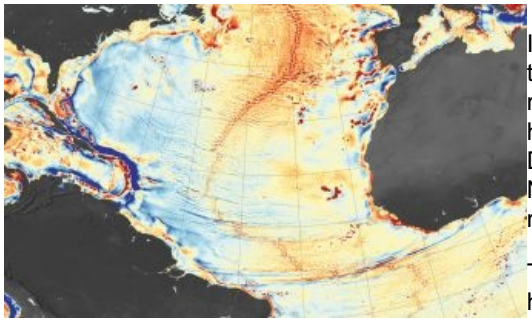
Satellite Altimeters Help Reveal Sub-Ocean Topography



It has been said that we have more complete maps of the surface of Mars or the Moon than we do of Earth. Close to 70% of our planet is covered by water, and that water refracts, absorbs, and reflects light so well that it can only penetrate a few tens to hundreds of metres. To humans and most satellite eyes, the deep ocean is opaque. But David Sandwell of the Scripps Institution of Oceanography and Walter Smith of the National Oceanic and Atmospheric Administration have produced a global dataset revealing the topography of the ocean bed.

Their methodology used a combination of global gravity anomaly data and sea surface height data. The sea surface heights were observed by Jason-1 and other satellite altimeter missions. They revealed ocean bed topography because the mass of the sea mountains applies a gravitational attraction on the surrounding water, so there are small ridges in the ocean surface above sea mountains and conversely there are depressions in the ocean surface above troughs. The new map gives an accurate picture of seafloor topography where each pixel represents five kilometres.

Jason-3 is Launched

Jason-3 was launched in January from the Vandenberg Air Force base in California. It will measure sea level in the open ocean to an accuracy of 40mm. The satellite will spend the first few weeks working in tandem with its predecessor Jason-2, to calibrate their microwave radar altimeters, and reliably continue monitoring global sea level topography.

El Niño - Higher Seas and Shorter Days

One might imagine that the onset of an El Niño event would be heralded by satellite remote sensing of increased water temperature in the Eastern Pacific. But the initial heating actually takes place at depth and it is the bulge in sea level caused by the expansion of the heated water that is detected by satellite altimetry, months ahead of surface water temperature. The 1997 El Niño was the first event to be detected by satellite altimetry from the TOPEX/Poseidon satellite, whilst the 2015 event has been recorded by Jason-2.

Shorter Day

El Niño also has geodetic effects that are less obvious. The appearance of warm water in the eastern Pacific is accompanied by a rise of sea level due to the lower density of the water. Mass movement of water is however minimal and so this has a small effect on gravity anomalies. But, the slowing and reversal of the trade winds and equatorial current that takes place during an El Niño affects Atmosphere Angular Momentum (AAM). During an El Niño, the AAM increases which, to preserve global angular momentum, is matched by a decrease in momentum of the solid earth. This slows the velocity of the Earth's rotation with a consequent increase in length of day by up to a millisecond with a time lag of about a month. This is a daily change so the effect on time is cumulative. At the peak of the 1983/4 El Niño, 0.12 seconds of time had been gained. The AAM recovers, the length of day shortens and the gained time is lost as the event passes into the La Niña phase.

Studies have also shown El Niño has a high impact on the correlation between AAM and polar motion for single El Niño events, but not if the data spans more than one event. Kotaczek et al report that the impacts have an impulsive character causing irregular variations in polar motion during El Niño events.

This article was published in Geomatics World March/April 2016