Societal benefits of ocean altimetry data

Margaret Srinivasan[1]
Robert Leben[2]
[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA
[2]Colorado Center for Astrodynamics Research, University of Colorado, Boulder, CO

Abstract— **The NASA/CNES Jason satellite, follow-on to the highly successful TOPEX/Poseidon mission, continues to provide oceanographers and marine operators across the globe with a continuous twelve-year, high quality stream of sea surface height data. The mission is expected to extend through 2007, when the NASA/NOAA/CNES follow-on mission, OSTM, will be launched with the wide-swath ocean altimeter on board. This unprecedented resource of valuable ocean data is being used to map sea surface height, geostrophic velocity, significant wave height, and wind speed over the global oceans. Altimeter data products are currently used by hundreds of researchers and operational users to monitor ocean circulation and improve our understanding of the role of the oceans in climate and weather. Ocean altimeter data has many societal benefits and has proven invaluable in many practical applications including;**

- **Ocean forecasting systems,**
- **Climate research and forecasting,**
- **Ship routing,**
- **Precision marine operations such as cable-laying and oil production,**
- **Fisheries management,**
- **Marine mammal habitat monitoring,**
- **Hurricane forecasting and tracking,**
- **Debris tracking**

The data has been cited in nearly 2,000 research and popular articles since the launch of TOPEX/Poseidon in 1992, and almost 200 scientific users receive the global coverage altimeter data on a monthly basis. In addition to the scientific and operational uses of the data, the educational community has seized the unique concepts highlighted by these altimeter missions as a resource for teaching ocean science to students from grade school through college. This presentation will highlight societal benefits of ocean altimetry data in the areas of climate studies, marine operations, marine research, and non-ocean investigations.

Keywords-altimetry; applications; ocean surface topography; sea surface height; TOPEX/Poseidon; Jason-1; operational oceanography

I. INTRODUCTION

This paper will highlight some of the applications, both scientific and operational, of ocean altimetry data. The internet is a primary resource for access and retrieval of the data by users, and as a tool to reveal some of the many uses to potential users as well as the interested public. To this end, we report on data resources and on available web-based tools for accessing the data, on some of the specific uses of the data, and on the Ocean Altimetry Yellow Pages, a growing web based database of applications that is sponsored by NASA and CNES.

NASA's ocean altimetry data is available free of charge to researchers and to the general public. The use of the data, that is, who is using it and how they are using it, is an important focus for the missions. Most researchers have sophisticated data processing routines to support their work. They acquire varied data products from either the NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC) in the U.S., or from the CNES-sponsored data distribution center, Archivage, Validation et Interprétation des données des Satellites Océanographiques (AVISO) in France, largely via ftp web sites on the internet. On the other hand, operational users, those using the data not *as* their work, but to *support* their work, must rely upon readily accessible data and graphics from web-based interfaces to aid in interpreting ocean conditions relevant to their needs.

Numerous web-based data resources exist for the operational user community. NASA's Jet Propulsion Laboratory supports an effort at the University of Colorado Center for Astrodynamics Research (CCAR) where they host a near real-time web site that combines global ocean altimetry data from all active altimetry mission. The CCAR Global Near Real-Time Sea Surface Anomaly Data Viewer (http://www-ccar.colorado.edu/~realtime/gsfc_global-real-time_ssh/) allows users to view maps of the sea surface anomaly for any region in the global ocean (70°S to 70°N latitude). Maps are produced from Jason, TOPEX/Poseidon (T/P), Geosat Follow-On (GFO) and ERS-2 altimeter data processed in near real-time, usually within 12 to 36 hours of overflight. An analysis product is based on the latest 10 days of Jason and T/P, 17 days of GFO and 35 days of ERS-2 sampling, if available.

Another important resource for operational users is the U.S. Naval Research Laboratory web site (http://www7300.nrlssc.navy.mil/altimetry/) which supports a wide range of users of not only raw altimetry data but also of the data from ocean prediction models. A pilot project of the National Oceanic and Atmospheric Administration also hosts the OSCAR (Ocean Surface Current Analyses – Real-time) web site, at http://www.oscar.noaa.gov/index.html which uses both altimetry and wind measurements to produce maps of surface currents in the tropics.

II. APPLICATIONS

Data and images from TOPEX/Poseidon and Jason altimeters are being used for a wide range of practical applications. The JPL Ocean Surface Topography web site features many of these applications at http://sealevel.jpl.nasa.gov/science/applications. Included on the site are summaries of some of the important research and

operational applications that utilize sea surface height data to improve our understanding of Earth systems, climate, marine wildlife habitats, and more.

Examples of some of these applications follow.

A. *Climate*

By modeling changes in the distribution of heat in the ocean, scientists can study the evolution of weather patterns from the ocean system. Understanding the pattern and effects of climate cycles such as El Niño and La Niña helps predict and mitigate the disastrous effects of floods and drought. When data sources are combined, such as altimeter and scatterometer data, the products can be incorporated into atmospheric models for hurricane season forecasting and individual storm severity.

Figure 1. TOPEX/Poseidon sea surface height anomoly map of November 1997 El Niño.

B. *Marine Operations*

Maps of currents, eddies, and vector winds are used in commercial shipping and recreational yachting to optimize routes. Cable-laying vessels and offshore oil operations require accurate knowledge of ocean circulation patterns to minimize impacts from strong currents. In the areas of fisheries management satellite data identify ocean eddies that bring an increase in organisms that comprise the marine food web, attracting fish and fishermen. The fishing industry is using data to locate likely places of higher fish concentrations and also to pinpoint locations of target species. Fishery managers also use TOPEX/Poseidon data in conjunction with other remotely sensed data sets.

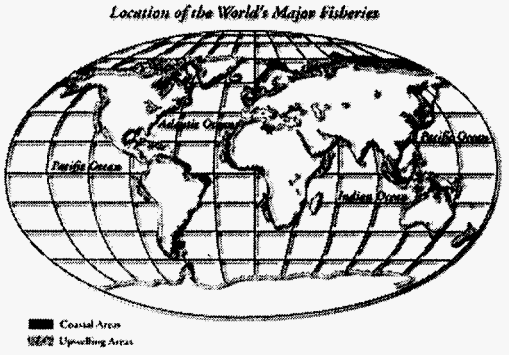

Figure 2. Major fisheries of the world.

C. *Marine Research*

Sperm whales, fur seals, turtles and other marine animals are tracked and studied in the vicinity of ocean eddies where nutrients and plankton are abundant.

A lobster larvae survival study[1] by researchers at the National Marine Fisheries Service Southwest Fisheries Science Center - Honolulu Laboratory showed that altimeter derived geostrophic currents may be of use in predicting natural repopulation success. This topic is of growing interest as overfishing occurs and efforts are made to replenish stock. Remotely sensed data are also used to monitor and assess coral reef ecosystems, which are sensitive to changes in ocean temperature[2].

Lost or abandoned fishing nets, timber, and ship debris threaten fish, birds, sea turtles, and marine mammals in the open ocean. This material collects in locations based on wind and currents. When entangled in coral reefs, these nets can also damage the reef environment and can entangle marine animals. The GhostNet project[3] (an industry, Government, and academia partnership) utilizes circulation models, drifting buoys, satellite imagery, and airborne surveys with remote sensing instruments in the detection of derelict nets at sea. Altimeter data from CCAR is among the suite of data used to locate convergent areas where nets were likely to collect. An aircraft survey locates debris in the targeted locations.

D. *Land Operations*

Ocean altimeter satellites are typically associated with providing data to support ocean operations and research. There are, however, several land applications of this important data. For instance, Jason data are currently being used to monitor the variation of surface water height of large inland water bodies in Africa. Using near-real time data, a time series of surface water height variations is constructed and is delivered to a website for public access and to serve the US Department of Agriculture, Foreign Agriculture Service for its flood/drought investigations. This project is the first of its kind to utilize near-real time altimeter data over inland water in such an operational manner (http://www.fas.usda.gov/pecad).

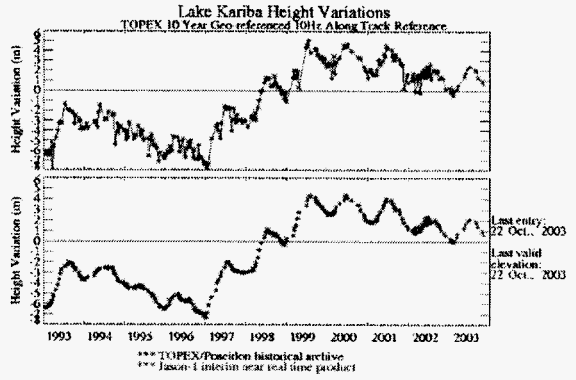

Figure 3. Lake Kariba, Africa; lake surface height variations from TOPEX/Poseidon and Jason data, 1993 through 2003.

Other land applications include research in Greenland where altimeter data has been used to measure surface elevation change on the southern Greenland ice sheet, and the Simpson Desert, Australia where a radar surface backscattering coefficient is used as a measure of surface reflectivity. Cycle-to-cycle stability of the computed factor is assessed to discern any temporal changes in the signal.

E. Other

Other uses of the data include insurance claims adjustors confirming claims of cargo loss at sea. Recreational boaters use charts of sea surface height to identify eddies and swift moving currents to increase safety and gain a competitive edge.

III. ALTIMETRY YELLOW PAGES

A directory of ocean altimetry data applications, the Satellite Altimetry Yellow Pages, has been developed as an index to research and practical applications of ocean altimetry data and of data users. It is posted on the AVISO web site at http://www.aviso.oceanobs.com/html/swt/yp/. The Yellow Pages directory is designed to serve as a tool to identify both operational and research applications of these highly effective ocean-observing systems, and to identify the individual users. The directory serves as a professional guide for satellite altimetry users, both experienced and new.

This ready reference of practical and research uses of ocean altimetry systems is meant to be a tool for acquainting existing and potential users of the myriad of opportunities to enhance research and operational activities with ocean surface topography data. Each entry includes a summary of the application, how the data are being used, and contact information on the specific user.

The Yellow Pages is also intended to serve as a working guide to define and track altimetry applications, and to facilitate communication between current and potential data users. It is also designed to serve as a model working method for close collaboration between scientists and commercial users to clarify distinct uses and to accurately describe and present the practical applications and societal benefits of altimetry data[4].

IV. SUMMARY

OSTM, the next generation ocean topography mission will take ocean surface topography measurements into an operational mode for continued climate forecasting research as well as scientific and industrial applications. It will carry on the valuable time series beyond the TOPEX/Poseidon and Jason missions.

REFERENCES

[1] Polovina, J., Kleiber, P., and Kobayashi, D. R. Application of TOPEX-POSEIDON satellite altimetry to simulate transport dynamics of larvae of spiny lobster, Panulirus marginatus, in the Northwestern Hawaiian Islands, 1993-1996. Fisheries Bulletin 97:132-143.

[2] NASA/JPL Ocean Surface Topography web site, http://sealevel.jpl.nasa.gov

[3] Pichel, W.G., T. Veenstra, J. Churnside, E. Arabini, K.S. Friedman, D. Foley, R. Brainard, D. Kiefer, S. Ogle, P. Clemente-Colon, X. Li, J. Nicoll, 2003, GhostNet - derelict net detection in the North Pacific and Alaska waters using satellite and airborne remote sensing and surface drifters, Proceedings, 30th International Symposium on Remote Sensing of Environment, November 10-14, 2003, Honolulu, Hawaii, 4 pp.

[4] Srinivasan, M., Blanc, F., Rosmorduc, V., The Satellite Altimetry Yellow Pages; A Guide for Users, AGU Fall Meeting, Abstract OS52A-0207, San Francisco, CA, Dec. 2002.

[5] Srinivasan, M., Leben, R., Fu, L., Menard, Y., Dombrowsky, E., Blanc, F., Satellite altimetry applications: Operational oceanography from space, IGARSS Annual Meeting, Abstract INT1-A28-11, Toronto, Canada, 2002.