NASA Facts

National Aeronautics and
Space Administration

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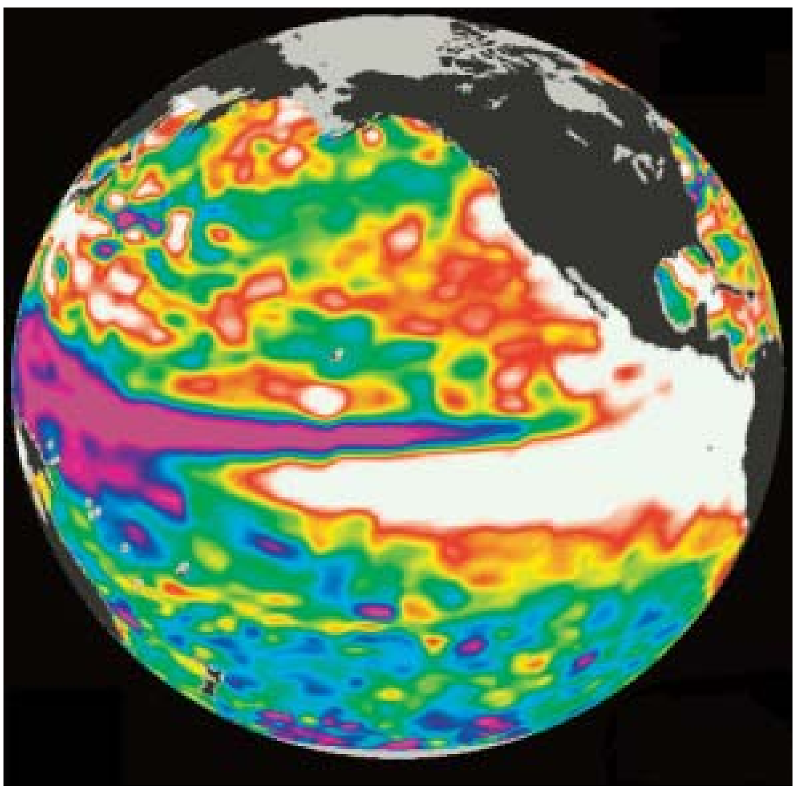
Oceanography from Space

When the Apollo astronauts looked back at Earth from the Moon, they saw the planet as a bright, blue marble glistening against the vast, black background of space. It was the stark blueness of the oceans in those first space-based images of Earth that struck many viewers. With nearly 70 percent of Earth's surface covered with water, the oceans make a spectacular impression when viewed from space. Today, scientists at NASA's Jet Propulsion Laboratory are using the vantage point of space to study how our oceans work.



El Nino warm water pool as measured by the TOPEX/Poseidon.

In the past, oceanographers had to study the sea from ships, a process that provided only spotty measurements from fixed locations. Today, several JPL robotic missions and instruments are designed to give oceanographers a panoramic view of Earth. Scientists hope to find out what role the oceans play in global climate and the greenhouse effect, and their studies will yield more accurate weather forecasts and predictions of long-term environmental change. All of JPL's current Earth-observing missions are part of NASA's Earth Science Enterprise, and all of the investigations involve some type of international cooperation.

Roots in Seasat

All of JPL's ocean-observing satellites and instruments use some form of radar to study the seas. Radars are useful tools because they can penetrate clouds, they operate in all weather conditions and they provide their own illumination so they can function day and night.

Seasat was launched in 1978 as a "proof-of-concept" mission to determine if radar remote sensing was valuable for ocean studies. The satellite carried five instruments to measure sea-surface temperature, wind speed, wind direction, the amount of water in the atmosphere, ocean waves and ice fields. Seasat operated for 100 days before an electrical short circuit ended the mission. However, the data collected before the mission stopped proved that accurate measurements of the oceans could be made from space.

Is Sea Level Rising?

Most scientists believe that as carbon dioxide and other emissions are added to our atmosphere, Earth is getting warmer. Ocean levels may rise due to melting ice and the expansion of ocean water as it warms. Rising ocean levels would make hurricanes and other storms more dangerous. More than half the people in the United States live within 50 miles of a coastline, and some entire nations, like Bangladesh and the Netherlands, are at or near sea level.

JPL manages a U.S./French satellite called Topex/Poseidon that accurately measures global sea height. Topex/Poseidon was launched on an Ariane rocket from French Guiana on August 10, 1992. The satellite's primary science goal is to improve our understanding of how the oceans circulate. Such information allows oceanographers to study the way the oceans transport heat and nutrients and how the oceans drive global weather and climate. Topex/Poseidon data are being used to understand the ocean's role in global change and to track potentially dangerous phenomena, such as El Niño.

The El Niño phenomenon is triggered when steady westward trade winds weaken and even reverse direction. This change in the winds allows the large mass of warm water normally located near Australia to move eastward along the equator until it reaches the coast of South America. This displaced pool of unusually warm water affects where rain clouds form and, consequently, alters the typical atmospheric jet stream patterns around the world. The change in the wind strength and direction also affects global weather patterns. Scientists are using these space-based data to better forecast when El Niños will occur.

Topex/Poseiden allowed scientists at JPL to track the evolution of an entire El Niño event for the first time. Data collected throughout 1997 and early 1998 provided the first detailed view of how El Niño's warm pool behaves, because the Topex/Poseidon satellite measures the changing sea-surface height with unprecedented precision. The 1997-98 El Niño event was the worst on record, causing world-wide destruction, loss of life and billions of dollars in damage.

Topex/Poseidon uses a radar altimeter to bounce signals off the ocean's surface. The device records the time it takes the signal to return to the satellite and calculates the precise distance between the satellite and the sea surface. These data are combined with measurements from other instruments that pinpoint the satellite's exact location in space. Every 10 days, scientists are able to produce a complete map of global ocean topography — the barely perceptible hills and valleys on the sea surface. With knowledge of ocean topography, scientists can then calculate the speed and direction of worldwide ocean currents.

As part of the satellite's mission, Topex/Poseidon data are being used in the Gulf of Mexico to help scientists and a U.S. oil company study potentially dangerous ocean phenomena, called eddies, that can disrupt offshore oil drilling. In another application, the precision of the satellite's ocean measurements has enabled scientists to calculate global tides across all the open oceans, an important step toward monitoring global ocean circulation from space and understanding the complexities of global climate change.

A Topex/Poseidon follow-on mission, called Jason 1, is planned for launch in 2001. Jason 1 will make it possible to study global ocean dynamics and the ocean's interaction with the atmosphere on a longer time scale. The data will help scientists improve their computer models to predict long-term global change.

Winds Over the Oceans

Winds are a driving force for oceanic motions, ranging from small-scale waves to large-scale systems of ocean currents. Winds directly affect the turbulent exchanges of heat, moisture and greenhouse gases between the atmosphere and the ocean. These air-sea exchanges, in turn, determine regional weather patterns and shape global climate.

On August 17, 1996, a JPL instrument called the NASA Scatterometer was launched onboard the Advanced Earth Observing Satellite by Japan's National Space Development Agency. The satellite functioned until June 1997 when a mechanical problem ended the mission. However, before the mission ended, the instrument took 190,000 wind measurements per day, mapping more than 90 percent of the world's ice-free oceans every two days. The instrument provided more than 100 times the amount of ocean wind information than had been available from ship reports. In addition, because the scatterometer was a radar instrument, it was capable of taking data day and night, regardless of sunlight or weather conditions.

A scatterometer looks off the side of a satellite, instead of straight down as an altimeter does. A scatterometer measures the total power returned from its transmitted signal after the radar pulse has struck the ocean's surface. The NASA Scatterometer is measuring the roughness of the surface, and consequently, the winds over the surface of the ocean.

Another important part of the NASA Scatterometer was the ground system that processed the data. Within two weeks of receiving raw data from the satellite, the ground processing system could determine wind speed and wind direction. This information was used to develop wind-field maps of the ocean. The National Oceanic and Atmospheric Administration used the data in its computer models for predicting weather and storm movements.

NASA Scatterometer measurements were combined with other space-based observations, like Topex/Poseidon data, to improve our understanding of El Niño and long-term climate change. The data were also used to pinpoint the location, structure and strength of storms at sea. The instrument's accurate wind information is greatly enhancing overall weather forecasting capabilities.

Due to the importance of scatterometer ocean wind observations, NASA approved a new mission to fill in the measurements lost with the failure of the Advanced Earth Observing Satellite. QuikScat was a quick recovery mission to fill the gap and used the spare SeaWinds scatterometer. QuikScat was launched on June 19, 1999, from Vandenberg Air Force Base aboard a Titan II vehicle. SeaWinds is a specialized microwave radar that measures near-surface wind speed and direction under all weather and cloud conditions over Earth's oceans. Data collected by the instrument help scientists to determine atmospheric forcing, ocean response and air-sea interaction mechanisms on various spatial and temporal scales.

A second SeaWinds scatterometer will fly aboard Japan's Advanced Earth Observing Satellite II, scheduled for launch from Tanagashima, Japan, in 2002. In a major functional change from their predecessor, the SeaWinds instruments use a rotating dish antenna with two radar beams instead of the NASA Scatterometer’s array of six 3-meter (10-foot) long antennas.

Other Platforms

Oceanography was also one of the many disciplines studied by the joint U.S./German/Italian Spaceborne Imaging Radar C/X band Synthetic Aperture Radar that flew on the space shuttle Endeavor in April and October 1994. The relatively low altitude of the shuttle was particularly advantageous for oceanography investigations since this project’s radars are more sensitive to ocean features than are radars on satellites in higher orbits. Oceanographers used data from the project to study surface and internal waves and interactions between waves and currents. In addition, extensive wave-energy information was collected over the Southern Ocean by an associated experiment provided by the Johns Hopkins University Applied Physics Laboratory. These data helped scientists study how the Earth's climate is moderated by the ocean. During the second flight, data were also collected in support of a controlled oil spill experiment conducted by Germany in the North Sea that was designed to measure the radar signatures of different weights and types of oils. Radar images were also acquired of sea ice in the Weddell Sea.

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