Geo Factsheet

El Niño Explained - 'The Little Child with the Big Kick'

The latest El Niño event has been blamed for extreme weather events in 1997 and 1998, especially in the USA, where the popular press have nick-named the phenomenon 'El Meano' or 'El Meanie'. This Factsheet will explain how the El Niño occurs (scientists are not sure why it occurs) and assess the true extent of its impact, with particular reference to the latest 1997-98 event which appears to be the worst on record in terms of destruction and human suffering.

What is El Niño

El Niño was a term originally used to describe the appearance of warm surface water in the Eastern Equatorial Pacific along the coasts of Peru and Ecuador. The name El Niño means 'Christ Child' and was first given to the **'warm event'** by the Peruvian fishermen who noted the anomalously high sea surface temperatures (SSTs) about every 2-3 years around Christmas, largely because it had such a bad impact on the size of their anchovy catch.

What scientists now call the 'El Niño' effect is reserved for a stronger event which leads to the development of a warm water cell off the coasts of **Peru** and **Ecuador**, thus disrupting the normal Pacific ocean circulation. The El Niño refers to this oceanic component, and **the Southern Oscillation** refers to the see-saw in air pressure which occurs at the same time. The acronym ENSO **(El Niño Southern Oscillation)** is used to describe the combined oceanic and atmospheric impacts of the phenomenon which leads to an intermittent disruption of the climate system centred on the equatorial Pacific. Whist the El Niño affects the climate short-term all around the Pacific Basin, and the effects are now well documented, increasingly the phenomenon is thought to lead to atmospheric interactions around the world (known as **teleconnections**), largely because of distortion to the jet stream patterns.

As well as warm events in the Eastern Pacific, there are cold events where the SSTs become anomalously colder compared to the long-term average for the region. The name **La Niña** refers to the appearance of colder than average conditions. The 1997-98 El Niño would seem to be followed by a 1998-99 La Niña event according to the latest monitoring records. This has also had different disastrous consequences for the same areas hit by the 1997-8 El Niño.

Definitions
El Niño event describes the appearance of warm surface water from time to time in the Eastern Equatorial Pacific i.e. a **warm** event.

La Niña refers to the appearance of colder than average sea surface temperatures in the central and East Equatorial Pacific i.e. a **cold** event.

The Southern Oscillation is a see-saw of atmospheric pressure between the Pacific and Indo-Australia area.

The Southern Oscillation Index has been developed to monitor the Southern Oscillation.

ENSO (El Niño-Southern Oscillation) is the term used by scientists to describe the full range of events including the El Niño oceanic component and the Southern Oscillation atmospheric component.
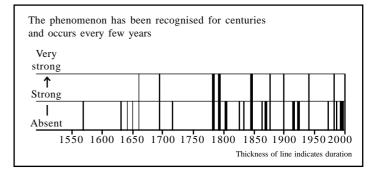
Teleconnections are defined as atmospheric interactions between widely separated regions - in this context 'knock on' effects of El Niño.

Thermocline is the sharp boundary between the cold deep water and the warmer upper layer.

How often does El Niño occur and can we predict it?
As can be seen from Fig 1. El Niño occurs irregularly, approximately every four to seven years.

Fig 1. Known El Niño events

The phenomenon has been recognised for centuries and occurs every few years

Very strong

Strong

Absent

1550 1600 1650 1700 1750 1800 1850 1900 1950 2000

Thickness of line indicates duration

Recent El Niño years when there were very high sea surface anomalies included 1976-77, 1982-83, 1986-87, 1990-1994 (the longest on record) and the most recent (1997-1998). There is some concern that occurrences are increasing, therefore people try to link this to the phenomenon of global warming as an indirect effect. This is yet to be confirmed by scientists although recent drilling on the coral reefs off Southern New Guinea would suggest that the frequency of El Niño events has increased over the last 200 years.

Every El Niño is different in terms of its duration (average 12-18 months) and magnitude. Magnitude can be measured by looking at variations in the Southern Oscillation. The Southern Oscillation Index (SOI) has been developed to monitor the Southern Oscillation using the differences between sea level atmosphere pressures at Darwin, Australia and Tahiti. Plots of sea surface temperature anomalies can also be made, to measure sea warming or cooling.

El Niño events can be detected and monitored by many methods. Firstly there is much better satellite coverage for looking at oceanic patterns. Secondly the design for buoys has improved so that the Tropical Atmosphere Ocean (TAO) buoy can now measure SST, surface winds, air temperature, humidity and occasionally subsurface currents. The buoys can be deployed mid ocean as well as in shallow water and can remain active for a year. They transmit daily (sometimes hourly) into the weather forecasting system. Further information can be gained by analysing the sea levels on coasts around the Pacific.

Increasingly, **biological** surveys are being used. During an El Niño event the phytoplankton which is so vital to support the whole of the food web does not grow, as there is no upwelling of cold nutrient-rich water from the deep ocean. Consequently sea birds are starved of food for the breeding season. On islands off the coast of California scientists have been looking at 3 different species and how an El Niño can affect feeding habits and the subsequent breeding season.
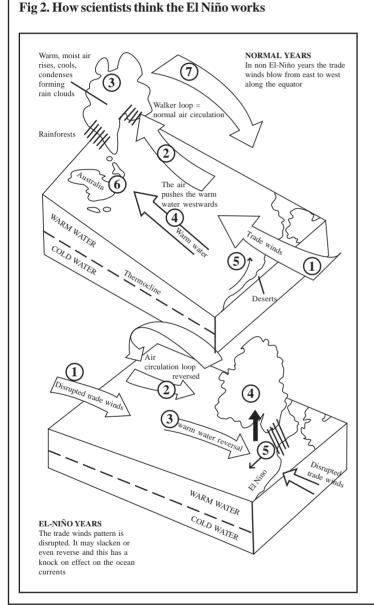
Researchers were very successful in predicting the recent 1997-8 El Niño event using a combination of statistical forecasts based on:
(i)   historical records
(ii) satellite coverage
(iii) computer models
The amount of data available, the range of research, and the use of sophisticated programs to analyse it is growing exponentially.

How and why does El Niño occur?
The actual process is summarised by Fig 2.

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Exam Hint - *Once you have read through the explanation as to how El Niño works, practice drawing a simple diagram or map to show some of the effects (Fig 2 or 3).*

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Fig 2. How scientists think the El Niño works

In a normal year

1. The great NE and SE trade wind belts occur, which blow equatorward and westward across the width of the tropical Pacific.
2. The winds blow towards the warm water of the Western Pacific.
3. Convectional uplift occurs as the water heats the atmosphere.
4. The tradewinds push the warm water westwards, whereas along the East off the coast of Peru, the shallow position of the thermocline allows winds to pull up water from below.
5. This results in an upwelling of nutrient rich cold water along the Peruvian coast-heading to optimum fishing conditions because of the abundance of phyloplankton.
6. Because of the pressure of the trade winds, sea levels in Australasia are about half a metre higher than Peru with sea temperatures 8°C higher than in Peru.
7. At this point the air sinks creating the Walker loop.

In an El Niño year
the entire system relaxes

1. The trade winds weaken or even die in the Western Pacific.
2. In an extreme El Niño year there is sometimes even a reverse direction of flow.
3. The piled up water in the West, sloshes back east, leading to a 30cm rise in sea level in Peru carrying the water pool east with it.
4. Thus the region of rising air moves east with the associated convectional uplift. The upper air disturbances distort the path of the jetstreams which can lead to **teleconnections** all around the world, not just the Pacific.
5. The Eastern Pacific ocean becomes 6-8°C warmer. The El Niño effect overrides the cold Northbound Humboldtanment, thus breaking the foodchain. Lack of phytoplankton has a knock-on effect on the foodchain. An absence of fish affects fish-eating bird colonies on the Galapagos.
6. Conditions are essentially calmer across the whole of the Pacific.

Although scientists are increasingly confident about the effects of El Niño, they are by no means certain as to why it occurs.

There are two main theories at present:

1. The event is initiated by the reflection from the Western boundary of the Pacific of an oceanic **Rossby wave**. This wave acts as a trigger supposedly by lowering the thermocline in the west central Pacific, thus warming the SST by reducing the efficiency of upwelling to cool the surface water. Winds blow towards the slightly warmer water and start the event. Presumably if you observe these oceanic Rossby waves prior to reflection you can predict the onset of an El Niño.
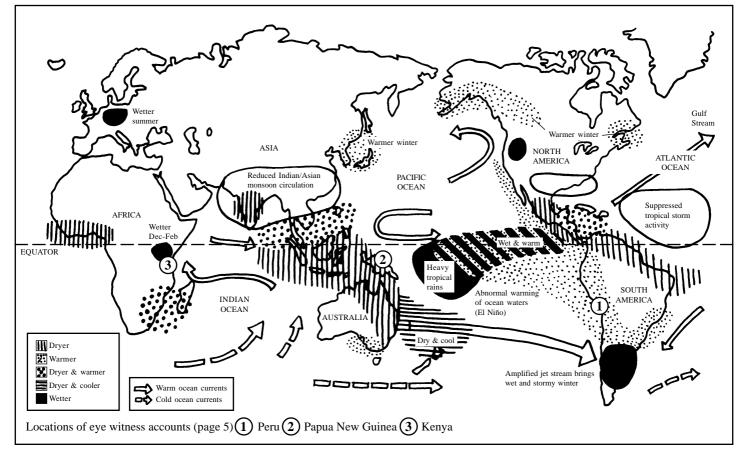
2. The other theory suggests an essentially random occurrence. Tropical convection in the rising air tends to occur in bursts and these bursts propagate out of the Indian Ocean (known as the Madden-Julian Oscillation). If the storms are violent enough or last long enough, eastward blowing storm winds start the sloshing of the ocean eastwards from Indonesia to Peru.

The idea of the heat from sea floor venting of volcanoes causing the El Niño was briefly fashionable but there is no evidence for this. The theory arose because researchers noted that the eruption of Mount Chichon preceded the 1982-83 El Niño and the Mount Pinatubo eruption preceded the 1991-92 El Niño.

The impact of El Niño
The impact of El Niño is summarised in Fig 3.

Fig 3. The Global Impact of El Niño 1997-8

Whilst the direct impacts are very clearly seen in the equatorial Pacific, researchers are increasingly discovering teleconnections which would suggest that although its impact is piecemeal, the cumulative effects are global. Most of the impacts are seen to be negative; for example the impacts of the latest El Niño event killed approximately 1000 people in South America alone, and hundreds of thousands of livestock. Equally, it caused $20 billion damage. Many of those countries that were badly hit were LEDC's lacking the capital to purchase technology to cope with the aftermath of the disasters.

There are some positive impacts too - for example the Caribbean was almost free from hurricanes in 1997 and the North Chilean tourist industry flourished as tourists flocked to see the 'desert in bloom'. The major problem however with El Niño is its ability to overturn established climate patterns in a very unpredictable way (Fig 3). The desiccation of Indonesia and East Australia led to forest fires in Indonesia and bush fires in Australia, whereas the arrival of torrential rains in Western Peru led to enormous flash floods in Ica, accompanied by landslips and the cholera epidemic which followed because of contaminated water supplies.

> *Exam Hint - If you find it difficult to draw a block diagram such as Fig 2, practice drawing a simple map. You should be able to draw a map or diagram to explain both the causes and effects of El Niño.*

If you relate Fig 3 to Table 1 overleaf you can see the very widespread impacts of the El Niño event especially around the Pacific Ocean.

The table also shows impacts of the principal **teleconnections** between the tropical pacific and the Northern Hemisphere circulation which is called the Pacific North America pattern or PNA. The downstream jet wave appears as a result of higher than normal pressures over Western Canada and lower than normal pressures in south east USA.

In El Niño periods, the jet approaching North America is strengthened. The increased warmth in the Eastern Pacific leads to increased tropical convection and the moisture pumped in to the atmosphere is carried North East by sub tropical jet streams, thus contributing to heavier rainfall across Southern USA (but not necessarily to the small scale systems of the Florida tornadoes).

Other important teleconnections include the droughts of Brazil and Africa which often occur during El Niños. When the warm pool and the Walker loop moves east during an El Niño, the sinking motion is correspondingly displaced, producing drought in the equatorial Atlantic region. It is the eastward displacement of the Walker loop, see Fig 2, which possibly leads to stronger upper atmosphere winds which sheer off the tops of developing tropical storms preventing them from becoming hurricanes in the Caribbean.

Table 1. A summary of the impacts of El Niño around the Pacific Region.

LOCATION	El NIÑO CLIMATE CHANGE	ENVIRONMENTAL IMPACTS	SOCIO ECONOMIC IMPACTS
Australia	Extremely unpredictable conditions. Eastern coast droughts but some rainfall for harvest in NSW. Victoria warmer.	Major bushfires around Sydney. Plague of flies.	Problems of water supply. Falling ground water levels impact on Queensland cattle industry. Poor quality wheat harvest. Best ever tourist season along Victorian coast.
Indonesia	Severe droughts. Rainfall deficits up to 500mm.	Huge rainforest fires. Destruction of Orang-utan population. Problems of smoke throughout SE Asia.	Disruption of air travel in SE Asia. Health risks to Sarawak people. Disruption of business and tourism industry e.g. in Brunei and Sabah.
Papua New Guinea	Worst drought for 50 years.	Flashfires.	Low water levels in Fly River disrupted copper exports. Major famine.
Hawaii	Increased hurricanes.		
French Polynesia	Unusual number of South Pacific hurricanes possibly related to heavy convectional storms and warm oceans.	Some destruction.	
Christmas Island	From dry hot conditions to moist monsoon conditions ↑75mm rainfall per day. Humid.	Rare corals killed by sedimentation and bleached white. Migration of bird population.	Collapse of scuba tourism. Flooded roads. Collapse of fishing industry.
India/China/ Japan	Reduced Indian/Asian monsoon. Dryer and cooler.	Generally quiet monsoon season. Limited impact. Major flood events in 1998 possibly associated with La Niña.	No major problems in 1997.
North America (T)	California wetter than normal. Wet cool winters in south. Wetter in Rocky Mountains. Dryer and warmer in Newfoundland and Alaska.	Badly eroded Californian coast. Storms and high tides. Widespread early snow.	No major harvest problem. Difficult opening for New Denver airport. Long ski season. Increased heavy winter oil demand. Booming tourist industry in 1997. Citrus Glut in Florida.
Caribbean (T)	Absence of hurricanes. Areas drier than usual.	Dried up forests in Guyana, Trinidad. Forest fires in Cuba. Low level in canal drought - restrictions on Canal (Panama). Loss of water for H.E.P. Dustbowl in Central Panama.	Raised salt levels from irrigation systems (e.g. coastal Guyana), salinised crops. Loss of toll revenue in canal. Famine in Guatemala. Power cuts in central America. (70% power from HEP) 30% Salvador coffee lost.
Columbia	Drought conditions.	Low levels in all rivers.	Disruption of river transport on River Magdalena.
Brazil (T)	Very dry especially in NE. Regular rainfall elsewhere.	Extreme drought conditions in NE. Amazonian fires of huge proportions.	Bumper season for NE tourism. Good crops in SE Brazil (Sao Paulo).
Andean States	Warmer than usual. Unpredictable thunderstorms. Heavy rainfall in Ecuador and Peru. Drought in high Andes.	Flooding events. Sechura desert converted into a lake. Floods in Ica, Peru and Chile. Low snowfall - loss of water for crops and livestock in high Alteplano.	Huge damage to roads and bridges in Peru. Disaster at Ica floods and landslides buried 20 people. Superb 1997 Chilean ski season. Filled reservoirs solved irrigation and HEP problems in 1997 (reverse in 1998). Disruption of communications networks. Destruction of Perusian fishing industry. Closure of fishmeal plants.
Galapagos	6°C warmer seas. Increased rainfall.	Drives away fish. Impact on breeding birds e.g. Blue Footed Booby. Loss of seaweed for iguanas. Extensive bleaching of corals.	Knock-on effects on tourism.
Paraguay & Argentina	Much wetter than usual.	Widespread floods in Parana Paraguay system.	Disruption of ranching economy. $3 billion costs of floods. Loss of rice, soya, tobacco (50%) crops. Storm damage of vines in Mendoza.
South Africa (T)	Drought in Transvaal in early 1998.		Possible impact on maize crop - sky high prices.

T   Teleconnections

Fig 4. The havoc of El Niño - Eye Witness accounts

Case Study 1: Peru - the home of El Niño
Up and down the country El Niño weather phenomenon brought devastating floods, causing an estimated £700 billion in damage. Ica, located in the desert several hundred kms south of Lima was the most severely affected town. Massive floods hit it twice in a week in January 1998. Water poured from the mountains like a tidal wave causing the river to burst its banks and flood the large shantytown of Acomayo. Six days later as the people were recovering, another wall of water rushed into Ica. 15,000 houses were flooded and 5000 destroyed. Often these were the homes of the poorest citizens. The houses, built of sundried brick for a desert climate, melted like chocolate and this contributed to massive mud flows, which covered the whole area with a layer of mud a foot deep. Almost immediately disease became a problem. Without proper plumbing in the shanty town the sewage rose to the surface of the flood waters and cholera returned to the settlement. Although only 3 people died in the flood, many more died afterwards from disease.

The Perusian Army has provided temporary shelters, and stand pipes. A local women's group and health clinic have used foreign aid to provide basic relief of food, clothes, cooking utensils. With the commercial district flooded and thousands of homes wiped out it will be a long time before Ica recovers.

Case Study 2: Papua New Guinea
Papua New Guinea suffered the worst drought in living memory. In this area of rainforest rainfall is usually between 3000-4000mm per year. However, in 1997 many areas received no rain at all. In all, a quarter of a million people were living in the affected areas. The forested valley sides were blackened by flash fires, wiping out both forest resources and crops. Hunger was very widespread with 80,000 people critically at risk from famine and related malnutrition. Many families ate their cattle and unusual crops to keep alive. Luckily some rains did come in early 1998 allowing people to plant crops, but Food Aid was necessary to feed the people temporarily.

Case Study 3: Eastern Kenya
In the Tana River valley, it was disastrous flooding again which ruined the livelihoods of many. Some 70,000 people had to flee the remote area. Flooding destroyed the crops of the Pokomo people who farm the flood plains, and the Orma pastoralist people lost some 30% of their cattle. The floods came at the end of January in what should have been the dry season. The little rainy season in the Autumn was unusually wet and this meant that the local people were unable to plant crops. Their tree crops (a long term cash crop investment for small holders) bananas, coconuts and mangoes were completely destroyed by the force of the flood water as it flooded such a wide area.

For weeks, Hola, the regional capital of the area, was cut off except by air. The local people ran out of basic food such as maize flour. Food shortage of items such as bananas led to inflated prices, 50% beyond the people's reach. The relief programme was organised by the local drought relief committee who were very well prepared for desert conditions, but not for flooding. They provided with the help of International Aid, shelters, clothing, cooking utensils and food. Malaria became endemic because of the huge areas of temporary swamp so mosquito nets were also an essential aid item. The villagers are going to rebuild, but all the new villages will be sited on higher ground to be flood proof.

Common Threads
* * Although the disaster was expected by scientists, the groups of people affected did not know about the risk and were ill prepared for it.*
* * In all cases these were very poor people who were hit. This led to maximum suffering including famine and disease.*
* * The natural disaster provided conditions which the people were just not used to - a complete reverse of the norm.*
* * The areas were remote areas. In all cases aid was difficult to organise. The most effective way was for NGO's to support existing self-help groups.*

Conclusion
There is no doubt that El Niño events lead to disastrous weather changes, which scientists are just beginning to understand. These impacts are felt regionally, over wide areas of the world. El Niño events give governments a big headache as they are difficult to predict at a local scale and expensive to manage. Governments by and large ignored the warnings of scientists concerning the 1997-8 which was the most accurately predicted El Niño on record. One of the main problems is that many of the countries around the Pacific, where the primary impacts of El Niño are experienced, are some of the poorest countries in the world. However El Niño cannot be blamed for every meteorological hazard event especially in Europe or Russia, and there is no doubt that human actions can exacerbate its impact, for example where shanty towns have sprung up on insecure land, storms and floods can cause disastrous impacts.