Report of the High-Resolution Ocean Topography
Science Working Group Meeting

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Edited by
Dudley B. Chelton
College of Oceanic and Atmospheric Sciences
Oregon State University
Corvallis, OR 97331-5501

e-mail: chelton@coas.oregonstate.edu
phone: (541) 737-4017

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Executive Summary

The nine-year record of TOPEX/POSEIDON (T/P) altimeter data has demonstrated the utility of highly accurate ocean topography measurements for a wide range of scientific and operational applications. While the 9.9156-day exact-repeat sampling pattern of the T/P orbit minimizes temporal aliasing of mesoscale variability at the measurement locations along the satellite ground track, the corresponding 2.834° longitudinal spacing of ground tracks restricts the spatial scales of sea surface height variability that can be resolved by the T/P sampling pattern. There are many physical processes that occur on spatial scales that are not fully resolved by the T/P dataset. In recognition of the importance of these shorter-scale phenomena, the National Aeronautics and Space Administration (NASA) established a High-Resolution Ocean Topography Science Working Group to review the scientific and operational rationales for high-resolution measurements of ocean topography, and to review the status of existing and developing technologies for measuring ocean topography with higher resolution than has heretofore been possible.

To address these issues, a two-day meeting was convened on 28-29 March 2001 at the University of Maryland Conference Center in College Park, Maryland. The meeting began with presentations summarizing the resolution capability of ocean topography measurements from presently operating and soon-to-be launched altimeters. This was followed by a series of presentations articulating the scientific and operational needs for higher resolution measurements of ocean topography:

- Studies of mesoscale eddies and fronts that are essential to understanding the dynamics of ocean circulation on all space and time scales, including the large-scale meridional transport of heat by eddies and the mass transport by large-scale currents through eddy-mean flow interaction.
- Studies of mesoscale and shorter-scale variability in the coastal regions associated wind-driven upwelling, flow perturbations by abrupt bathymetric features, and eddies and meanders generated by flow instabilities.
- Operational applications for prediction of ocean circulation on a wide range of scales. Military applications include naval operations such as sea-lift ship routing, search and rescue, antisubmarine warfare, and coastal and mine warfare. Civilian applications include tidal information for navigation and hazard mitigation, ship routing, fisheries forecasting, pollutant spill dispersion forecasting, El Niño and other seasonal-to-interannual anomaly forecasting, oil rig design, location and monitoring of hazardous currents, marine resource management, and water level changes in the Great Lakes.
- Data constraints for data assimilation models being developed for research and operational forecasts of open-ocean and coastal ocean circulation.
- Improved resolution of global tide models in coastal regions and near major bathymetric features in the open ocean.
- Studies of deep-ocean mixing associated with internal tides, and an investigation of the importance of this small-scale mixing to the large-scale circulation and climate variability of the world ocean.
- Studies of physical-biological interaction associated with mesoscale and shorter-scale variability in the open ocean and coastal regions, determination of gas transfer velocity across the air-sea interface, and an investigation of the importance of these biogeochemical processes in the global carbon cycle.
- Estimation of short-scale features of ocean bathymetry and their association with lithospheric and mantle processes in the Earth’s interior, and an investigation of the importance of the short-scale roughness of the seafloor on the overlying large-scale and mesoscale ocean circulation.

Following the presentations on applications, the High-Resolution Ocean Topography Science Working Group heard presentations summarizing new technologies for high-resolution measurements of ocean topography:

- A constellation of dual-frequency Ku-band (~14 GHz) and C-band (~6 GHz) altimeters named WITTEX. The WITTEX altimeters are based on the delay-Doppler design that provides
measurements with high accuracy and small footprint size from small, low-power and low-cost altimeters.

- A constellation of Ka-band (~35 GHz) altimeters named AltiKa. The AltiKa altimeters are based on altimetric measurements at high frequencies for which ionospheric effects are negligible. The ability to measure ocean topography with a single-frequency altimeter allows for a low-power, low-cost design with a small footprint size.
- A Wide-Swath Ocean Altimeter (WSOA) that is based on interferometric measurements of ocean topography with a 15 km sample spacing across a swath width of 200-km centered on the satellite ground track.
- Altimetric measurements from the reflections of signals from the Global Positioning System (GPS) constellation of satellites, which could potentially provide global ocean topography measurements with a 25 km sample spacing.

Written summaries of all of the meeting presentations are included in this report. The meeting concluded with an open discussion of the strengths and limitations of the various new technologies for obtaining higher resolution measurements of ocean topography than have been possible from traditional altimeter systems.

Through email correspondence subsequent to the March 2001 meeting, near-term and long-term strategies were developed for establishing high-resolution measurements of ocean topography. On the basis of these proceedings, the High-Resolution Ocean Topography Science Working Group recommends an evolutionary development of a system for addressing the scientific and operational needs for high-resolution measurements of ocean topography:

- NASA should continue operation of T/P for as long as the instrument continues to function well. In tandem with the Jason-1 altimeter, this will provide the first opportunity to acquire high-resolution measurements of ocean topography from a coordinated tandem sampling pattern. A tandem T/P and Jason-1 sampling pattern will address many of the needs for high-resolution ocean topography. This will enable fundamentally new scientific studies and applications, as well as provide a framework for future mission formulation. In addition to improved spatial resolution, extended operation of T/P will provide backup in case of instrument malfunction or failure of the Jason-1 satellite.
- After the initial 6-month calibration and validation phase of the Jason-1 mission, Jason-1 should be maintained in the present T/P orbit and T/P should be maneuvered into an orbit that samples along ground tracks half way between the present T/P ground tracks, thus doubling the resolution of ocean topography measurements from the tandem mission. The resolution obtainable from such a tandem T/P-Jason sampling pattern is significantly better than that from tandem Jason-ENVISAT sampling. After the January 2002 launch of ENVISAT, simultaneous operation of T/P, Jason-1 and ENVISAT would further improve the resolution of ocean topography measurement through the triplet altimeter sampling pattern.
- In the same manner, Jason-1 should be operated in tandem with Jason-2 after a 6-month calibration and validation phase following the planned December 2005 launch of Jason-2.
- Planning should begin immediately to build and launch a constellation of at least three low-cost, low-risk altimeters (e.g., WITTEX or AltiKa) as a follow-on of the ENVISAT and Jason-2 altimeters. In a coordinated sampling pattern with the 9.9156-day orbit repeat period of T/P, Jason-1 and Jason-2, such a multi-satellite mission would provide significantly higher-resolution measurements of ocean topography than are possible from the triplet T/P-Jason-ENVISAT sampling pattern.
- At the earliest possible opportunity, which appears to be on the Jason-2 platform with a planned launch in December 2005, flight demonstration of WSOA should be conducted as a proof of concept of very high-resolution measurements of ocean topography by interferometric altimetry.
- More extensive flight demonstrations of GPS altimetry should be conducted in concert with further technology development to improve the understanding of the GPS capability for high-resolution measurements of ocean topography.