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Editorial

Views of ocean processes from the Sea-viewing Wide Field-of-view Sensor mission: introduction to the first special issue

It is hard to overstate the impact that the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) has had on the environmental sciences. Imagery from the SeaWiFS mission provided scientists, for the very first time, high-quality views of ocean (and land) biospheric processes on local to global spatial scales for temporal changes ranging from days to a continuous record of more than 6 years. As the contributions in this special issue attest, SeaWiFS data have proven useful for quantifying the ocean's biological response to global-scale changes as well as understanding its detailed response on local time and space scales. The duration, consistency, stability, coverage, documented quality, and data accessibility has made SeaWiFS extremely popular. More than 2300 scientists from more than 80 countries have registered to use the SeaWiFS data set in their work. We expect these numbers to only grow in time. SeaWiFS data are now used by the full spectrum of marine scientists; from physical oceanographers looking at the mixing of water masses to marine ecologists assessing the coupling of pelagic and intertidal environments to modelers attempting to validate their numerical solutions. Further, SeaWiFS has had impacts beyond marine science applications to atmospheric science and questions pertaining to the terrestrial biosphere. Simply stated, the success of the SeaWiFS mission is unprecedented, surpassing our wildest hopes and dreams.

The SeaWiFS mission was launched on August 1, 1997, and operational global data collection and processing began soon after. SeaWiFS data collection and science mission operations are now in their seventh year of nearly flawless performance. These observations have provided climate data records of ocean surface layer chlorophyll *a* (Chl *a*) concentrations and water-leaving radiances ($L_{wN}(\lambda)$) from which consistent studies of ocean biological and biogeochemical processes can be conducted. This period also included most of the 1997–99 El Nino–La Nina event, the strongest on record. The 6-year "climatological" Chl distribution (see the cover image) mirrors much about what we understand about the coupling of physical and biological processes via large-scale vertical water motions (e.g., Sverdrup, 1955). High Chl values are found where large-scale, wind-driven upwelling occurs (coastal zones, the equatorial divergences, the subpolar gyres, etc.) while relatively lower values are found in downwelling regimes (subtropical gyres, tropical warm pools, etc.). SeaWiFS truly "colored in" our cartoon-like understanding of the role of large-scale oceanographic processes in ocean productivity. Elevated Chl concentrations are also found in regions characterized by a large degree of temporal variability, such as the Benguela and Agulhas Currents and the Costa Rica Dome. These elevated Chl concentrations are presumably caused by the superposition of many current instability events which have lead to increased vertical nutrient fluxes and therefore elevated pigment concentrations. SeaWiFS is the first ocean color mission to map the global ocean in a consistent way at high temporal and spatial resolution, thus enabling the net effects of these processes to be diagnosed. This consistent view of the ocean biosphere is the immediate legacy of the SeaWiFS mission.

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As we will describe here, several fortuitous and somewhat unusual factors contributed to the success of the SeaWiFS mission. Much of the credit in taking advantage of these opportunities goes to the staff and scientists of the SeaWiFS Project Office at the NASA Goddard Space Flight Center. Several of these factors are discussed in the first contribution in this volume describing how the SeaWiFS mission has produced climate data records of ocean color parameters (McClain et al., 2004). The discussion that follows is one view of why the SeaWiFS has mission succeeded.

First, there was a gap of more than 10 years between the end of the ''proof of concept'' Coastal Zone Color Scanner (CZCS) mission and the launch of SeaWiFS. This period of time was very frustrating and the ocean color science community endured a seemingly endless series of planning meetings. However, by the time of the SeaWiFS launch, SeaWiFS Project Office and the ocean color community were very well prepared for conducting a global satellite mission. Mission improvements implemented over this time included the elimination of stray light effects in the SeaWiFS instrument, launch vehicle readiness, the pixel-by-pixel correction of atmospheric influences and the availability of cheap, powerful computational and storage equipment. The delay between missions also provided time to fully develop the ''vicarious calibration'' procedure which in turn required new ocean radiometric instrumentation and procedures to quantitatively link satellite data processing activities with in situ data. The ability of the SeaWiFS Project Office to use delays to its advantage was critical in the success of the mission.

Second, the SeaWiFS mission is conducted as a so-called data buy. NASA purchased imagery for research and educational uses from the Orbital Sciences Corporation (now their subsidiary, Orbimage). All commercial and operational uses are licensed directly from Orbimage. The data buy gave life to the mission at a time when US politics were not necessarily friendly to large governmental science initiatives (especially ones that were environmental). Although the need for a contract has made it difficult to continue the SeaWiFS global data collection mission past its initial 5-year contract, the commercialization of the SeaWiFS sensor as the lead instrument in the Orbview-2 spacecraft gave the mission its chance.

Third, SeaWiFS has set the standard for data accessibility for satellite ocean color missions. Registered users from around the world are able to acquire local and global imagery with just a few keystrokes. SeaWiFS data access is logical, easy, and efficient. To date, the volume of SeaWiFS data distributed to the research community from its archive is about nine times the data volume put into the archive. This demonstrates the widespread use of the SeaWiFS data set. SeaWiFS is now the basis by which all future satellite missions will be measured. Again, the credit here goes to the SeaWiFS Project Office and other groups at the NASA Goddard Space Flight Center.

Fourth, product algorithms, methodologies for calibration factors and processing procedures were arrived collaboratively among NASA staff and the research user community. Throughout the mission, public workshops were held to address ways by which the SeaWiFS data set could be improved. The four reprocessings of the SeaWiFS data set (to date) were the direct results of these interactions (see http://seawifs.gsfc.nasa.gov/SEAWIFS/RECAL/). The operational Chl *a* algorithm for SeaWiFS (OC4v4) also was a product of a public workshop (O'Reilly et al., 1998). All results were publicly vetted and made available by the SeaWiFS Project Office. These collaborations between the community and the project provided transparency to the many processing and decision steps required thereby giving users a better sense of how the data sets used in their science were created. More importantly, these interactions gave the entire user community a sense of ownership of the SeaWiFS mission.

Last, the SeaWiFS mission was only a small piece of NASA's overall Earth observing strategy and, in many ways, SeaWiFS was the little sister of the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor programs. Comparatively, SeaWiFS is a simple, inexpensive, small ocean color sensor with modest design specifications. Its simplicity made it (relatively) easy to optimize performance, making SeaWiFS presently the best characterized ocean color sensor in space.

As a result, it is widely used as a cross-platform calibration tool. In many ways, the SeaWiFS sensor is ''the little engine that could'' bringing the good little boys and girls the data they desperately wanted (Piper, 1930).

The goal of this special issue is to present a series of contributions that demonstrate the application of SeaWiFS for examining the ocean biosphere and ocean biogeochemical processes. In particular, this issue addresses the application of SeaWiFS imagery to the understanding of ocean phenomena from local (1–50 km) to regional (50–1000 km) to global and basin (500–10,000 km) scales. The contributions to this special issue are ordered approximately in this way in the hope of illustrating the utility of SeaWiFS ocean color imagery in bridging scale disparities in ocean biological and biogeochemical systems. Due to the large volume of submissions, a second special issue will follow shortly. These latter papers are of no lesser quality, but timings of reviews and resubmissions have necessitated the two issues.

The guest editors hope you will find these contributions useful.

Acknowledgements

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