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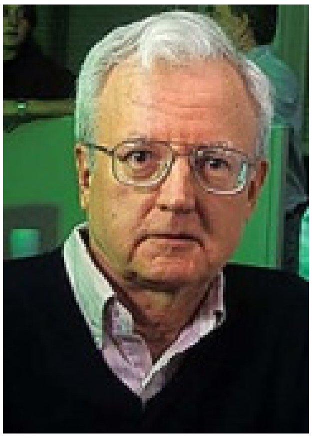
Editorial



Advances in Ocean Observations

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Oceans influence the Earth's climate because they transfer and redistribute heat over the entire planet and absorb greenhouse gases. Oceans also cover about 70 percent of the Earth's surface and are dynamic across a spectrum of temporal and spatial scales. They contain most of the Earth's water, support important marine ecosystems, help stabilize the atmosphere and climate, provide ship routes for transportation and are one of the main food suppliers for many coastal and island countries. Yet the oceans' size and depth make it difficult to monitor them with ships and buoys alone.

Satellites with a wide range of remote sensors have proven to be highly effective for observing the physical and biological surface features and processes of large ocean areas. Multispectral and hyperspectral imagers on satellites are available for mapping coastal land cover, concentrations of organic/inorganic suspended particles and dissolved substances in coastal waters. Thermal infrared scanners can map sea surface temperatures accurately and chart coastal currents, while microwave radiometers can measure ocean salinity, soil moisture, and other hydrologic parameters. Radar imagers (SAR), scatterometers, and altimeters provide information on ocean waves, ocean winds, sea surface height, and coastal currents, which strongly influence coastal ecosystems. Using airborne LIDARS one can produce bathymetric/topographic maps, even in moderately turbid coastal waters. Since coastal processes and ecosystems have high spatial complexity and temporal variability, they frequently have to be observed from both, satellites and aircraft, in order to obtain the required spatial, spectral and temporal resolutions. Reliable field data collection methods using ship, buoy, and field instruments with suitable sampling schemes are used to calibrate and validate the remotely sensed information.

Despite major successes in characterizing the sea surface, satellite remote sensors cannot directly observe subsurface and deeper ocean processes and features, such as ocean thermal and hyaline structures. Yet many important ocean processes and features are located well below the surface and at considerable depths. Examples include Mediterranean eddies (meddies), mixed layer depth, internal waves, submarine oil wells, shipwrecks and sea bottom topography. Traditionally these have been studied with models and in-situ sensors deployed from research vessels or attached to moorings or drifter buoys. In-situ measurements have been fairly accurate, yet unable to provide suitably wide coverage in near-real time. Many of these subsurface phenomena have surface manifestations which can be interpreted with the help of models and satellite data to derive key parameters of deeper ocean processes. Because this information is important to physical, biochemical and geological studies of the oceans, new models and algorithms are being developed that will enable scientists to use satellite data to determine mixed layer depths, monitor meddies, characterize internal waves, map deep ocean bathymetry, and study other deep ocean processes. Deeper ocean remote sensing and modeling are becoming particularly important, because there are clear indications that the deeper ocean is responding to global warming, climate variability and change.

Despite improved deep ocean models, there still remains the problem of calibrating the models and validating model results. Acoustic techniques, such as echo-sounding profilers and side-scan sonars operated on research vessels, are limited in their range, coverage and resolution. The recent development of Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) that can dive to considerable depths has helped solve this problem. The vehicles can carry scientific instruments, take samples and conduct surveys, while allowing scientists to follow their progress from the safety and convenience of a ship. ROVs and AUVs are now used for deep sea observation, mapping of underwater environments, and surveys of biodiversity and water quality trends. ROVs and AUVs can also be used in restricted areas and inhospitable environments, such as Antarctic krill research and under-ice missions.

ROVs are tethered to the ship by a cord (umbilical), which provides power as well as control and video signals. ROVs come in many sizes and shapes and can even be custom-built to suit a particular application. ROVs are best suited for complex manipulations and sampling on the seafloor. Beyond their value as research tools, they have been used for sampling toxic algal blooms, bridge inspections, inspections of offshore oil rigs, and retrieving equipment from the ocean floor. ROVs are usually equipped with acoustic and optical sensors/imagers in addition to instruments for measuring ocean temperature, salinity etc.

AUVs are programmed for a specific course and then set loose to operate without a connecting tether. After a dive, AUVs rise to the surface to be recovered by the ship. AUV are best for surveys that can be accomplished without constant supervision, such as subsurface oil plume detection, submarine pipe inspection, marine archeology, finding massive sulfide deposits, mine countermeasures etc. For instance, to measure current profiles, CTD profiles, water level and water depth, AUVs have been equipped with instruments such as upward-looking acoustic Doppler current profilers (ADCP) and down-looking ADCPs and CTDs. Deep Ocean AUVs are designed to operate down to depths of 4,000 meters. A typical coastal AUV might operate down to several hundred meters with a survey capability of 6-8 hours at 3.5 knots per battery charge. It can follow the terrain with 5 cm accuracy within 2 meters of the seabed. Ocean gliders are one type of AUV', running on a computer program, following a path laid out for them and "calling home" when they reach the surface to obtain new instructions. Ocean gliders were deployed successfully to monitor ocean conditions after the Deepwater Horizon oil spill in the Gulf of Mexico and in other similar disasters.

The development and successful application of ROVs, AUVs and ocean gliders has ushered in a new era of direct deep ocean observations that could not have been accomplished with traditional oceanographic instruments, ship-borne acoustic sensors, or satellite remote sensors. This offers ocean scientists and engineers a long-awaited opportunity to validate their advanced models of deep sea processes and features.