Testimony of
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before the
U.S. Commission on Ocean Policy
October 30, 2002

In support of NASA's mission to understand and protect our home planet, NASA's Earth Science Enterprise (ESE) is dedicated to developing a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations. This complex system is comprised of the atmosphere, oceans, and land, and the bio-geo-chemical and physical processes that link them. The oceans play a critical role in this system. Ocean circulation, together with the atmosphere, constitutes the mechanism by which solar energy is re-distributed from the tropics to the entire planet. Therefore, improved understanding of this interaction is critical to improved weather and climate prediction.

Understanding and predicting the evolution of the ocean's circulation requires observing all meaningful scales of motion. Spatial scales of interest in the ocean are smaller by a factor of 10 than the atmosphere, whereas the analogous time periods are longer by a factor of 10. Understanding the dynamics of ocean circulation requires systematic measurements of the velocity field at a frequency of at least weekly, but also spanning decades, commensurate with the characteristic time scales of anomalies such as ENSO, the North Atlantic Oscillation, and the Pacific Decadal Oscillation. Only global satellite observations can meet these needs. Our efforts in the past decade have resulted in a wealth of observations, but NASA could not have been successful had we worked alone. **Our collaboration with other Federal Agencies and international partners was a critical element in this success**.

Altimeter data from TOPEX/Poseidon and Jason provide monitoring of the El Niño/La Niña conditions in the Pacific ocean and have been used as input to short-term climate forecasts. Such seasonal forecasts can provide important planning information to farmers, energy providers, and other decision makers. Use of altimeter data products has been growing in other areas, including applications such as deep-sea cable laying, fisheries management, marine habitat assessment, and ship routing. CNES (France), NASA, NOAA, and EUMETSAT have agreed to work towards the joint implementation of an Oceanographic Surface Topography Mission (OSTM) to ensure the continuation of precise altimetry data to meet the needs of the user community. The addition of precise geoid measurements from the GRACE mission will enable the use of dynamic topography for studying surface and deep currents.

On February 22, 2002, the QuikSCAT satellite turned operational as the United States and Europe began incorporating wind speed and direction in their global weather analysis and forecast systems. Forecasters can now predict hazardous weather events over the oceans as much as six to 12 hours earlier than before. Near term continuity of this dataset will be assured with the ADEOS-II launch scheduled for this fall (NET November).

SeaWiFS has provided 5 years of continuous daily global observations of ocean color and the abundance of oceanic vegetation, making this the most complete and consistent data set available for environmental studies. The 3-hour difference in daytime equator crossing times of the MODIS instruments on two EOS satellites will allow scientists to track changes in these ocean features within a single day. NASA and NOAA are planning for an operational ocean color observing system with the VIIRS instrument on NPP and NPOESS.

MODIS on Terra and Aqua are also providing global daytime and nighttime sea surface temperature on a daily basis with accuracy more than twice that of previous satellite sensors. This data is particularly helpful in forecasting events like El Niño and La Niña, and predicting how temperature anomalies will affect weather patterns around the world.

We have made significant progress in transitioning many of these sensors from research to operations. But we need to pro-actively plan for future operational systems to ensure data continuity, provide adequate spatial and temporal coverage, and to satisfy users' information needs. To that end, **we must involve the operational and user communities at all stages of planning, from mission formulation, to technology development and infusion, and finally to applications development**. We must also continue to plan for research satellites to fill the gaps in critical datasets. For example, the Aquarius ocean salinity mission was recently selected in an open competition for innovative remote sensing missions in key science areas. Aquarius will measure global sea surface salinity synoptically every month for 3 years, resolving key physical processes that link the water cycle, the climate, and the ocean.

For science to serve societal needs, providing ample data is not enough. **Data assimilation and modeling are key to providing decision makers with information with economic and policy relevance.** NASA's Seasonal-to-Interannual Prediction Project (NSIPP) is developing coupled ocean-land-atmosphere models and testing ocean data assimilation systems. Scientists at JPL are developing numerical models to describe and understand the processes governing the circulation of the ocean and its effects on climate. NASA is contributing full-depth ocean models with data assimilation to the Global Ocean Data Assimilation Experiment (GODAE). GODAE aims to demonstrate the feasibility and practicality of real-time global ocean data modeling and assimilation systems, both in terms of their implementation and their utility. Combined, the use of more global satellite observations, faster computers, and more accurate models will result in more accurate prediction for decision makers.

NASA is working with partner Agencies to develop benchmark decision support systems for national applications in 12 focus areas, including coastal management, community disaster preparation, and agricultural competitiveness. The ocean community must focus on an end-to-end strategy to provide products that meet the needs of the user community. This strategy must:

- Ensure continuity and integrity of calibrated data and information.
- Integrate remote sensing data with in situ observations.
- Develop comprehensive and realistic coupled land-ocean-atmosphere models.
- Coordinate efforts among researchers, data providers, and users of ocean and climate data and services.
- Develop applications and infrastructure to deliver meaningful products to users.

In summary, global satellite observations are required to improve understanding of the complex role of oceans in the Earth system, and to apply this knowledge to prediction of weather, climate, and natural hazards. We need to pro-actively plan for operational systems in all areas of ocean observation. There must be open dialog among the research, operational, and user communities at all planning stages. And most critically, successful global observational systems require inter-agency and international collaboration. The national and international ocean communities must continue to work together to build a global ocean observing system that can deliver products for economic and policy decision-making.