



# The Doldrums

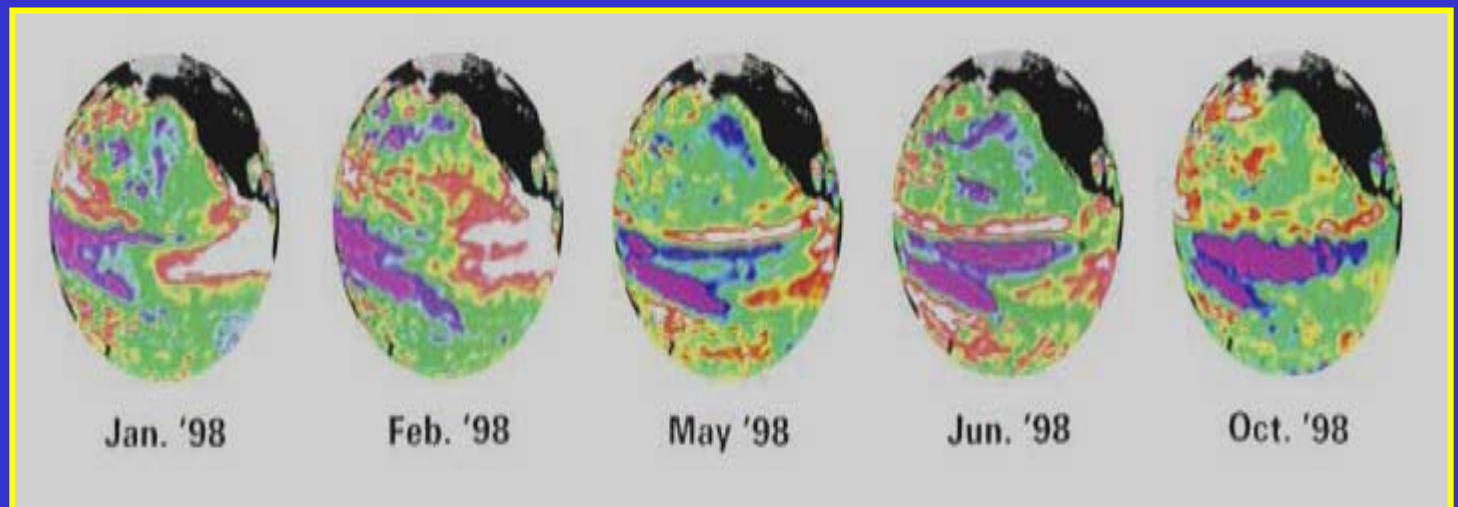
The southward displacement of the inter-tropical convergence zone(downwelling), also refereed to as the Doldrums,is another sign of El Niño. This movement of the south coincides with a lessening of the southeast trade winds and development of a deep thermocline in the south west tropical Pacific. This southern shift occurs early in the year, when the southeast trade winds are at a minimum and sea surface temperatures are at a maximum. The coming of an El Niño is associated with a greater-than-average southward deflection of the doldrums.

By mid-summer, the El Niño effect lessons; in two to three months the surface water cools as upwelling is reestablished in the eastern tropical Pacific. In November and December another slight warming is often observed; the atmospheric pressure distribution in the Southern Ocean Oscillation reverses again, and the trade winds return to their normal state. A severe El Niño usually lasts about 15 months.

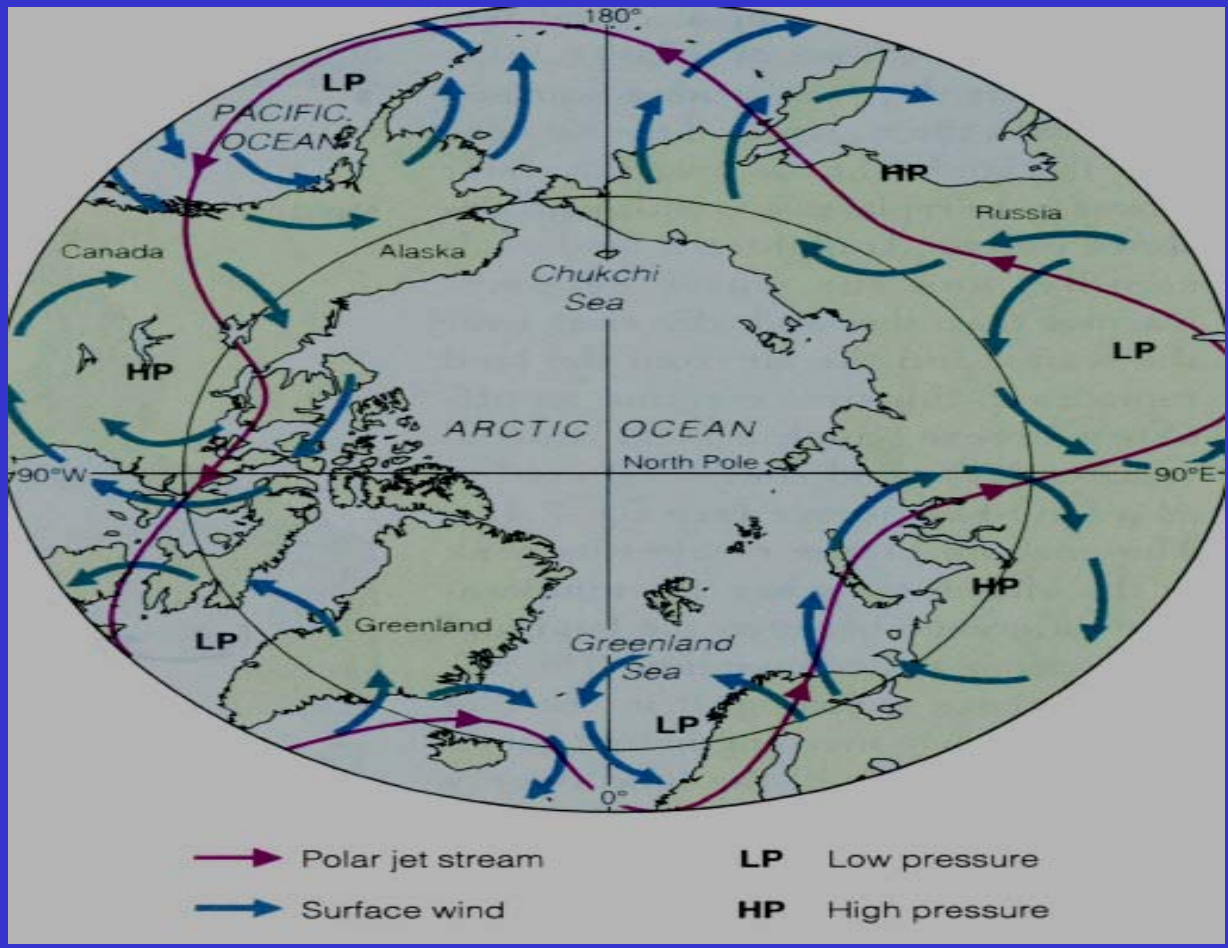
# The La Niña Phenomenon and affects

During a La Niña event cooling of the eastern Pacific causing opposite conditions produced during an El Niño event. Westbound trade winds are intensified, pushing warm western Pacific water further west, causing more precipitation in India, Australia and southwest Africa.

The polar jet stream in Canada moves south causing colder temperatures in the southern U.S.



# Jet Streams




The polar jet stream circles the earth in the Northern Hemisphere above the boundary between the polar easterlies and the westerly winds. Its is deflected north and south by the alternating air-pressure cells of the northern temperate zone (Duxbury and Duxbury 214).

# The La Niña Phenomenon and affects

The subtropical jet stream, which blows across the Gulf of Mexico is weakened by a difference in atmospheric pressure systems the northeast Pacific Ocean, so draught occurs in the southwestern U.S. and the Atlantic hurricanes reaching the U.S. increase

The 1998 La Niña hurricane season was the deadliest of the past two centuries(NGM 99). Hurricane Mitch alone killed 11,000.

http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.html

# Forecasting & Prediction

**NOAA** has the primary responsibility within the Federal Government to provide climate forecasts to the nation and play a leadership role in sponsoring El Niño observations and research
Most NOAA groups and services are in some way involved.

**Climate Prediction Center** is responsible for forecasting rain fall percentage and drought conditions in many countries.

**Office of Global Programs** funds scientific research focused on El Niño.http://www.ogp.noaa.gov/enso
*Contact: Stephanie Kenitzer at (301) 713-0622*

**Climate Diagnostic Center** explores climate variations like draught and floods and is working to a better understanding and prediction of ENSO. http://www.cdc.noaa.gov/ENSO

*Contact: Barbara McGehan at (303) 497-6288*

**Hurricane Research Division** in cooperation with academic institutions studies the relationship between hurricanes and climate events like El Niño.

at http://www.aoml.noaa.gov/hrd/
*Contact: Dane Konop at (301) 713-2483*

# Forecasting & Prediction

**Pacific Environmental Marine Lab** is responsible for installing and maintaining a network of buoys (ATLAS) in the tropical ocean which record wind temperature and currents.

http://www.pmel.noaa.gov/toga-tao/el-nino/home.html
*Contact: Dane Konop at (301) 713-2483*

**NOAA Corp** maintains The *Ka'imimoana*, the R/V which supports a system a 70 buoys(Tropical Atmosphere- Ocean. The buoys measure wind direction and speed, temperature and humidity and temperature of the ocean at the surface and various depths to 500 meters. The buoys help scientist predict the movement of warm water and earlier forecasting of El Niño.

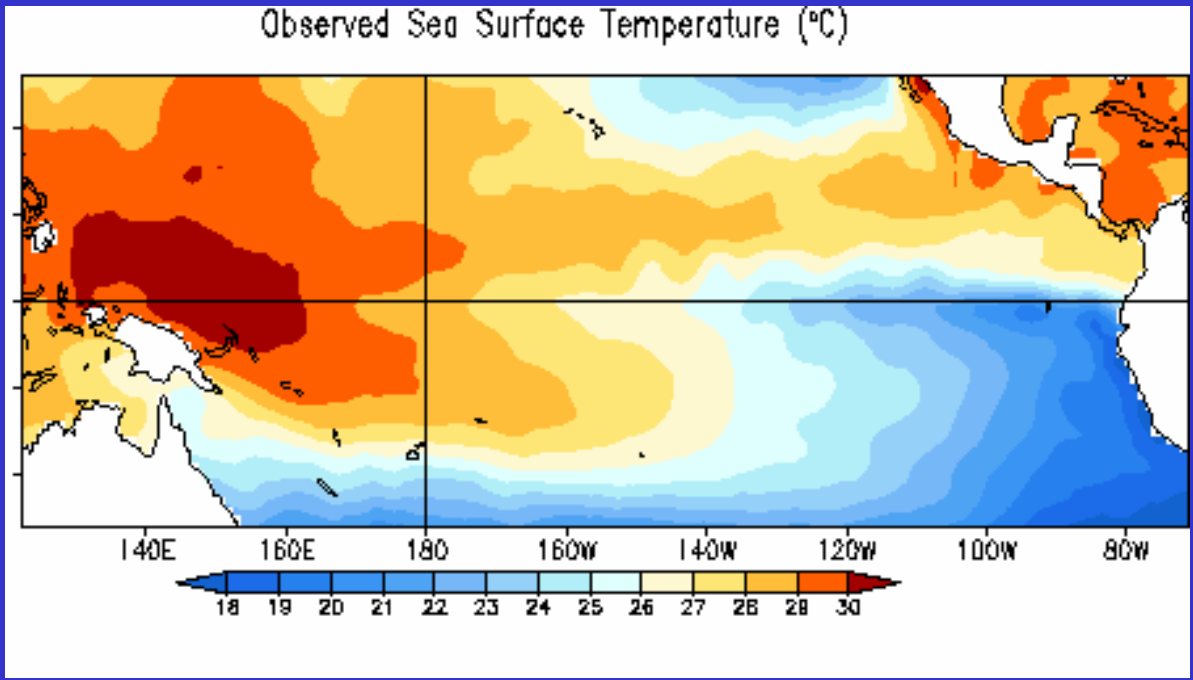
http://rho.pmel.noaa.gov/atlasrt/kaimi.html .
*Contacts: Jeanne Kouhestani at (202) 482-6090 or Commander Tim Wright at (206) 526-6403*

## Current Conditions

El Niño/La Niña advisories are only issued by the Climate Prediction Center if warm or cold condition across the Equatorial Pacific intensify. Currently the conditions are near neutral.

Weekly updates can be found @:

http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_update/index.html




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

## North Atlantic 2000 Hurricane Season

The National Oceanic and Atmospheric Administration's Climate Prediction Center, National Hurricane Center and Hurricane Research Division has came to a consensus that there would be above average overall hurricane activity in the North Atlantic for the 2000 season.
An above average Atlantic hurricane season is characterized by at least 2 of the following 3:
1) at least eleven tropical storms (Nadine # 18 on Oct. 20th)
2) seven or more of which become hurricanes (there have been six so far)
3) three or more which become major hurricanes( 2, both category four-Isaac and Keith)

## Contributing Atmospheric factors to North Atlantic Hurricanes

- The structure and location of the African easterly jet which provides energy to developing tropical systems as they travel westward from the African coast.
- Low surface air pressure across the tropical Atlantic and Caribbean
- A moist unstable atmosphere over the tropical Atlantic Ocean

http://www.weather.com/weather_center/special_reports/hurricanes/inside/fury.html

## North Atlantic 2000 Hurricane Season

There are five important factors in predicting the outlook for this hurricane season and others as well. These factors are 1) vertical wind sheer (the change of wind speed and direction from near the ocean surface up to an altitude of approximately 8 miles), 2)the sea surface temperature.
3) Coriolis Force, 4) an existing disturbance and 5) rain and thunderstorms.

Low vertical wind sheer is an imperative component for tropical storm and hurricane development. They do not form or intensify in regions of high vertical wind sheer. The vertical wind shear over the main development region is currently uncertain because of the increased variability of the global-scale circulation patterns, in response to a weakening of the La Niña-related tropical rainfall patterns.
The tropical rainfall establishes the global-scale circulation patterns that controls the winds and the vertical wind shear over the North Atlantic and Caribbean.Currently, tropical rainfall is weaker than previously predicted, resulting in stronger vertical wind sheer across the main development region of the tropical Atlantic and Caribbean Sea.

Sea surface temperature(80° or higher with reasonable depth) are the other contributing factor. Warmer sea surface temperatures produce moist air above the ocean surface, which hurricanes used as energy to strengthen and intensify. The sea surface temperatures of the tropical Atlantic and Caribbean Sea are near-average.
(http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.html)

## North Atlantic 2000 Hurricane Season

Hurricane expert Dr. Steve Lyons claims the Coriolis Force, or the deflection force on a system due to the earth's rotation is fundamental the a hurricane or cyclone's rotation. Hurricanes form mostly north of the equator because the Coriolis Force there is zero.

Tropical storms can not just spawn, they require a basic ingredient. The ingredient is a pre-existing weather disturbance in a potential area for tropical storms. Low pressure centers or moist sea surfaces would do what it takes to spawn a tropical storm.

Unstable environments in which rain and thunderstorms can form is the last condition that needs to be fulfilled for a tropical storm to develop. The heat released from the condensation within the storms is the main energy for a tropical storm to develop or to progress into a hurricane.

If all these conditions occur within a short period of time of one another than a tropical storm or hurricane will develop. If these conditions persist and intensify, than so shall the storm. Areas just south or north of the equator where these conditions are frequent, produce the most storms.
(http://www.weather.com/weather_center/special_reports/hurricanes/inside/fury.html)

## Conclusion

El Niño is powerful and complicated weather phenomenon which effects people all over the globe. It disturbs marine processes like upwelling and has an immense effect on atmospheric and weather processes like jet streams, wind flow and precipitation. The exact why reason an El Niño occurs is still not fully understood. The National Oceanic and Atmospheric Administration is monitoring it daily via satellites and networks of buoys ocean and predictions of it are becoming more accurate.

## References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Suplee,Curt. National Geographic:Nature's Vicious Cycle- El Niño/La Niña. March 1999.


## Web Sites


National Oceanic and Atmospheric Administration;
http://www.ogp.noaa.gov/misc/coral/coralit.html
http://www.nnic.noaa.gov/products/special_summaries/97_3/fig1.gif
http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.html

The weather Channel
http://www.weather.com/weather_center/special_reports/hurricanes/inside/fury.html

University of Illinois
http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/eln/upw.rxml