EL NIÑO

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The Child

Fishermen who ply the waters of the Pacific off the coast of Peru and Ecuador have known for centuries about the El Niño. Every three to five years during the months of December and January, fish in the coastal waters off of these countries virtually vanish, causing the fishing business to come to a standstill. South American fishermen have given this phenomenon the name El Niño, which is Spanish for “The Child,” because it comes about the time of the celebration of the birth of the Christ Child.

An understanding of the complex processes at work to produce the El Niño requires information about phenomena occurring all across the Pacific, not just its eastern boundary, the west coast of South America. Remote sensing, particularly from the weather satellites, has been the source of data that finally has made it possible to understand the interactions between atmospheric winds and oceanic temperatures and currents that lead to the El Niño.

Worldwide Effects

El Niño effects are not limited to the disturbed areas off of Peru and Ecuador. They can be transmitted great distances. In many parts of the world, the disruption of normal climate can have tragic and/or profound economic consequences. El Niño has been shown to be related to the unusual flooding in Texas in the winter of 1991-1992, and to the anomalous warmth experienced in the southeast United States in the same period.

Nightly cloud images on television news from weather satellites show us the paths followed by the storms that cross the Pacific and travel northward from equatorial regions to the central lands of North America. Important indirect or secondary El Niño effects have been noted in other locations worldwide. During the 1982-1983 El Niño, there were huge drought-related fires in Borneo and Australia, drought-related eradication of sea bird populations on islands in the Pacific, and flooding on the east coast of equatorial South America, the Rocky Mountain region of the United States, and in Brazil, south of the Equator.

Air/Sea Interaction

The key element of the El Niño phenomenon is the interaction between the winds in the atmosphere and the sea surface. Without this air/sea interaction, there would be no El Niño. Taking advantage of observations from the National Oceanic and Atmospheric Administration (NOAA) weather satellites, scientists have been able to track shifting patterns of sea surface temperatures. The pool of warm waters that normally resides in the western waters of the Pacific has been seen to drift eastward toward the western coast of South America.

NASA satellite images also help us see the shifting patterns of storms over the equator that are a consequence of the shifting locations of the warm water pool. Towering cumulus clouds, reaching high into the atmosphere with multiple regions of strong up-and-down vertical (convective) motions, form and move eastward across the Pacific as they are generated by the warm surface waters. This movement of the powerfully active convective regions alters the

surface winds, and weakens the normally prevailing east-to-west trade winds.
Space Observations Pin Down the El Niño Phenomenon

Scientists at the Goddard Space Flight Center have used numerical models and theoretical studies to understand the processes that lead to El Niño. Comparison with data has shown the sequence of events leading up to El Niño. In normal years, when there is no El Niño, the trade winds tend to blow from east to west across the coastal waters of the eastern Pacific. They tend to drag the surface waters westward across the ocean. In turn, this causes deeper, colder waters to rise to the surface. The “upwelling” of deep ocean waters brings with it the nutrients that otherwise would lie near the bottom of the ocean. The fish population living in the upper waters is dependent on these nutrients from below for survival.

In an El Niño, the westward trade winds weaken, causing the upwelling of deep water to cease. The consequent warming of the ocean surface further weakens the trade winds, and strengthens El Niño. Without upwelling, the nutrients from deep water are no longer available. This signals the end of the fishing industry until the time that normal conditions return.

Prediction of El Niño events is now the focus of a major scientific initiative. The prediction of El Niño requires sophisticated numerical models to simulate:

1) the changes within the ocean that cause surface temperatures to warm; 2) the changes in atmospheric convection and clouds due to surface warming; and 3) the changes in surface winds that are caused by the convective disturbances. The societal impacts of accurately forecasting El Niño up to a year in

advance are huge, allowing economic and agricultural policy makers to adapt to short-term climate fluctuations in a beneficial way. Satellite observations will continue to play a crucial role in ensuring the success of these forecasts, by providing accurate measurements of the present conditions in the region, an essential first task for prediction.

NASA Missions to Study El Niño

Over the years, several NASA missions have studied the effects associated with El Niño, such as changes in sea-surface temperature (SST) and cloud cover changes. These studies are augmented by data from operational satellites of the National Oceanic and Atmospheric Administration (NOAA).

Initial efforts at mapping SST and cloud cover were conducted using data from NASA's Nimbus series of satellites. The four-channel Advanced Very High Resolution Radiometer (AVHRR) instrument, flown on NOAA's TIROS-N weather satellite in 1978 and on the NOAA-6 satellite in 1979, greatly increased the accurate measurements of El Niño effects. ("Four channel" means that the instrument views in four different parts of the electromagnetic visible and infrared spectrum.)

Still further increases in accuracy resulted when a fifth channel was added to the AVHRR instrument flown on NOAA-7 in 1981, and on subsequent NOAA satellites. The fifth channel improved the measurement of SST by providing corrections for atmospheric water vapor that otherwise would have interfered with the temperature measurements.

The joint U.S.-French TOPEX/Poseidon mission was launched in 1992 and is providing global determinations of changes in ocean surface currents that are related to the El Niño phenomenon. The currents are determined from changes in ocean surface elevations measured by altimeters on TOPEX/Poseidon with accuracies of a few centimeters.

In the near future, small NASA missions, known as Earth Probes, are planned to address specific Earth science investigations that will improve our knowledge of El Niño. Also NASA has initiated a “Pathfinder Program” to make higher-quality data available from past and current missions. These efforts will lead up to the Earth Observing System (EOS), the main initiative of NASA’s Mission to Planet Earth. The first in the series of EOS satellites will be launched in 1998. The accompanying table lists some of the missions that relate to the study of El Niño, and some of them are discussed briefly here.

A NASA scatterometer will fly on the Japanese Advanced Earth Observing System (ADEOS) in 1996 and will provide data on the speed and direction of ocean-surface winds. A novel Earth Probe is the joint U.S.-Japanese Tropical Rainfall Measuring Mission (TRMM), scheduled for launch in 1997. TRMM will, for the first time, use both active (radar) and passive microwave detectors from space to provide measurements of precipitation, clouds, and radiation processes in lower latitudes, including the portions of the Pacific Ocean where El Niño occurs.

Key sources of Pathfinder data related to El Niño are data from the five-channel AVHRRs flown on NOAA-7, 9, and 11. These historic data sets cover the period 1981 through 1992 and beyond and will permit more-accurate SST determinations than were previously available. These data are important to the development and testing of a new generation of computer models in which the interacting processes of the land, the atmosphere, and the oceans are coupled. These coupled models will lead the way to an increased understanding of phenomena such as El Niño and the teleconnections that tie El Niño into changes in weather patterns throughout the world.

With the launch of the EOS satellites, starting in 1998, we will have the means to collect and analyze the most-comprehensive data set ever acquired for the development of coupled models. This data set will increase markedly our understanding of the causes and effects of such large-scale ocean-atmosphere phenomena as El Niño.

Source: NASA