Lecture 7 – THC & El Nino

- Atmospheric and ocean circulations.
- El Nino.

OCEAN CIRCULATION

It was identified that the oceans store an immense amount of heat energy, and consequently play a crucial role in the regulation of the global climate system.

At present, northern maritime Europe is warmed by heat carried polewards by the Gulf Stream. When the warm water meets cold polar air in the North Atlantic, heat is released to the atmosphere and the water cools and sinks. This is assisted by the increases in salinity (and therefore density) that occur when sea ice forms in the Arctic regions. The bottom water so formed, called the North Atlantic Deep Water (NADW), flows southward through the western Atlantic, round Southern Africa and Australia, and then northwards into the Pacific Ocean. The North Atlantic is warmer than the North Pacific. The increased evaporation there therefore serves to increase salinity, relative to the North Pacific. This salinity gradient is thought to drive the global thermohaline ocean circulation. Such a picture of thermohaline circulation is schematised in Figure 2.6.

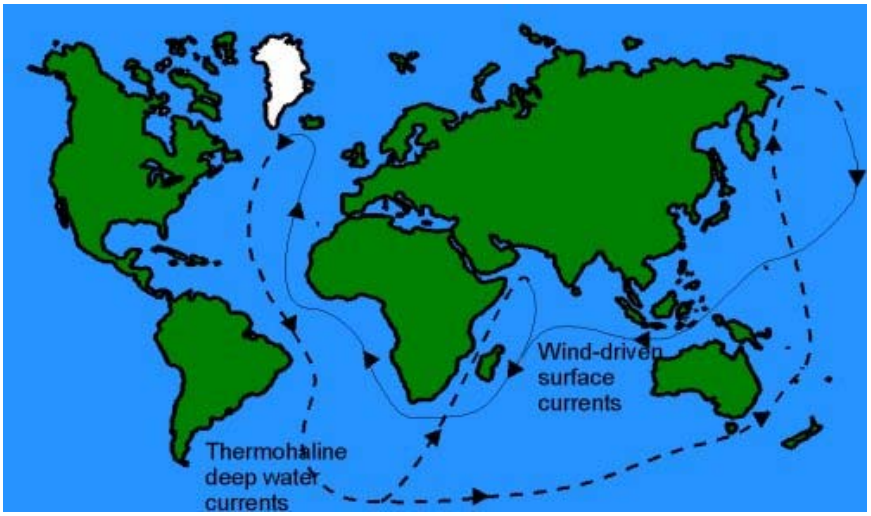
What is the global ocean conveyor belt?

The global ocean conveyor belt is a constantly moving system of deep-ocean circulation driven by temperature and salinity.

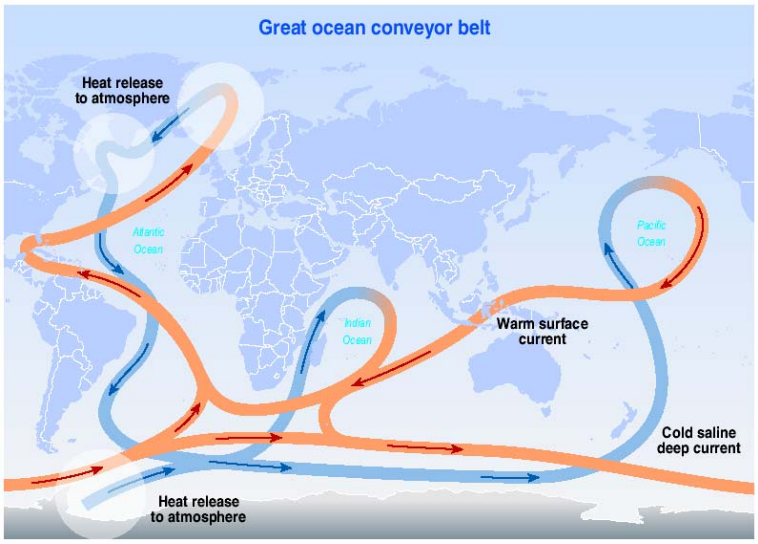
- The ocean is not a still body of water. There is constant motion in the ocean in the form of a global ocean conveyor belt. This motion is caused by a combination of thermohaline currents (thermo = temperature; haline = salinity) in the deep ocean and wind-driven currents on the surface. Cold, salty water is dense and sinks to the bottom of the ocean while warm water is less dense and remains on the surface.
- The ocean conveyor gets its "start" in the Norwegian Sea, where warm water from the Gulf Stream heats the atmosphere in the cold northern latitudes. This loss of heat to the atmosphere makes the water cooler and denser, causing it to sink to the bottom of the ocean. As more warm water is transported north, the cooler water sinks and moves south to make room for the incoming warm water. This cold bottom water flows south of the equator all the way down to Antarctica. Eventually, the cold bottom waters return to the surface through mixing and wind-driven upwelling, continuing the conveyor belt that encircles the globe.

http://oceanservice.noaa.gov/facts/conveyor.html

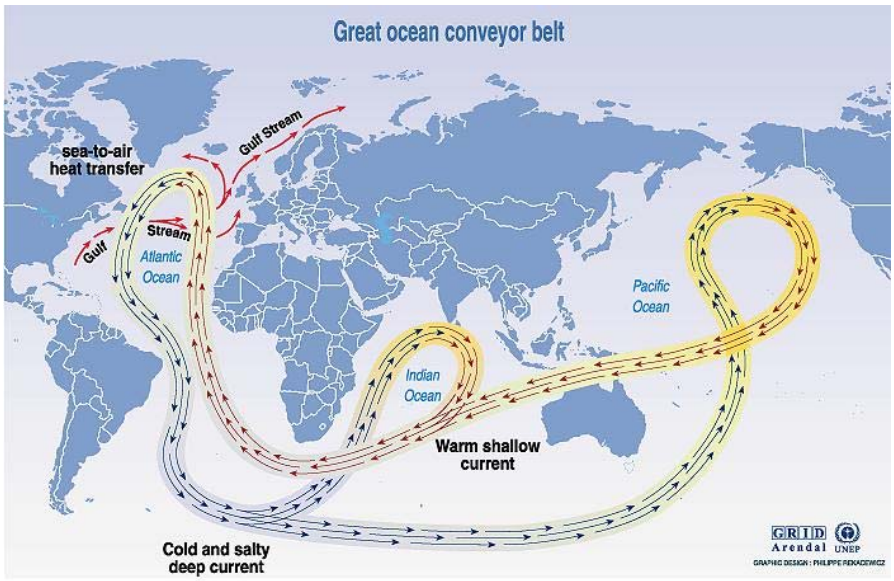
The global thermohaline ocean circulation



http://www.ace.mmu.ac.uk/Resources/gcc/2-6-4.html

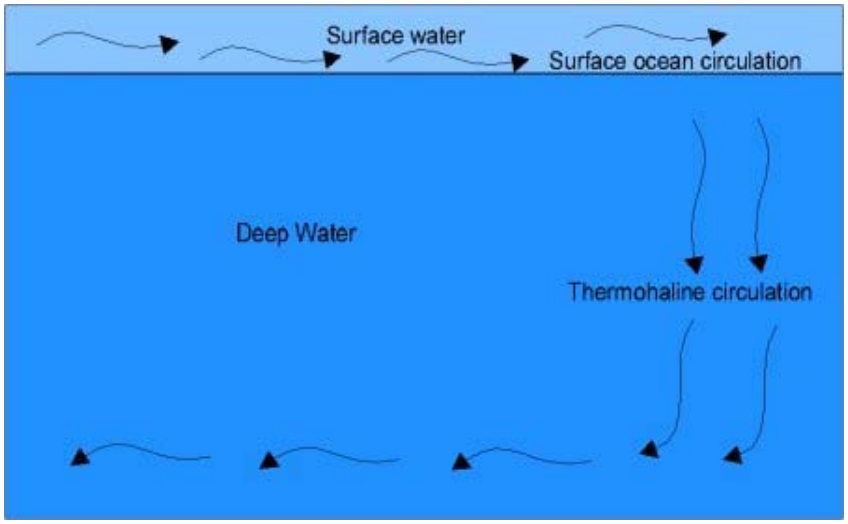


Schematic illustration of the global circulation system in the world ocean consisting of major north-south thermohaline circulation routes in each ocean basin joining in the Antarctic circumpolar circulation.



Source: Broecker, 1991, in Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

Vertical structure and circulation of the oceans



http://www.ace.mmu.ac.uk/Resources/gcc/1-3-1.html

Video clips\Al Gore on Greenland Melting.flv

https://www.youtube.com/watch?v=02NRKzemXYE

Video clips\Greenland Melting.flv

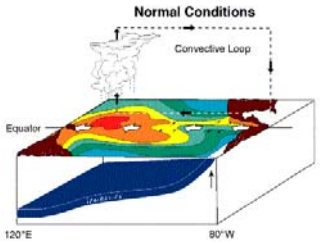
https://www.youtube.com/watch?v=0IjvLavB23Q

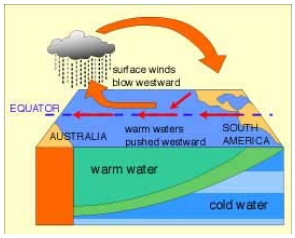
Published on Jul 25, 2012
New satellite images have revealed almost all of Greenland's surface ice has suddenly started melting.
Published on Jul 25, 2012
On July 8, NASA satellite imagery showed about 40 percent of Greenland's top ice layer intact. By July 12, only four days later, 97 percent of the ice had melted. Margaret Warner asks NASA's [**Greenland Goes Green: Ice Sheet Melted in Four Days]**

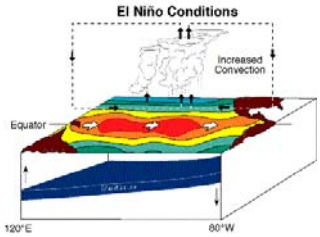
El Nino

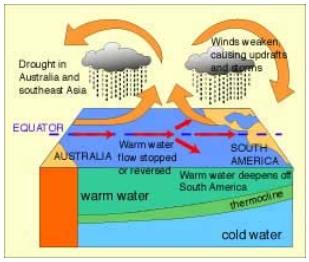
- Change in Pacific currents: a periodic change in the currents of the Pacific Ocean that occurs every five to eight years and brings unusually warm water to the coast of northern South America. It often leads to severe climate disruption to countries in and beside the Pacific.
- The name *El Niño* (Spanish, “the child”), refers to the infant Jesus Christ and is applied because the current usually begins during the Christmas season. Because a fluctuation in air pressure and wind patterns in the southern Pacific accompanies El Niño, the phenomenon is known as the El Niño Southern Oscillation, or ENSO.
- El Nino is the name given to the warm ocean currents along the Pacific coast of South America that arise every few years at about Christmas time. The El Nino phenomenon is a part of a chain of meteorological events that extends from the eastern Pacific to northern Australia, Indonesia and into the heartland of India.

El Nino





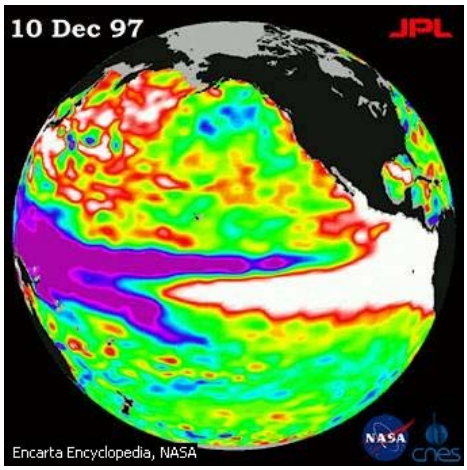


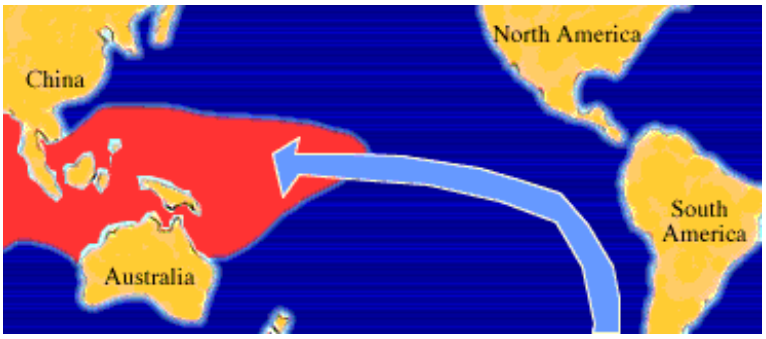


NOAA/PMEL/TAO

Satellite Picture of El Niño

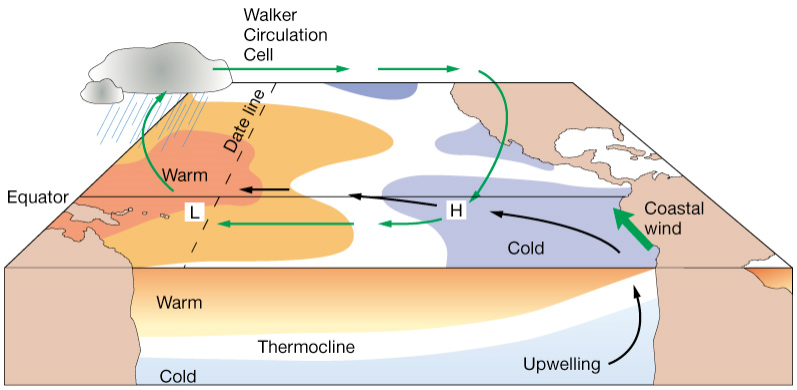
This image of the Pacific Ocean was taken by the French-American satellite TOPEX/Poseidon on December 18, 1997. It shows the height of the sea surface—an indication of the heat present in the waters—taking into account normal conditions in the same area on December 10. The volume and area of the warm zone is a manifestation of El Niño, the unusually warm southward current that appears in the region every **three to seven years**. In this image, the red and white areas indicate unusual patterns of heat storage. In the white zones, the marine surface is between ***14 and 32 cm higher than normal***, and is correspondingly ***warmer***; in the red zones it does not surpass 10 cm. The green areas indicate normal conditions, while the ***purple area*** in the western Pacific indicates a height of ***at least 18 cm below*** normal sea level.





In the tropical Pacific, trade winds generally drive the surface waters westward. The surface water becomes progressively warmer going westward because of its longer exposure to solar heating. El Niño is observed when the easterly trade winds weaken, allowing warmer waters of the western Pacific to migrate eastward and eventually reach the South American Coast (*shown in orange*). The cool nutrient-rich sea water normally found along the coast of Peru is replaced by warmer water depleted of nutrients, resulting in a dramatic reduction in marine fish and plant life.

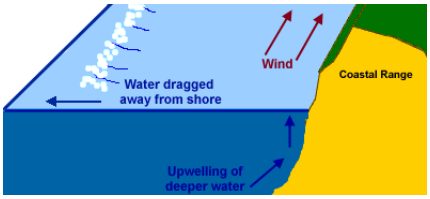
Normal conditions in the Pacific Ocean (pg. 218)

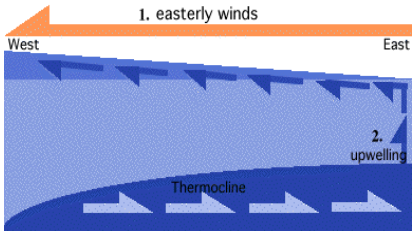


(a) Normal conditions

Figure 7-18a

Upwelling – The transport of deeper water to shallow levels

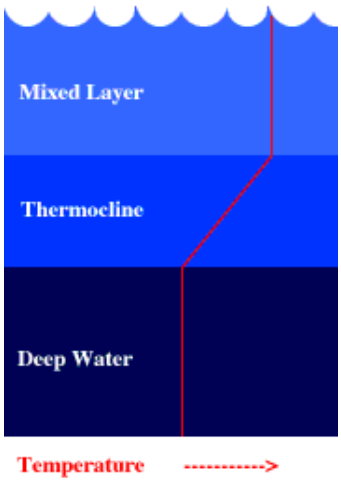




The diagram shows how upwelling occurs along the coast of Peru. Because of the frictional stresses that exist between ocean layers, surface water is transported at a 90 degrees angle to the left of the winds in the southern hemisphere, 90 degrees to the right of the winds in the northern hemisphere. This is why winds blowing northward parallel to the coastline of Peru "drag" surface water westwards away from shore.

Nutrient-rich water rises from deeper levels to replace the surface water that has drifted away and these nutrients are responsible for supporting the large fish population commonly found in these areas.

Thermocline

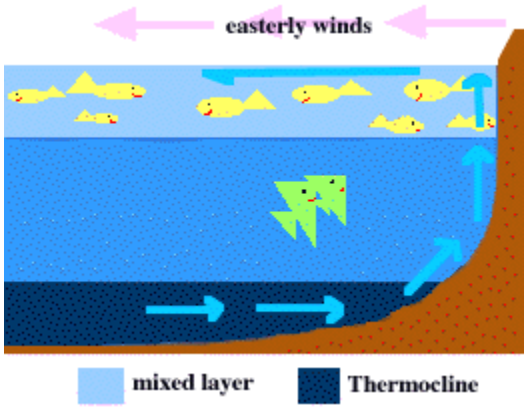


The thermocline is the transition layer between the mixed layer at the surface and the deep water layer. The definitions of these layers are based on temperature.

A deeper thermocline (often observed during El Nino years) limits the amount of nutrients brought to shallower depths by upwelling processes, greatly impacting the year's fish crop.

http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/eln/home.rxml

Non-El Nino Years

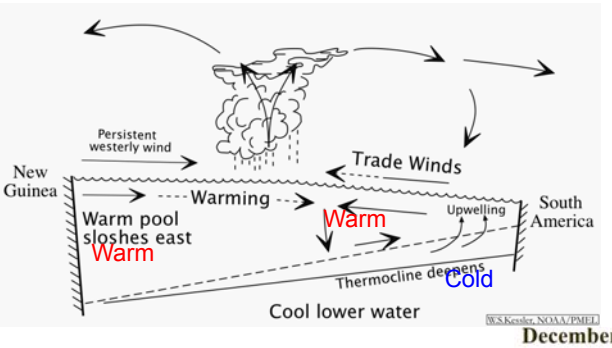


During non-El Nino years, the southeast trade winds, drag surface water westward away from shore. As surface water moves away, upwelling brings up colder waters from depths of 40-80 meters or more. This deep sea water is rich in nutrients which can sustain large fish populations

The first signs of an El Niño are:

- Rise in surface pressure over the Indian Ocean, Indonesia, and Australia
- Fall in air pressure over Tahiti and the rest of the central and eastern Pacific Ocean
- Trade winds in the south Pacific weaken or head east
- Warm air rises near Peru, causing rain in the northern Peruvian deserts
- Warm water spreads from the west Pacific and the Indian Ocean to the east Pacific. It takes the rain with it, causing extensive drought in the western Pacific and rainfall in the normally dry eastern Pacific.

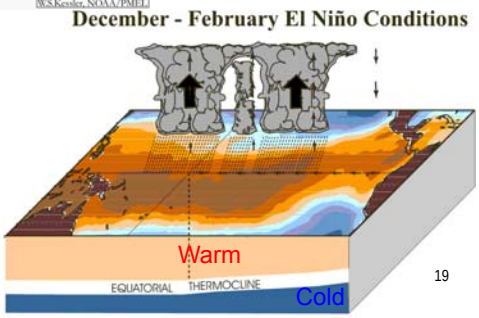
"El Niño"



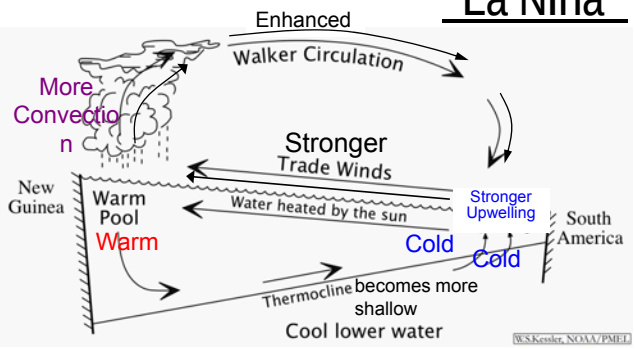
NOTE: Location of the warmest SSTs (>~28°C) determines where tropical convection will be located.

- Convection shifts eastward over the central and/or eastern Pacific Ocean. Convection becomes suppressed over the far western Pacific/ Indonesia.

- Easterly trade winds weaken
- Thermocline deepens and the cold water upwelling decreases in the eastern Pacific.

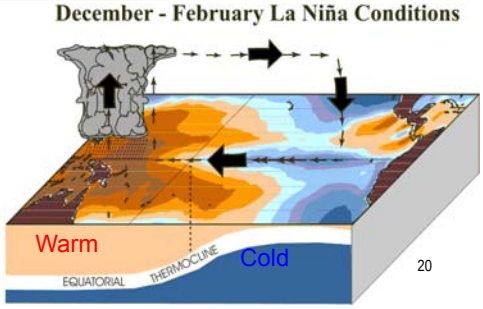


"La Niña"



• Convection becomes stronger over the far western Pacific Ocean/ Indonesia and more suppressed in the central Pacific.

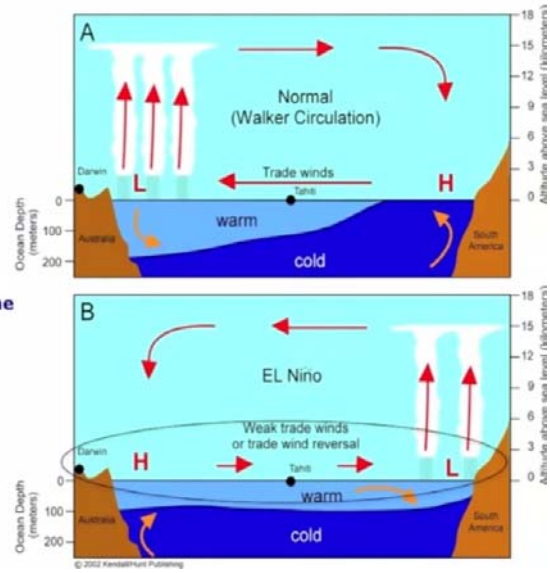
- Easterly trade winds strengthen
- Thermocline becomes more shallow and the cold water upwelling increases in the eastern Pacific.



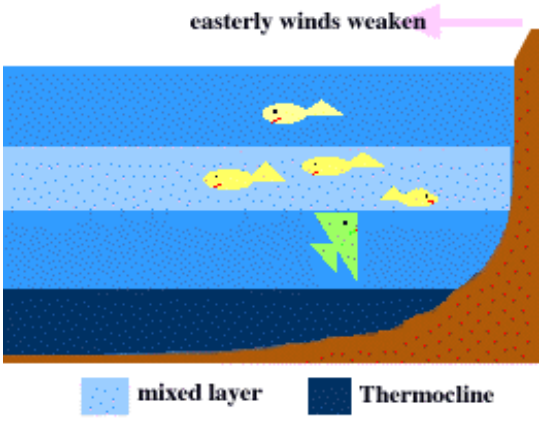
El Nino

Sequence of Events:

1. Sfc pressure systems weaken.
2. Slows the trades (might even stop or reverse them).
3. Warm water sloshes back to the east.
4. Precipitation shifts eastward.



El Nino Year

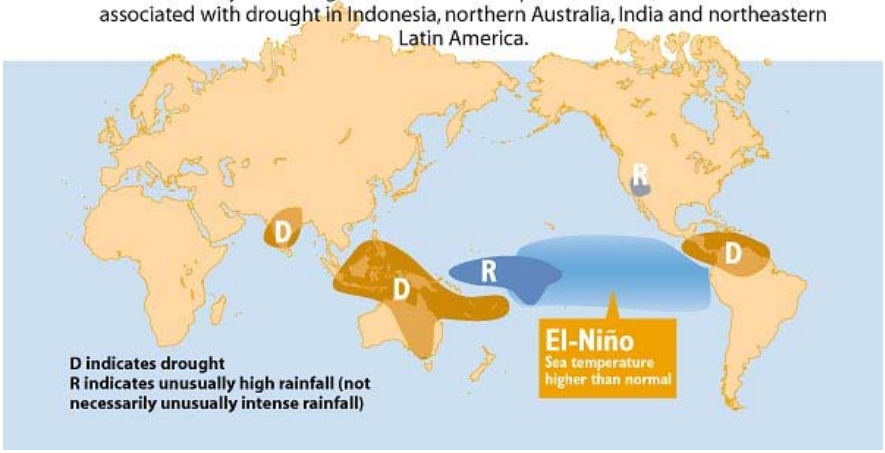


During an El Nino event, the southeast trade winds weaken and so does the amount upwelling in the eastern Pacific.

The deeper thermocline means that any upwelling that does occur is unable to tap into the rich nutrients found in deeper water. Consequently, warm nutrient-poor water predominates the region and a decrease in the fish population is observed.

Climatic impacts of warm El Niño events
(April-September)

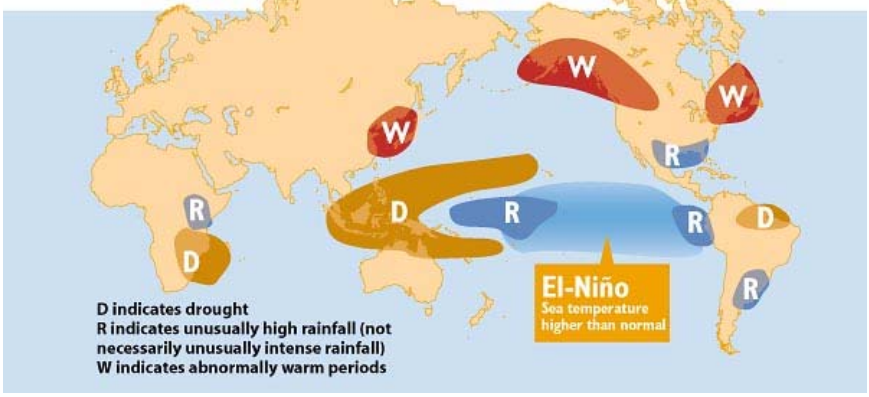
El Niño has different impacts in different parts of the world and at different times of the year. During the northern hemisphere summer, El Niño has been associated with drought in Indonesia, northern Australia, India and northeastern Latin America.



Source: Factfile – FAO of UN

Climatic impacts of warm El Niño events
(October-March)

El Niño has different impacts in different parts of the world and at different times of the year. During the northern hemisphere winter, El Niño's expected impacts include drought in southern Africa, continuing drought in northern Australia and Indonesia, high rainfall in three continents and unseasonably warm weather in parts of North America and eastern China.

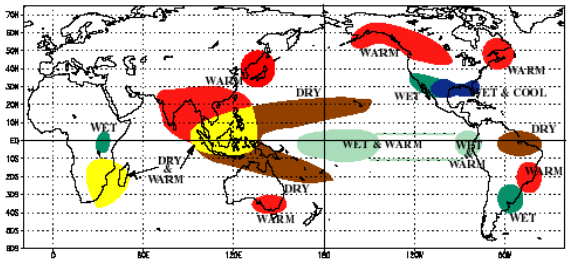


Source: Factfile – FAO of UN

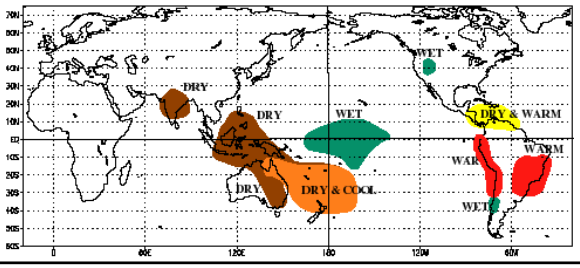
Global El Niño Impacts

Impacts are generally more extensive during the northern winter.

WARM EPISODE RELATIONSHIPS DECEMBER - FEBRUARY



WARM EPISODE RELATIONSHIPS JUNE - AUGUST



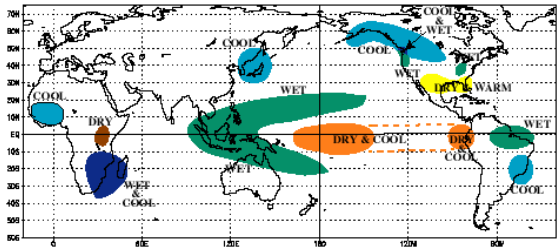
Typical Global El Niño Impacts

Region	Period	Impact
Indonesia	Life of event	Drier
Northeast Brazil	March-May	Drier
Central America /Mexico	May-October	Drier
West Coast South America	March-May	Wetter
Central South America	June-December	Wetter
Southeast Africa	December-February	Drier

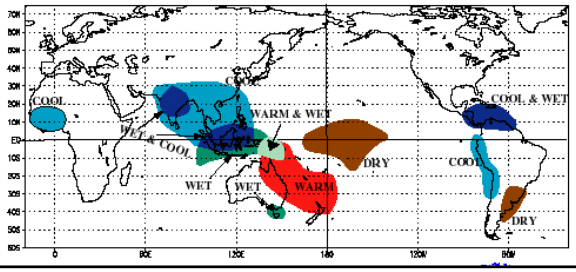
Global La Niña Impacts

Mid-latitude impacts generally occur during the winter season (NH – DJF; SH-JJA).

COLD EPISODE RELATIONSHIPS DECEMBER - FEBRUARY



COLD EPISODE RELATIONSHIPS JUNE - AUGUST



Typical Global La Niña Impacts

Region	Period	Impact
Indonesia	Life of event	Wetter
Northeast Brazil	March-May	Wetter
Central America /Mexico	May-October	Wetter
West Coast South America	March-May	Drier
Central South America	June-December	Drier
Southeast Africa	December-February	Wetter

Some of the abnormal weather pattern observed during El Nino (1982-83)

	Drought in Southern Africa, Southern India, Sri Lanka, Philippines, Indonesia, Australia, Southern Peru, Western Bolivia, Mexico, Central America
	Heavy rain and flooding in Bolivia, Ecuador, Northern Peru, Cuba, U.S. Gulf States
	Hurricanes in Tahiti, Hawaii

El Nino Years

El Nino (Spanish name for the male child)

- initially referred to a weak, warm current appearing annually around Christmas time along the coast of Ecuador and Peru (not good for their fishing industry and quano birds!)
- can produce significant economic and atmospheric consequences worldwide
- occur every 3-7 years, lasting about one year
- Recent major events: 1982-1983 and 1997-1998
- The 97-98 event was the strongest ever recorded!!

Previous El Niño Years			
1902-1903	1905-1906	1911-1912	1914-1915
1918-1919	1923-1924	1925-1926	1930-1931
1932-1933	1939-1940	1941-1942	1951-1952
1953-1954	1957-1958	1965-1966	1969-1970
1972-1973	1976-1977	1982-1983	1986-1987
1991-1992	1994-1995	1997-1998	2002-2003
2006-2007	2009-2010	2012-2013	2015-2016

Source: http://apollo.lsc.vsc.edu/classes/met130/notes/chapter10/elnino.html

El Nino and La Nina Years and Intensities

El Niño				La Niña		
Weak	Mod	Strong	Very Strong	Weak	Mod	Strong
1951-52	1963-64	1957-58	1982-83	1950-51	1955-56	1973-74
1952-53	1986-87	1965-66	1997-98	1954-55	1970-71	1975-76
1953-54	1987-88	1972-73	2015-16	1964-65	1998-99	1988-89
1958-59	1991-92			1967-68	1999-00	
1968-69	2002-03			1971-72	2007-08	
1969-70	2009-10			1974-75	2010-11	
1976-77				1983-84		
1977-78				1984-85		
1979-80				1995-96		
1994-95				2000-01		
2004-05				2011-12		
2006-07						

http://ggweather.com/enso/oni.htm

The table shows the impact of El Nino and La Nina over a decade

Year	Occurrence	Impact	Monsoon*
2004	El Nino	Drought	88%
2005	Neutral	Normal	101%
2006	Neutral	Normal	103%
2007	La Nina	Excess	110%
2008	La Nina	Above normal	105%
2009	El Nino	Severe drought	79%
2010	La Nina	Normal	100%
2011	La Nina	Normal	104%
2012	Mild El Nino	Below normal	92%
2013	Neutral	Above normal	106%

* Monsoon as percentage of 50-years average

https://www.youtube.com/watch?v=fJVKpQKITsk&spfreload=10

El Nino – Walker Cell Explained

https://www.youtube.com/watch?v=f-r82_HRfNw

El Nino and La Nina

https://www.youtube.com/watch?v=tyPq86yM_Ic

El Niño-Southern Oscillation (ENSO)

- **El Niño** (Spanish for "the Child" in reference to baby Jesus) = warm surface current in equatorial eastern Pacific that occurs periodically around Christmastime
- **Southern Oscillation** = change in atmospheric pressure over Pacific Ocean accompanying El Niño
- ENSO describes a combined oceanic-atmospheric disturbance

ENSO Economic effects continues……. :

- ENSO Economic effects continues……. Economic Benefits Polar Jet Stream saving money:
- During El Nino in North America, the jet streams that travel 5 to 8 miles [8 to 13 kilometers] above Earth's surface shift dramatically. The polar jet stream tends to stay farther north over Canada than usual; as a result, less cold air moves into the upper United States. In fact, northern-tier states saved an estimated five billion dollars in heating costs during the 1997-98 El Niño.
- The potential uses of advance information are almost limitless: Governments and industries around the world can make planning for El Niño and La Niña pay off. For example, Kenyan coffee growers find their product in greater demand when droughts affect coffee harvests in Brazil and Indonesia. Palm oil production in the Philippines typically declines during El Niño, as does the squid catch off the California coast. Countries that anticipate these developments can fill the gaps and prosper.

ENSO Economic effects continues……. :

- Economic Loss The giant El Niño of 1997-98 had deranged weather patterns around the world, killed an estimated 2,100 people, and caused at least 33 billion [U.S.] dollars in property damage.
- In the U.S. mudslides and flash floods flattened communities from California to Mississippi, storms pounded the Gulf Coast, and tornadoes ripped Florida. By the time the debris settled and the collective misery was tallied, the devastation had in some respects exceeded even that of the El Niño of 1982-83, which killed 2,000 worldwide and caused about 13 billion dollars in damage. (Suplee, 1999)
- Just in USA, El Nino caused real economic losses such as storm damage or crop losses. These are losses that can't be prevented or reduced by a better forecast or mitigation. For example, on average, El Ninos resulted in agricultural losses approaching $2 billion, or nearly 1-2 percent of total crop output.

ENSO Economic effects continues……. :

- In the 1997-98 El Nino, property losses were estimated at nearly $2.6 billion. (Spacedaily)
- During an El Niño event, the southeast trade winds weaken and so does the amount upwelling in the eastern Pacific.
- The deeper thermocline means that any upwelling that does occur is unable to tap into the rich nutrients found in deeper waters. Consequently, warm nutrient-poor water predominates the region and a decrease in the fish population is observed.
- A reduction of the fish population reduces the amount of fishmeal produced and exported (by local industry) to other countries for feeding poultry and livestock. If the world's fishmeal supply decreases, more expensive alternative feed sources must be used, resulting in an increase in poultry prices worldwide.

Source: http://www.authorstream.com/Presentation/arvindtirkey-297854-el-nino-simple-la-nina-enso-ib-geography-effects-climatic-education-ppt-powerpoint/

Reference

- http://www.authorstream.com/Presentation/arvindtirkey-297854-el-nino-simple-la-nina-enso-ib-geography-effects-climatic-education-ppt-powerpoint/
- http://www.youtube.com/watch?v=MzcKBeW44ao
  (BBC: The Life and Times of El Nino.avi)

Home works

- What will be the effects of El Nino and La Nino for Monsoon in India and Nepal?
- What will happen to fish industry in Peru during El Nino year?
- Describe the precipitation pattern in South West coast of North America during El Nino.

Effects on salinity

Evaporation	Increase salinity
Precipitation	Decrease salinity
Sea ice formation	Increase salinity
Run off	Decrease salinity
Ice melting	Decrease salinity