

# EL NINO

## The Climate Changer

**EL NINO — an abnormal warm situation in the Pacific Ocean — is believed to be associated with floods, droughts, cyclones, monsoon, etc., on the one hand, and rich vegetation and fisheries on the other**

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**E**L Nino is an abnormal warm situation in the Pacific Ocean which manifests once in a few years due to ocean-atmosphere interaction. It is much talked about in recent times because it is believed to be associated with floods, droughts, cyclones, monsoon, fisheries, sea birds, and so on. Not only scientists, but policy makers are also concerned about it as its impact on the economies of many countries is devastating.

Following the 1982-83 El Nino, Indonesia, a typical rice exporter in Asia, experienced a severe drought which upset its economy due to fall in export revenue. Australia had a drought, the worst in the present century, which led to agricultural losses and widespread forest fires. The USA had the warmest winter in the last 25 years, which saved energy to the tune of 500 million dollars. The west coast of the USA witnessed unusual storms and mud slides, whereas droughts in north and floods in the southern USA drastically brought down corn and soyabean production. Large parts of Africa were once again under the grip of a severe drought. The Republic of South Africa, the major food producer in the African continent, was forced to import corn from the USA to make up for production lost on account of drought. In addition to these effects, the 1982-83 El Nino was also responsible for the failure of winter monsoon rains in south India, Sri Lanka and the Philippines; floods in south America, unusually large number of hurricanes in French Polynesia and Hawaii in the Pacific, and fewer hurricanes in the Atlantic Ocean.

### **What is El Nino?**

El Nino refers to a condition that develops in the eastern Pacific Ocean most often near the coasts of Peru and Ecuador once in a few years as a result of abnormalities in

ocean-atmosphere coupling. Unusual warm waters invade this area during December-January period. The local Peruvian fishermen originally coined the term "El Nino" meaning "The child" while referring to the abnormal warm conditions that prevail in the coastal sea around Christmas' time. Fishermen worry about its invasion into their environment as warm waters cause a decline in fish catch. Fish migrate from coastal areas to lake shelter in cold, neighbouring regions. Besides a fall in fisheries, the economy of Peru is also affected on account of low production of guano, which is a natural domestic fertilizer exported by the local people. Guano is the droppings of pelicans, a sea bird which thrives on Peruvian anchovy fish. When El Nino arrives, sea birds die on a large scale due to scarcity of anchovy fish.

There are some positive gains of El Nino as well, but they are insignificant and often ignored. After the appearance of El Nino, vegetation is in full bloom along the coastal desert of Peru due to unusual rains. Rich vegetation helps local Peruvians raise cattle. Dissolved oxygen levels in the near-bottom waters along the coast increase due to cessation of upward motions in water column and as a result some benthic communities flourish. Food for near-bottom dwelling rays therefore becomes abundant. Shrimp and crab populations also increase.

### **El Nino and global climate**

Recent scientific studies on "El Nino" indicate that its effects are felt both on the overlying local atmosphere and on the global atmosphere extending beyond the Pacific region. The abnormal environmental situation is now broadly referred to as El-Nino-Southern Oscillation (ENSO), which is a combination of a regional oceanic and global atmospheric phenomena.

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Sir Gilbert Walker, one of the earlier Directors General of Observatories in India a post which is now known as Director-General of Meteorology had first shown the existence of a large atmospheric oscillation over the southern hemisphere. He had termed it "Southern Oscillation (SO)" while trying to forecast year-to-year fluctuations in Indian monsoon. This oscillation is normally characterised by high atmospheric pressure over the eastern Pacific Ocean and low pressure over Indo-Pacific region resulting in an east-west air flow. As a part of this circulation, popularly known as Walker circulation, air rises over the Indo-Pacific region and moves at high altitudes towards the eastern Pacific, where it sinks and returns to the west at surface (Fig. 1). Sir Gilbert was, however, not aware that this is controlled by oceanic events.

Only in 1989, Jacob Bjerknes, a famous atmosphere scientist, could establish an intimate link between warm waters in the Pacific and changes in the Southern Oscillation. He found that the unusual warming in the eastern Pacific off Peru coast was responsible for disturbing the normal westward pressure fall. This caused the Southern Oscillation to swing in opposite direction like a seesaw. When ocean temperatures were abnormally high in the eastern Pacific, the evaporation rates increased and, in turn, high rates of condensation of water vapour heated the atmosphere further, resulting in the fall of atmospheric pressure. The Walker circulation was reversed with a rising limb of air over the eastern Pacific and a sinking limb over the Indo-Pacific Oceanic region (Fig. 2). Subsequent research on ENSO conducted in the last VS. years has.

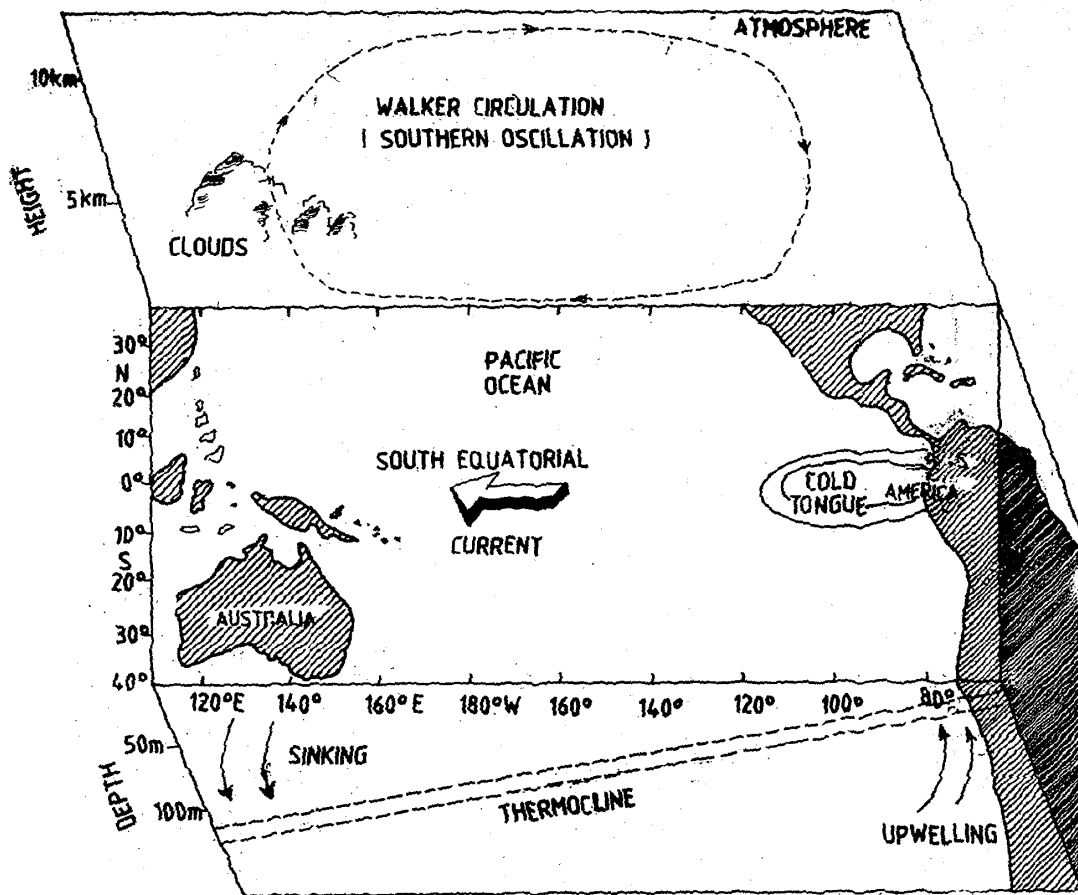


Fig. 1. Normal situation

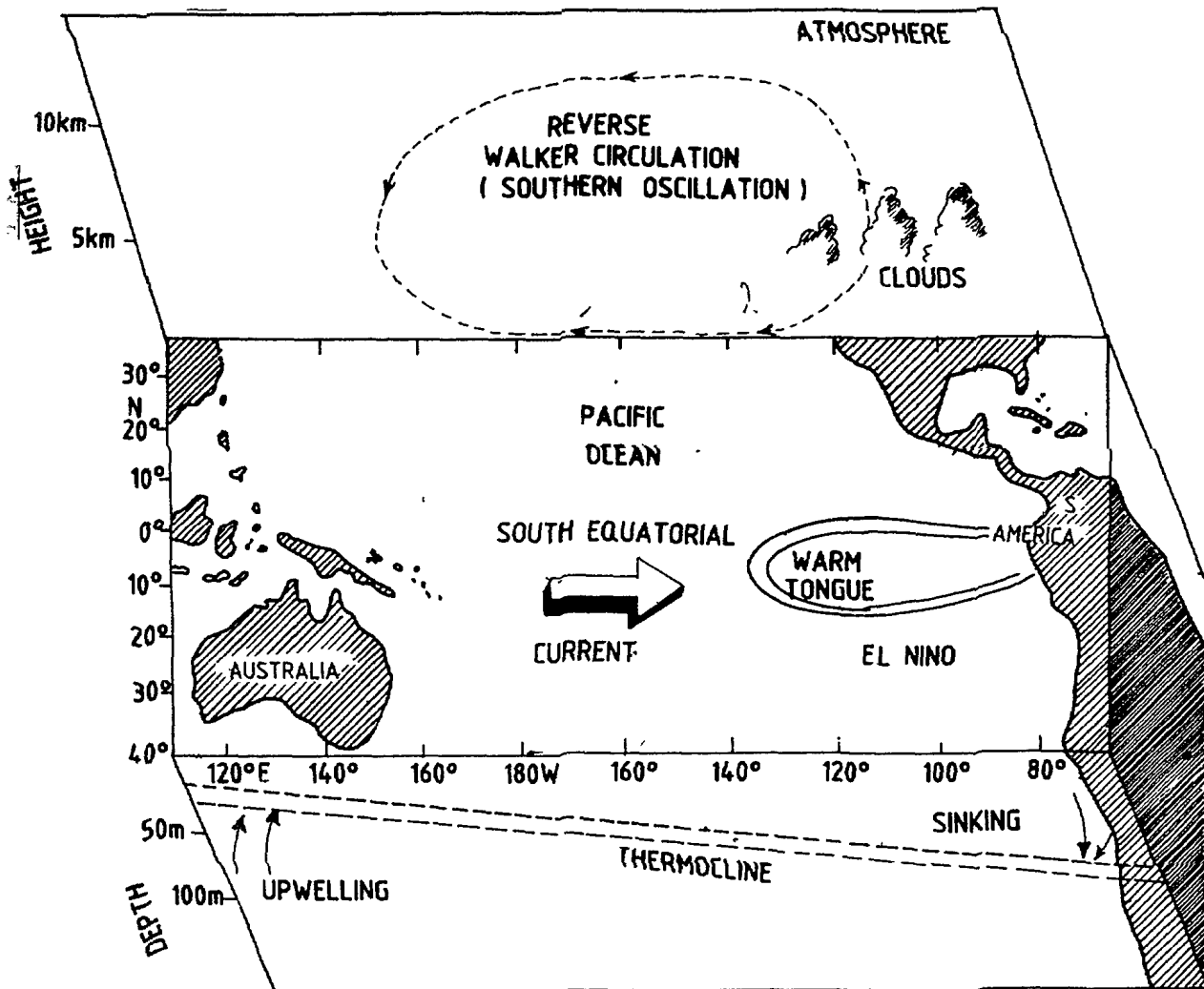


Fig 2 Anomalous situation

further shown that oceans act like a fly wheel to the world climate engine

#### Evolution of El Niño

Of all El Niño and Southern Oscillation events, the recent one of 1982-83 was better understood because of large scale observational support from National Science Foundation (NSF) and National Oceanic and Atmospheric Administration (NOAA) of the USA. As the changes in sea surface temperature reflect the intensity of El Niño, composite sea surface temperature anomaly maps have been prepared for different seasons utilising the data obtained in different individual events. On an average, abnormal warming starts during March-May period, especially in the coastal regions off South America and remains there upto July without

much development. It intensifies during August-October period and the mature stage, characterised by maximum areal extent of warming, occurs around January. By the following March the abnormal feature completely disappears. However, there are some deviations from this generalised picture. In the cases of strong events abnormal warming continues to exist. For example, during 1982-83 event, sea surface temperature patterns had not returned to normal even in March 1983.

#### Mechanisms of ocean warming

Normally, temperature of sea surface is low in the eastern and high in the western tropical Pacific Ocean with a tongue of cold waters along the equator. Vertical thermal gradient of the region shows an eastward rise of the dis-

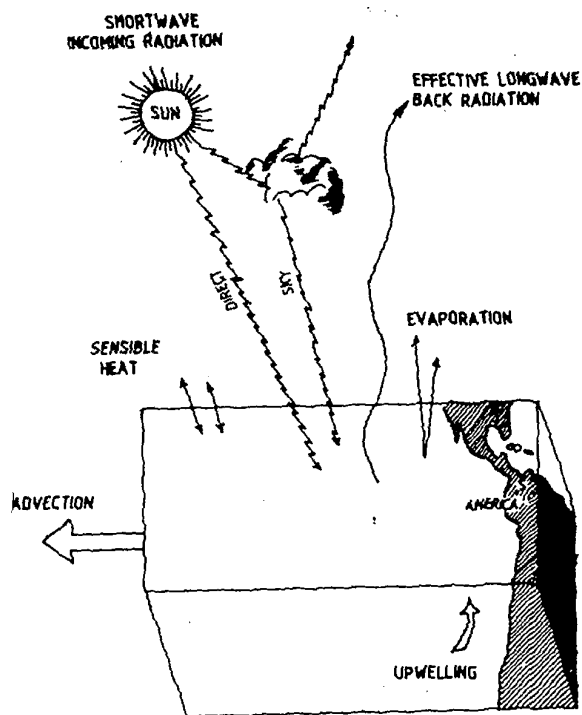


Fig. 3. Heat budget of the ocean

continuity layer, known as thermocline, which separates the upper warm and deeper cold waters (Fig. 1). This is the response of the ocean to southwest trade winds. It drives surface waters westward and causes a divergent circulation in the upper layers near south American coast, where waters from deeper layers move upward to replace warm waters.

Processes occurring both on the surface and in the interior of the sea (Fig 3) can change the water temperature if they are not balanced. Incoming global radiation, which consists of components of both direct radiation from sun and indirect scattered radiation from sky, gets absorbed at the sea surface and warms the waters. Its intensity depends on many parameters such as latitude, season, sun's elevation (angle of sun from the horizon), atmospheric turbidity, clouds and sea state. Under low elevation angles of sun from horizon, calm sea surface and cloudy and dusty atmospheric conditions, incoming radiation absorbed at sea surface is the least during winter in the northern hemisphere.

Both ocean and atmosphere simultaneously emit heat radiation. The heat radiated is a function of their absolute temperatures. In general, sea surface emits stronger and longer wave lengths of heat radiation into the atmosphere than what it receives from the latter. The resulting heat

balance is usually directed upward from the ocean. Another process, known as sensible heat transfer, exchanges heat between ocean and atmosphere through turbulent mechanisms. Heat diffuses either into or away from sea depending upon the difference between air and sea surface temperatures. If air is colder than sea, sea surface diffuses heat into the atmosphere. Heat transfer is in opposite direction in the case of warmer air.

At sea surface the most important cooling process is evaporation. The rate of evaporation is a function of both wind speed and moisture concentration in the lower atmosphere. At high wind speeds, if the overlying atmosphere is not saturated with water vapour, the turbulent mixing causes the moisture to be carried away from sea into atmosphere. The higher the sea surface temperature, higher is the water vapour holding capacity of the lower atmosphere. The combination of all these surface processes gives rise to a net input of heat energy at the rate of about 100 Watts per square metre into the tropical Pacific Ocean; if this is not balanced, it warms a 25 m water column by 1°C in about a fortnight. Under normal circumstances, the excess heat is taken away from the region by ocean currents.

#### Forecast of El Nino

Can El Nino be forecast before an attempt is made to predict long range climatic changes in the world? It seems possible. The onset and development of El Nino in the eastern Pacific can be reasonably predicted *four* months in advance by simple linear theoretical models from the knowledge of winds in the tropics. However, the prediction of the withdrawal of El Nino has not been found satisfactory.

The anomalies *in* climate following each El Nino event are not the same. Sometimes, effects are different indicating that other processes are also at work. Then, what is the use of predicting El Nino if there are variations in its effects? For any long range prediction of an atmospheric state, one sole input parameter to the model is not sufficient, rather a combination of different parameters is useful. So, long range forecasting of climate could be improved by including El Nino and Southern Oscillation Index in the models along with other parameters. It is hoped that in future differences between the effects of one El Nino and another will be resolved.

#### Future programmes

To understand year-to-year climatic fluctuations, an international programme known as Tropical Ocean and Global Atmosphere (TOGA), has been envisaged for ten years beginning from 1995. This global research programme, planned jointly by oceanographers and atmospheric scientists, will be operated as a part of the World Climate Research Programme (WCRP).

Under TOGA, not only El Nino Southern Oscillation but anomalies in other tropical oceans, apart from the Pacific Ocean, will also be examined in detail. Oceanographers will study the variability of the upper ocean, especially its temperature. As components of TOGA, different regional

programmes have also been planned. For example, under ERFEN (Estudio Regional del Fenomeno El Nino—Regional study on El Nino phenomenon) scientists will study the impact of 1982-83 El Nino on fisheries off South American coast. In the tropical Atlantic, plans for TOGA programme are already underway. In the tropical Indian Ocean, information on mean states of atmospheric and oceanic conditions has to be obtained before any plan is implemented.

The number of present observation systems will be increased and more satellites, ships, fixed as well as drifting buoys in sea will be deployed to collect data on sea surface temperature, wind stress at ocean surface, heat fluxes across air/sea interface, precipitation, sea level and currents. In the beginning, theoretical models will be developed to understand independent features of ocean and atmosphere and then, as TOGA progresses, coupled

ocean-atmosphere models will be evolved and tested for predicting the nature of interaction between these two fluids. Once the objectives of TOGA are achieved, effects of El Nino on world economy could be ascertained.

#### Further reading

- 1 Oceanus, vol 27, No 2(1984), Woods Hole Oceanographic Institution, Woods Hole (USA)
- 2 Rasmusson, E M and Carpenter, T H (1982), Variations in tropical sea surface temperatures and surface wind fields associated with Southern Oscillation/El Nino, Monthly Weather Review. 110 354-384
- 3 Woods, JD (1984), The upper ocean and air-sea interaction in global climate. In The Global Climate (Ed J T Houghton), Cambridge University Press, pp 141-178

## BIOTECHNOLOGY FOR EOR

(Continued from 491)

A typical example is Xanthan gum, the best known and most successful polymer, produced by fermentation of carbohydrates by the bacterium *Xanthomonas campestris*. It is a hydrophile polysaccharide with a molecular weight ranging from  $1 \times 10^6$  to  $1 \times 10^7$ . Some other interesting polysaccharides of microbial origin such as alginate from *Azotobacter vmelandu*, and pullan from *Aureobasidium pollulan* are also under investigation. The discovery of the biodegradation of Xanthan gum has caused concern over its continued effectiveness in EOR. The polymer can however be modified by reducing its rate of biodegradation without altering its rheological properties. At present, scientists from Stanford Research Institute, USA are studying ways to reduce biodegradation of Xanthan gum.

(b) *Biosurfactants* The use of surfactants in EOR represents an active research and development area. When surfactants are pumped into oil-bearing sandstone, oil is released due to change in its fluid dynamic properties. Applicability of biosurfactants for EOR has been ignored till recently, primarily due to the lack of definitive and cohesive literature on the subject and non-availability of the product.

Current research programmes focussing on the application of biosurfactants in oil recovery are promising. These products are commonly produced during aerobic growth of microorganisms in extracellular fluid, while growing on hydrocarbon or a mixed feed containing carbohydrate and hydrocarbon/fatty oils. A biosurfactant called "Emulsan" has been isolated from *Acetobacter calcoaceticus* RAG-1, and recently commercialized in USA. Structurally, emulsan is a lipo-polysaccharide of high molecular weight (approximately  $10^6$ ). The carbohydrate backbone consists of major amounts of D-galactosamine and aminouronic acid with fatty acids of carbon chain length from C<sub>10</sub>—C<sub>18</sub>

attached to the nitrogen and oxygen atoms of the sugar backbone. Potential application for the product has been suggested in micellar floods, emulsification, viscosity reduction of heavy crudes and rock-wetting agents.

Recently a glycolipid biosurfactant has been developed for use in MEOR. This biopolymer forms stable oil-in-water emulsion with a concomitant 95%-98% viscosity reduction of the oil. The glycolipid was produced by using 'Bacterium H-13' (belonging to coryne form bacteria), utilizing alkane as carbon source. The biosurfactant is comparable in its properties to sodium dodecyl sulfate, a commercial EOR surfactant. Further testing of this biosurfactant for commercial application is under progress.

Analysis of the existing literature indicates a real potential for the application of MEOR. This is specially so because of our growing ability to develop specific microbial processes through physiological and genetic means of manipulations.

#### Further reading

- 1 Shan, D O and Schechter, R S (eds), *Improved Oil Recovery by Surfactant and Polymer Flooding* Academic Press (1977)
- 2 Shankland, R V, Enhanced Oil recovery, *Chemtech*, p 684-688. Nov 1982
- 3 Moses, V, Microbes and Oil recovery an overview, *8/ofecn*, 83, (Proceedings of the International Conference on the Commercial Applications and Implications of Biotechnology) Online Publications, U K, p 415-422, 1983
- 4 Bubela, B, Microbial enhanced oil recovery—the problem underground, *Biotech*, 83, p 423-435, 1983
- 5 Jansheka, H, Microbial product for injection, *Biotech*, 83, p 437-453, 1983
- 6 Finnerty, W R and Singer, M.E, Microbial enhancement of oil recovery. *Biotechnology*, 1 (1), p. 47-54, 1983