National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Tracking the Oceans' Height To Understand Earth's Climate

A Decade of Data

Since 1992, Topex/Poseidon's precise measurements and global observations of the oceans have revolutionized our understanding of global climate.

These globes, created with Topex/Poseidon satellite altimeter data, show the average annual sea-surface height anomalies for the period from 1993 to 2002. What is an anomaly? In this case, the anomaly is the difference between the height of the sea surface derived from the satellite data and the average sea-surface height for the past nine years. These anomaly maps are generated from data points of sea-surface height that stray from this range of average variations in height for that year. Sea-surface heights move up and down in a slow, regular pattern as the Sun's heat expands or shrinks the upper ocean and as the seasons progress. This "normal" annual signal has been removed from the data to show clearly the largest year-to-year variations of the decade.

Sea-surface height reflects how much heat is stored in the upper ocean. In these images, "normal" sea-surface height appears as green. The blue and purple areas represent heights between 8 and 24 centimeters (3 and 9 inches) lower than normal and indicate cooler upper-ocean water. Red and white represent areas between 8 and 24 centimeters (3 and 9 inches) higher than normal and indicate warmer water. Ocean surface height tells us how much and where heat is being stored in the ocean to influence future climate events.

Topex/Poseidon observations led to early prediction of the great El Niño of 1997–1998, which severely disrupted weather patterns around the world. The advance warning of this significant climate event helped save lives and resources worldwide. And, just as important, Topex/Poseidon lets us see the global ocean. So in a few days, we can view the whole stage — a stage on which El Niño and La Niña are only two of the actors.

Along with data from follow-on missions, the ocean surface topography measurements from Topex/Poseidon will continue to be a vital resource for scientists and policy makers.

Why Do We Study the Oceans?

The oceans play a major role in Earth's weather and climate as they heat, cool, humidify, and dry the air and influence wind speed and direction. The weather determines not just what we'll wear next week but also whether the wheat crop in Nebraska will flourish, if there will be enough snow in the Sierra Nevada to water Southern California, whether the hurricane season in the Atlantic Ocean will be mellow or brutal, or if an El Niño will destroy the Eastern Pacific anchovy fishery. Climate influences our water supply, food supply, and economy. We can't escape the weather, or even change it — but being able to better predict it makes its impact manageable. And only by understanding the dynamics of the oceans can we begin to do this. Fortunately, the oceans provide abundant clues to help analyze the world's changing climate, giving us an opportunity to forecast significant climate events and ready resources to help manage them and minimize their negative impacts.

How Do We Study the Oceans?

The Topex/Poseidon satellite uses an altimeter to bounce radar signals off the oceans' surface. The time it takes the signals to return provides precise measurements of the 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 produce a complete map of global ocean topography — the hills and valleys of the oceans' surface.

Heat from the Sun warms the ocean waters. Warmer water expands and therefore has greater volume than the same amount of cool water. Satellites measure the higher surface height of warm water and the lower surface height of cooler water. With detailed knowledge of ocean topography, scientists can calculate the speed and direction of ocean currents worldwide.

The Jason-1 Mission

The Jason-1 satellite, launched December 7, 2001, continues the quest to understand our planet better through long-term monitoring of its oceans from space. As a follow-on to the Topex/Poseidon mission, Jason-1 continues to observe global ocean circulation. Like Topex/Poseidon, the mission is a joint effort between the French space agency, Centre National d'Études Spatiales (CNES), and the National Aeronautics and Space Administration (NASA).

Jason-1 travels in the same orbit as Topex/Poseidon — a 66-degree inclined orbit at an altitude of 1,336 kilometers (830 miles) above Earth. From there it can cover 95 percent of the ice-free oceans every 10 days. Like Topex/Poseidon, the primary instrument on board the satellite is a radar altimeter. The Jason-1 altimeter measures sea-surface height with an accuracy of about 4.2 centimeters (1.6 inches), allowing it to map and monitor small but significant changes in global sea level.

The Jason-1 satellite is the product of a successful international collaboration of government organizations and private companies. Alcatel Space in Cannes, France, manufactured the satellite. The Boeing Company manufactured the Delta II launch vehicle that carried the satellite into orbit. The primary instrument, the altimeter that measures the distance between the satellite and the ocean, was built by CNES. NASA/JPL designed and built the radiometer that provides measurements of water vapor in the atmosphere. There are three positioning instruments on board the satellite that enable satellite tracking: the Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS) instrument built by CNES, the Global Positioning System (GPS) instrument built at NASA/JPL, and the Laser Retroreflector Array (LRA), built by ITE, Inc., for NASA's Goddard Space Flight Center. The Jason-1 prime mission is scheduled for three years with a two-year extended mission.

To make comments about this lithograph or for more information on ocean surface topography, visit these web sites —

http://sealevel.jpl.nasa.gov

http://www.aviso.oceanobs.com

JPL 400-1059 10/02