SEA SURFACE REFLECTANCE MODEL

Recently developed sea surface reflectance models (SSRM) accurately reproduce radiance spectra observed in the field, at least for clear, marine waters. Simplifications to the radiative transfer equation permit the estimation of $L_wn(x)$ via a single input parameter, $C_n$, a measurement for which long-term, seasonal in situ time series exist. The OBPG recently explored the efficacy of an SSRM in the calibration of the NASA Coastal Zone Color Scanner and the JAXA Ocean Color and Temperature Scanner, both of which pre-date MOBY (Werdell et al. 2006).

The general form of the $L_wn$ model is:

$$L_wn = \frac{t_x}{n^2} I_0 f \frac{b_y}{Q \ a}$$

Table 1 provides parameter definitions and units and spectral dependence is implied. The SSRM of Morel and Maritorena (2001), with several modifications, and the bidirectional reflectance parametrizations of Morel et al. (2002) permit the estimation of the unknown spectrally dependent variables in this equation, $b_y$, $f$, and $Q$, via a single geophysical input, $C_n$. Following, knowledge of $C_n$ in a given Geo-1 location (phytoplankton being the only optical significant constituent) provides sufficient information to estimate $L_wn$ at low altitudes.

For vicarious calibration using the SSRM, we require candidate study sites to:

1. be in a location where SeaWiFS acquires regular LAC (1-km2) coverage
2. be considered Geo-1
3. have a well-characterized, annual in situ $C_n$ time series

The Hawaiian Ocean Time-series (HOT) Station ALOHA and Bermuda Atlantic Time-series Study (BATS) programs provide fluorometrically and HIPL-derived $C_n$ data sets that satisfy all of these criteria.

AUTONOMOUS ABOVE-WATER RADIOMETRY

Recent innovations in autonomous above-water radiometers, particularly those continuously deployed at fixed sites, have fortified their potential for ocean color satellite calibration and validation. The European Commission Joint Research Centre (JRC, Ispra, Italy), in collaboration with the OBPG and the NASA Aerosol Robotic Network (AERONET) group, recently developed such instrumentation, the SeaWiFS Photometer Revision for Incident Sea-Surface Measurements (SeaPRISM) (Hooker et al. 2000). AERONET's ocean color component (AERONET-OC; Zibordi et al. 2006) recently completed a four year testing phase of SeaPRISMs deployed at five offshore locations. In the forthcoming operational phase, AERONET-OC will routinely acquire, process, and publicly distribute SeaPRISM marine and atmospheric products in support of international ocean color research efforts.

We highlight data from the Acqua Alta Oceanographic Tower (AAOT), located 8 nautical miles outside the Venice Lagoon, Italy (Figure 3). This frontal region is predominantly characterized by oceanic conditions, modulated by Case-2 riverine influences, and continental aerosols originating from the Po River valley.

The standard operation of a CE-318 sun photometer consists of measurements of sky radiance at multiple instrument viewing angles and direct solar irradiance at routine intervals throughout the day. The extended capability of a SeaPRISM is a sea-viewing scenario to retrieve $L_wn$ from the OBPG for in situ measurements of sky radiance following the instrument’s location at the AAOT.

For over a decade, MOBY has endured as the premier source of historical and modern, and currently relies on its data for the vicarious calibration of both SeaWiFS and MODIS (Eplee et al. 2001). After a decade of technological advances and accumulated derived vicarious gains, $g$, are calculated (Eplee et al. 2001) and Level-2 validation results for deep water ($>1000$ m) are presented (Bailey and Werdell 2006).

ALTERNATIVE IN-WATER BUOYS

The COTS mooring instrumentation provides a viable ocean color calibration source. MOBY, at 7 wavelengths (Atlantic Inc.), initiated the BouSSOLOE project to facilitate the development of a long term in situ bio-optical time series to support their ocean color satellite calibration and validation activities (Antoine et al. 2006). While BouSSOLOE includes both a regular field program and a coastal AERONET station, its centerpiece is a permanent optics mooring located in the Ligurian Sea approximately 32 miles from Nice, France (Figure 5). This low current site is predominantly oligotrophic, however, $C_n$ on occasion approaches 5 mg m$^{-3}$ during the spring blooms of March and April.

The most notable physical feature of the mooring is its latticed structure. This novel design minimizes perturbation of the in-water light field (and, therefore, instrument shading), while ensuring platform stability by minimizing wave interaction.

The COTS mooring instrumentation provides:

1. (490) and (510) were calculated using a modified CMEL Electronique CE-318 sun photometer (Hooker et al. 2000).
2. The COTS mooring data may differ from $L_wn$ values obtained by independent means, due to the differences in the spectral dependence and the presence of absorbing aerosols).
3. The COTS mooring and $L_wn$ data agree to within 0.6% (Table 2). Excluding the mooring radiances (collected mid-2003 through mid-2004) and sent these data to the OBPG for inclusion in their calibration system. The SST SeaPRISM and MODIS gains agree to within 2.3% (Table 2).
4. The SeaPRISM measured $L_wn$ data were processed using the SeaWiFS on-board radiometric calibration factors. The SeaPRISM and MODIS gains agree to within 0.6% (Table 2).
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For a decade of technological advances and accumulated experience, however, there now appear to be maturing, credible alternatives to MOBY with potential for a greater geographic distribution of calibration sites within current budget constraints. While all approaches to vicarious calibration possess inherent weaknesses, those outlined in this paper enjoy a significant economical advantage in their use of COTS hardware and techniques.

Pioneering in design and operation, the community continues to acknowledge its value, both historical and modern, and currently relies on its data for the vicarious calibration of both SeaPRISM and MODIS (Eplee et al. 2001). After a decade of technological advances and accumulated experience, however, there now appear to be maturing, credible alternatives to MOBY with potential for a greater geographic distribution of calibration sites within current budget constraints. While all approaches to vicarious calibration possess inherent weaknesses, those outlined in this paper enjoy a significant economical advantage in their use of COTS hardware and techniques.