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Chapter 8

Refinement of Protocols for Measuring the Apparent Optical Properties of Seawater

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8.1 INTRODUCTION

Ocean color satellite missions, like the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) or the Moderate Resolution Imaging Spectroradiometer (MODIS) projects, are tasked with acquiring a global ocean color data set, validating and monitoring the accuracy and quality of the data, processing the radiometric data into geophysical units using a set of atmospheric and bio-optical algorithms, and distributing the final products to the scientific community. The long-standing requirement of the SeaWiFS Project, for example, is to produce spectral water-leaving radiances, $L_W(\lambda)$, to within 5% absolute (λ denotes wavelength) and chlorophyll *a* concentrations to within 35% (Hooker and Esaias 1993), and most ocean color sensors have the same or similar requirements. Although a diverse set of activities are required to ensure the accuracy requirements are met (Hooker and McClain 2000), the perspective here is with field observations. Assuming half of the total uncertainty budget is apportioned to the satellite sensor and that the uncertainties sum in quadrature (the square root of the sum of the squares), the allowed uncertainty in the *in situ* data is approximately 3.5% ($\sqrt{5^2 / 2}$).

The accurate determination of upper ocean apparent optical properties (AOPs) is essential for the vicarious calibration of ocean color data and the validation of the derived data products, because the sea-truth measurements are used to evaluate the satellite observations (Hooker and McClain 2000). The uncertainties with *in situ* AOP measurements have various sources: a) the sampling procedures used in the field, including the environmental conditions encountered; b) the absolute characterization of the radiometers in the laboratory; c) the conversion of the light signals to geophysical units in a processing scheme, and d) the stability of the radiometers in the harsh environment they are subjected to during transport and use. Assuming ideal environmental conditions, so this aspect can be neglected, the SeaWiFS ground-truth uncertainty budget can only be satisfied if each uncertainty is on the order of 1–2%, or what is generally referred to as *1% radiometry*.

In recent years, progress has been made in estimating the magnitude of some of these uncertainties and in defining procedures for minimizing them. For the SeaWiFS Project, the first step was to convene a workshop to draft the SeaWiFS Ocean Optics Protocols (hereafter referred to as the Protocols). The Protocols initially adhered to the Joint Global Ocean Flux Study (JGOFS) sampling procedures (JGOFS 1991) and defined the standards for optical measurements to be used in SeaWiFS calibration and validation activities (Mueller and Austin 1992). Over time, the Protocols were revised (Mueller and Austin 1995), and then recurringly updated on essentially an annual basis (Mueller 2000, 2002, and 2003) as part of the Sensor Inter-comparison and Merger for Biological and Interdisciplinary Oceanic Studies (SIMBIOS) project.