National Aeronautics and Space Administration

SEA LEVEL FROM SPACE: NEW APPLICATIONS OF OCEAN ALTIMETRY DATA

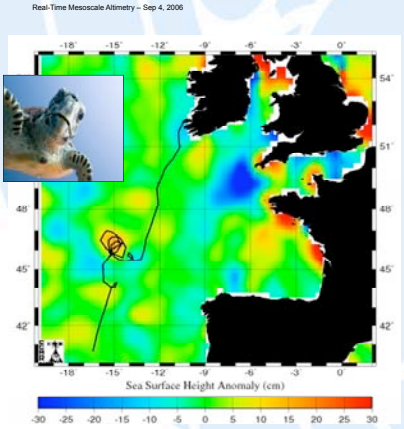
Margaret Srinivasan, *Jet Propulsion Laboratory, California Institute of Technology*, mss@jpl.nasa.gov
Robert Leben, *University Of Colorado*, leben@colorado.edu

Abstract

A sixteen year time series of sea surface height measurements from the NASA and CNES ocean altimetry missions has provided oceanographers and marine operators an exceptional opportunity for new discoveries in both scientific research and operational applications. The data continues to be used to map sea surface height, geostophic velocity and significant wave height over the global oceans. In combination with other data streams such as ocean color, winds, gravity and ocean profiling floats, scientific researchers are discovering new ways to view ocean processes and are increasingly able to discern more mesoscale structures.

The data has proved to be a key to understanding Earth's delicate climate balance, and is a critical component of global climate studies, research on El Niño, La Niña and longer term climate events, and studies of sea level rise. It has also many practical applications. The data can be used to map ocean currents and eddies, which have a major impact on coastal fisheries, offshore oil facilities, ocean shipping, marine ecosystems and hurricane dynamics. Private companies use and distribute altimetry data tailored specially for commercial and operational applications. For example, offshore oil operations require accurate information about ocean circulation to minimize the impacts from strong currents and eddies. Marine operators, recreational boaters, and marine animal researchers all benefit from increasingly more accessible near real time (NRT) data (for example, http://argo.colorado.edu/~realtime/welcome/). NRT data can allow marine operators and recreation boater to optimize routes, resulting in both economic and time savings.

With the successful launch of OSTM/Jason-2 in June 2008, and important new partnerships with Eumetsat and NOAA for operational weather and climate applications, the methodologies of ocean altimetry measurements will transition from basic research and technology verification to operational uses. The focus moves from research objectives to data applications that benefit society.



The path of a satellite-tracked turtle is overlaid on a sea surface height anomaly image. The turtle resided in an anticyclonic mesoscale eddy (yellow area) for 66 days, looping around in the same direction as the circulation. Image credit; T. Doyle/ Univ. College Cork Ireland

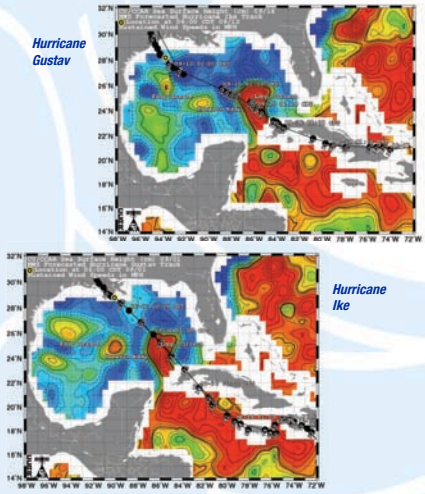
LEATHERBACK TURTLES
Altimetry Data Helps Track Endangered Species

Leatherback turtles have been listed as an endangered species since 1970. With threatened habitats due to chemical and physical pollution, commercial fishing (as by-catch), and threats to eggs and young turtles, research is underway to understand the populations, origins, and behavior of leatherback turtles. A collaboration between the University of Wales Swansea and University College Cork in Ireland, called the INTERREG IIIA Irish Sea Leatherback Turtle Project, tracks turtles from coastal seas in the northern Atlantic to their tropical breeding sites along the northeast South American coast. The question of how and why these animals travel so far to distant foraging grounds was answered, in part, by satellite altimetry data.

Researchers use near real-time altimetry data products from CCAR to identify mesoscale ocean circulation features frequented by leatherback turtles feeding, presumably on jelly fish, *See* http://www.turtle.ie/ for information on this study.

EXTREME WEATHER EVENTS
Hurricanes Gustav & Ike

Ocean altimeter data is used for long term seasonal forecasts of the numbers and strengths of hurricanes expected in a given hurricane season, as well as short term forecasts of the strength of individual



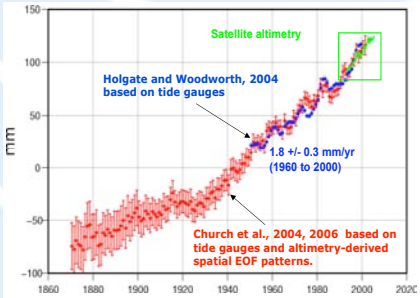
Data from Jason-1, ENVISAT, and GFO ocean altimeter satellites indicate the Loop Current, a large warm feature (red) directly beneath the forecasted path. Both Hurricane Gustav (top) and Ike (bottom) made landfall as strong Category 2 storms; Gustav on the Louisiana coast on 1 September 2008, and Ike on the Texas coast on 13 September 2008. Image credit: Univ. Colorado Center for Astrodynamics Research

hurricanes. These September 2008 images show the predicted path of Hurricanes Gustav (left) and Ike (right) from a NWS National Hurricane Center forecast. These track overlay near real-time maps of sea surface height and associated ocean circulation features in the Gulf of Mexico and northwestern Caribbean. Although the track of a hurricane is primarily dependent upon steering winds, the interaction of the hurricane with the upper ocean is the primary source of energy for the storm. Hurricane intensity is greatly affected by the upper ocean temperature structure and can exhibit explosive growth over warm ocean currents and eddies. Hurricane forecasters use satellite altimetry to estimate the heat content of the upper ocean to assess the potential for intensification.

130 YEARS OF SEA LEVEL RISE
Extended observations for climate studies

Global Sea level is on the rise. In the past 130 years the world has witnessed an increase in average global sea level of over 200 millimeters at a rate of 1.7 millimeters per year. The first step in anticipating a global future with higher sea levels, and all of the associated climate implications, is to understand the past and present. Past records of global sea level come primarily from tide gauge data.

With the high accuracy measurements available from the TOPEX/ Poseidon and Jason-1 satellites, this rate has been observed to increase to about 3 mm/year since measurements began in 1993. Now, the Ocean Surface Topography Mission on Jason-2 (OSTM/ Jason-2) launched this June, will extend this critical climate indicator into the next decade. This extended cross-calibrated time series will allow researchers to evaluate changes in sea level, and will help them understand what the implications are for the planet.



Sea levels for 1870 to 2000 indicate a 20th century rise of about 1.7 mm yr-1 and an acceleration in the rate of rise. Since TOPEX/ Poseidon launched in 1992, global sea level has risen about 3 mm yr-1. Image Credit: J. Church/CSIRO

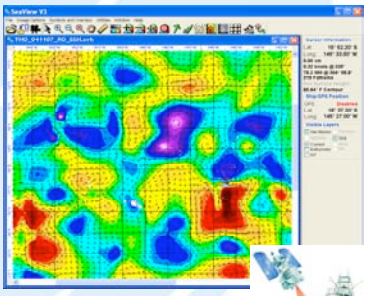
DEEPWATER OIL OPERATIONS
Pemex uses near real-time altimetry maps

In August 2007, a record number of oil and gas drilling rigs were working in deepwater in the Gulf of Mexico (GOM) with a total of 15 rigs in 1500 meters (5000 ft) of water or greater. This activity is in U.S. waters; however, by 2010 Petroleos Mexicanos (PEMEX), the Mexican national oil company, plans to start production in the southern GOM continental slope in waters deeper than 500 m. PEMEX is now funding oceanographic studies in the GOM to prepare for this push into deepwater. The goal of their research program is to develop predictive circulation modeling to support their exploration and production activities. As part of the program, CICESE and Horizon Marine Inc. have initiated a surface drifter program in the Bay of Campeche to obtain continuous measurements of the surface currents as well as to monitor in near-real time the eddies and jets present that may affect drilling operations in the region. They are using CCAR near-real time altimetry products to help identify important oceanographic features to efficiently plan and execute the monthly surface drifter deployments.

COMMERCIAL FISHERIES
Private companies utilize altimetry data

A commercial company, Ocean Imaging (OI) based in Solana Beach, California has been supplying ready-to-use oceanographic analysis products to commercial and recreational fishing fleets since 1983. OI pioneered the use of NOAA AVHRR-derived sea surface temperature imagery to help locate productive fishing grounds and continues to build upon this service by adding new and novel information products to its SeaView and OceanEye services world-wide.

OI provides pre-processed CCAR sea surface height and geostrophic velocity data products via the SeaView data retrieval and visualization to customers worldwide. These data are valuable to offshore commercial fishing vessels working in areas with persistent cloud cover in which ocean frontal features are not easily identifiable using SST imagery. Using the SSH data to locate potential convergence zones and areas of current shear has now become a common method among offshore captains. For more information see http://www.oceani.com.



SSH in the area surrounding Tahiti in the South Pacific Ocean as displayed in OI's SeaView program. Ocean current vectors are visible as a data layer. Image credit; OceanEye

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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