17 YEARS AND COUNTING: SATELLITE ALTIMETRY FROM RESEARCH TO OPERATIONS

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In 1992, NASA and the French space agency launched the first high-precision satellite altimeter to measure changes in sea surface height. With it began a new era in oceanography. After 17 years and two successful follow-on missions, Jason-1 and Jason-2/OSTM, the space agencies now are poised to transition this series of satellites to the operational weather and climate agencies, NOAA in the United States, and EUMETSAT, the European meteorological satellite agency. The recognition by the operational agencies of the need to maintain these observations is a testament to the overwhelming success of satellite altimetry as a critical tool, not only for research in oceanography and climate science, but also for marine operations.

Data from satellite altimeters continues to be used to estimate global sea level rise, sea surface height, geostrophic velocity, significant wave height and atmospheric water vapor over the global oceans. In combination with other ocean observations such as color, winds, and gravity, as well as temperature, salinity and velocity from profiling floats, researchers continue to discover new insights into a wide variety of ocean processes and are increasingly able to discern more mesoscale structures. Recent notable scientific discoveries include massive phytoplankton blooms, interactions between the mesoscale and the mean flow, zonally-elongated jet-like features in the mean flow, a census of icebergs in the Southern Ocean, and the complexities of the nearly ubiquitous ocean eddy field.

Satellite altimeter data have also proven central to detecting and understanding climate-related ocean signals such as El Niño, La Niña and longer term signals like the Pacific Decadal Oscillation. Altimeter data also have many practical applications. They can be used to estimate 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 industries such as cable-laying vessels and 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 recreational boaters to optimize routes, resulting in both economic and time savings.

Altimetry data is also used to study the feeding and migration behaviors of pelagic animals. Researchers have observed whales, seals, turtles and other species and tracked their movement to interpret animal behavior in conjunction with data collected from animal tags. Understanding when, where, and how pelagic animals exploit the ocean mesoscale environment is critical to the effective management and protection of threatened and endangered species.

In addition to its operational and scientific uses, precision satellite altimeters provide a critical observation of global climate change. As the Earth's climate enters a new era where it is driven primarily by human activities, it has become vitally important to monitor the impact of human-induced climate forcing. By providing an estimate of global sea level rise with sub-centimeter accuracy, altimeters capture one of the most profound consequences of global warming (see Figure 1). In addition to collecting the excess freshwater from melting glaciers and ice sheets, the oceans store over 80 percent of the excess heat captured by elevated levels of greenhouse gases causing thermal expansion. The resulting global sea level rise is one of the most direct and societally relevant impacts of global warming. Satellite altimeters therefore provide an important yardstick for scientists and policy makers to determine the extent of human-induced climate change and develop strategies to mitigate and adapt.

Ocean altimetry provides considerable benefits to society, through scientific research, climate monitoring, and operational applications. In this paper we strive to illustrate several of the ways that ocean altimetry data is being used in order to demonstrate its value to potential users and decision makers. We highlight new and innovative ways the data is used for the public good, including timely and critical climate and weather-related applications.

Responsibility for the operation of Jason-2 has now been assumed by NOAA and EUMETSAT, as have plans for the launch and operation of next altimeter mission, Jason-3. NASA and CNES will continue to support instrument and spacecraft operations and will archive select data from the mission. They will also continue to support an international science team that uses the data to do the important work of ocean and climate science, in addition to ensuring the quality of the long-term climate data record.

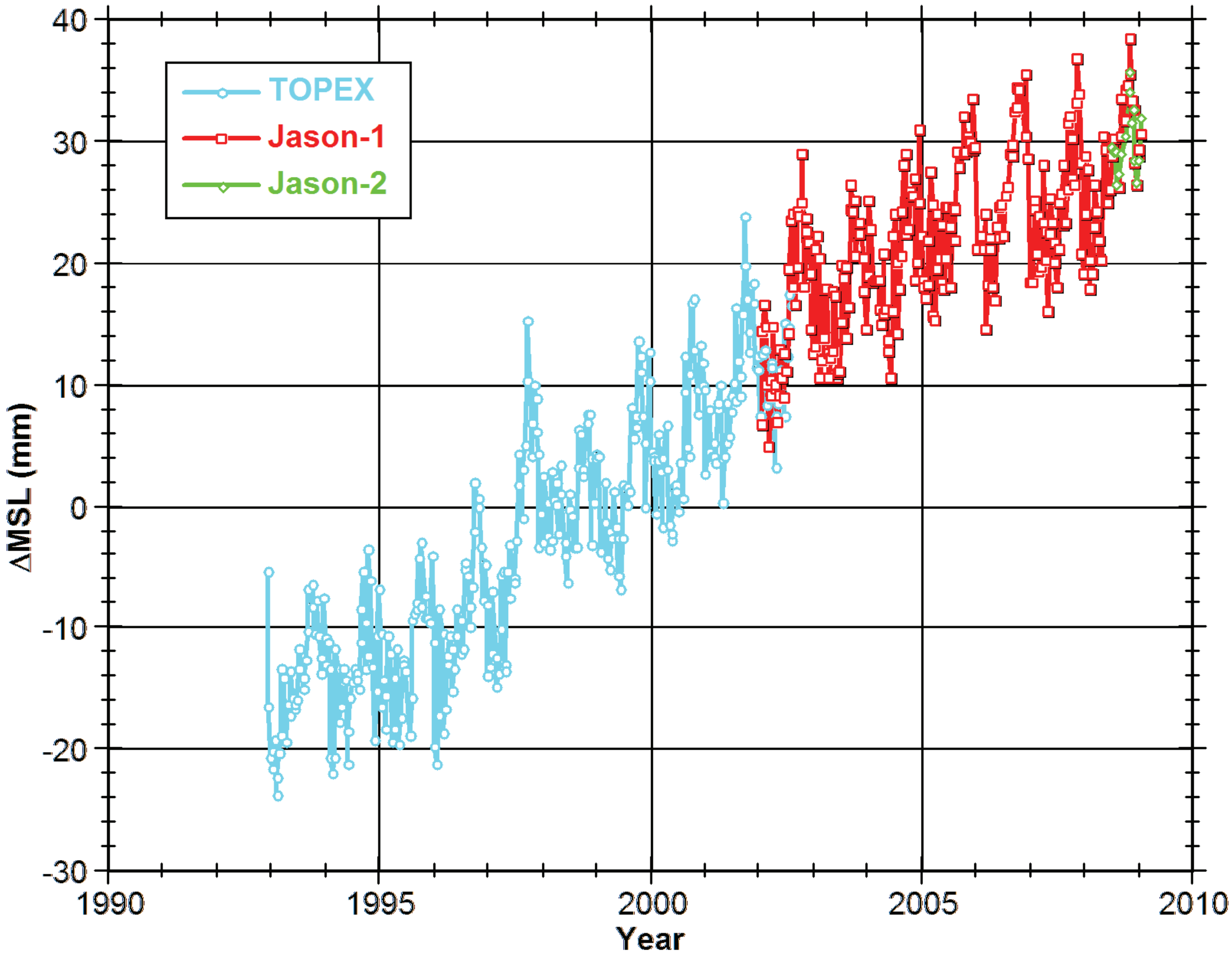

Figure 1. Globally-averaged sea level rise as observed by satellite altimeters. This record of global climate change is only possible due to the overlap of the successive high-precision altimeter missions, TOPEX/Poseidon, Jason-1 and Jason-2/OSTM, along with the careful work of the ocean surface topography science team. As responsibility for satellite altimetry transitions to the operational agencies, the science team will continue to play a central role in maintaining the accuracy of the observations as well as exploiting these data for scientific research. (Figure updated from [1]).

[1]. Leuliette, E. W, R. S. Nerem, and G. T. Mitchum, "Calibration of TOPEX/Poseidon and Jason altimeter data to construct a continuous record of mean sea level change," *Marine Geodesy*, 27(1-2), 79-94, 2004.

References

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