Chapter 2

MOBY, A Radiometric Buoy for Performance Monitoring and Vicarious Calibration of Satellite Ocean Color Sensors: Measurement and Data Analysis Protocols

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2.1 INTRODUCTION

The Marine Optical Buoy (MOBY) (Clark *et al.* 1997) is the centerpiece of the primary ocean measurement site for calibration of satellite ocean color sensors based on independent *in situ* measurements. Since late 1996, the time series of normalized water-leaving radiances $L_{WN}(\lambda)$ determined from the array of radiometric sensors attached to MOBY are the primary basis for the on-orbit calibrations of the USA Sea-viewing Wide Field-of-view Sensor (SeaWiFS), the Japanese Ocean Color and Temperature Sensor (OCTS), the French Polarization Detection Environmental Radiometer (POLDER), the German Modular Optoelectronic Scanner on the Indian Research Satellite (IRS1-MOS), and the USA Moderate Resolution Imaging Spectrometer (MODIS). The MOBY vicarious calibration $L_{WN}(\lambda)$ reference is an essential element in the international effort to develop a global, multi-year time series of consistently calibrated ocean color products using data from a wide variety of independent satellite sensors.

A longstanding goal of the SeaWiFS and MODIS (Ocean) Science Teams is to determine satellite-derived $L_{WN}(\lambda)$ with a relative combined standard uncertainty[1] of 5 % (Vol. I, Chapter 1). Other satellite ocean color projects and the Sensor Intercomparison for Marine Biology and Interdisciplinary Oceanic Studies (SIMBIOS) project have also adopted this goal, at least implicitly. Because water-leaving radiance contributes at most 10 % of the total radiance measured by a satellite sensor above the atmosphere (Gordon 1997), a 5 % uncertainty in $L_{WN}(\lambda)$ implies a 0.5 % uncertainty in the above-atmosphere radiance measurements. This level of uncertainty can only be approached using "vicarious-calibration" approaches as described below. In practice, this means that the satellite radiance responsivity is adjusted to achieve the best agreement, in a least-squares sense, for the $L_{WN}(\lambda)$ results determined using the satellite and the independent optical sensors (*e.g.* MOBY). The end result of this approach is to implicitly absorb unquantified, but systematic, errors in the atmospheric correction, incident solar flux, and satellite sensor calibration into a single correction factor to produce consistency with the *in situ* data (see *e.g.* Gordon 1981, 1987, 1988).

Clearly, the combined standard uncertainty of the *in situ* $L_{WN}(\lambda)$ determinations must be less than 5 % if the stated uncertainty goal is to be approached. The uncertainty budget of MOBY $L_{WN}(\lambda)$ determinations may be divided into environmental and radiometric factors. Environmental factors include uncertainties due to radiance and irradiance fluctuations associated with surface waves and platform motions during the radiometric measurements, and with extrapolation of upwelling radiance measurements from depths of 1 m or more to, and through, the sea surface. The uncertainties associated with these ambient conditions have been shown to be less than, but approaching, 5 % for upwelled radiance (Siegel *et al.* , 1995; Hooker and Maritorena, 2000). Radiometric uncertainty components associated with instrument characterization, calibration and stability, *i.e.* the radiance

[1] All uncertainties in this document are standard uncertainties, unless noted otherwise. Standard uncertainty is the uncertainty of the result of a measurement expressed as a standard deviation (Taylor and Kuyatt 1994).