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Ocean Optics Protocols For Satellite Ocean Color Sensor Validation, Revision 3, Volume 1

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Chapter 1

Ocean Color Radiometry and Bio-Optics

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1.1 INTRODUCTION

During the period from *circa* 1985 to 1991, the National Aeronautics and Space Administration (NASA) charged a series of successive science working groups with the task of recommending guidelines, goals and mission design criteria for future satellite ocean color remote sensors. The deliberations of these working groups were based on the ocean color science community's experiences with the Nimbus-7 Coastal Zone Color Scanner (CZCS). On the one hand, the highly successful CZCS mission firmly established ocean color remote sensing as a powerful tool for monitoring and studying the bio-optical properties of the global ocean. On the other hand, the radiometric responsivities of the CZCS channels declined progressively with time throughout its 8-year operating life, which just as firmly established the need to independently verify a satellite sensor's performance using *in situ* measurements of the ocean and atmosphere. From those two general perspectives, the principal recommendations of these NASA Ocean Color Science Working Groups (collectively) included:

1. **Baseline satellite ocean color products** should include
 - a. Normalized water-leaving radiances $L_{\text{WN}}(\lambda)$ (Gordon and Clark, 1981),
 - b. Aerosol radiances $L_a(\lambda)$,
 - c. Chlorophyll *a* concentration Chl [mg m^{-3}],
 - d. The diffuse attenuation coefficient $K(490)$ at a wavelength of 490 nm, and
 - e. Calibrated radiances $L_t(\lambda)$ observed at the satellite.
2. **Principal goals for product uncertainties** should be
 - a. Less than **5 % uncertainty** in $L_{\text{WN}}(\lambda)$ and
 - b. Less than **35 % uncertainty** in Chl .
3. An **ongoing satellite ocean color sensor system validation program** is necessary, using *in situ* measurements of ocean radiometric and bio-optical properties, and of atmospheric optical properties, to verify system performance - including algorithms - immediately after launch and throughout a satellite ocean color sensor's operating lifetime.

These and other recommendations of the earlier working groups were endorsed by the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Science Team and accepted by NASA. Of particular significance in the present context, the SeaWiFS Project Office moved immediately to implement a SeaWiFS Validation Plan designed to assure a best effort to achieve the above product uncertainty goals (McClain *et al.* 1992). A critical aspect of the validation plan was that *in situ* radiometric, optical and bio-optical measurements of uniformly high quality and accuracy be obtained for verifying SeaWiFS system performance and product uncertainties. Therefore, in 1991 the SeaWiFS Project Office sponsored a workshop to recommend appropriate measurements, instrument specifications, and protocols specifying methods of calibration, field measurements, and data analysis necessary to support SeaWiFS validation, leading to the first publication of *Ocean Optics Protocols for SeaWiFS Validation* (Mueller and Austin 1992). Continued discourse within the ocean color research community led to Revisions 1 (Mueller and Austin 1995) and 2 (Fargion and Mueller 2000) of these protocols.