Ocean Optics Course 2011:
Calibration and Validation for Ocean Color Remote Sensing

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Abstract

One of the challenges of ocean optics and satellite remote sensing is to obtain accurate, precise, quality data. Agreement between measurements obtained with different instruments or methods can be used as a quality control. Training graduates and postdocs in this area was the main goal of the 2011 Ocean Optics Summer Course, entitled "**Calibration and Validation for Ocean Color Remote Sensing**" and held from July 10-29th, 2011 at the Darling Marine Centre (University of Maine). The theoretical lectures, hand-on laboratories and field trips, allowed the students to develop an in-depth understanding of ocean optics concepts and current research methods. The present poster emphasizes some of the highlights of the work done during the summer class.

Introduction


Fig. 1. HyperSAS radiometer

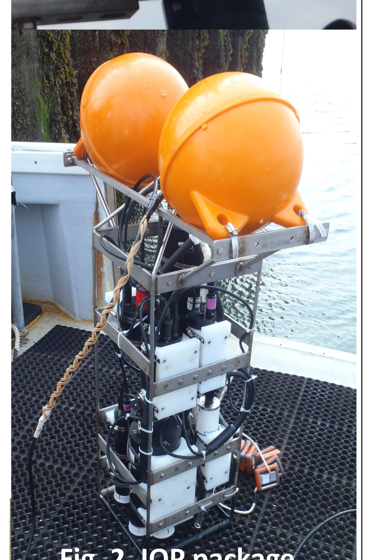


Fig. 2. IOP package


Fig. 3. AC-s set-up in lab

Closure is attained when similar results for a given parameter are obtained in at least two different ways (e.g. using different instruments, methodologies, models, ...). During two one-day cruises in the Gulf of Maine (July 20 & 21, 2011), students collected radiometric measurements (fig. 1) simultaneously with in-water inherent optical properties (IOPs, fig. 2 and 3). This cruise provided a perfect case-study to learn and assess protocols and methodologies for each instrument, to address possible issues that can arise when conducting this type of measurements as well as to evaluate closure.

In the present project Closure is evaluated by:

a) comparing different radiometrically measured Rrs with that modeled with HYDROLIGHT and measured by MODIS AQUA.
b) comparing chlorophyll a concentrations obtained from fluorometry, absorption spectra and spectrophotometry.
c) comparing diffuse attenuation coefficients (Kd) estimated from AOPs and IOPs

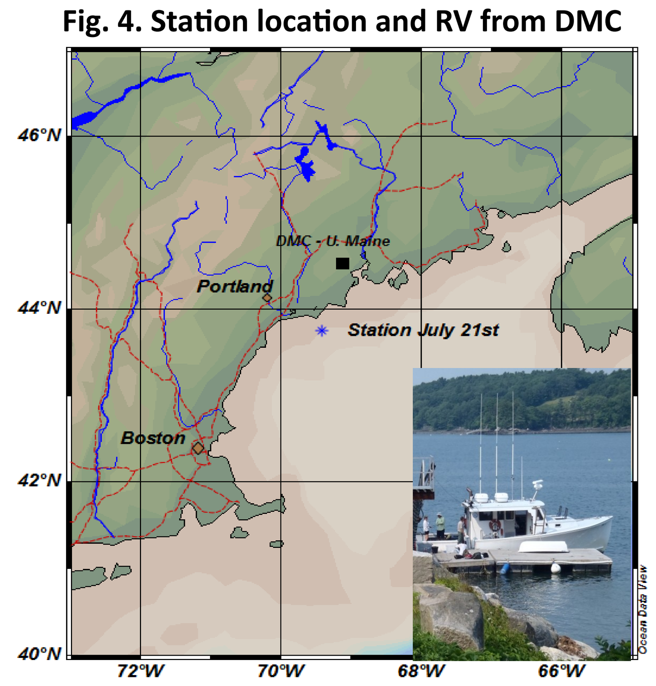
Data and Methodology

The IOP package and several radiometers (see Table 1) were deployed at the experimental station (43.7483N -69.4983W). Additionally, water samples were taken at 5, 10 and 15 meters deep using Niskin bottles. All of these measurements coincided with the MODIS AQUA satellite overpass (+/- 2 hours). Results were then processed and analyzed in the lab.

Table 1. Overview of instruments and associated optical properties

Instrument	Property measured
Acs, ac9	Particulate absorption (a_p), Dissolved materials absorption (a_{DOM}) Beam attenuation (c)
bb9	Backscattering (b_b)
ecoFL	Fluorescence emission
Turner Field fluorometer	Fluorescence emission
HyperSAS	Downwelling irradiance, sky & surface radiance
HyperTSRB	Downwelling irradiance (Ed) and upwelling radiance (Lu) Diffuse attenuation coefficient (Kd)
HyperPro	Downwelling irradiance (Ed) and upwelling radiance (Lu) Diffuse attenuation coefficient (Kd)

Fig. 4. Station location and RV from DMC



More information can be found in a detailed portfolio compiled by all the course participants* . This document includes detailed explanations on the instrument itself and set-up, protocols for accurate measurements as well as step-by-step descriptions for data processing.

*(ftp://misclab.umeoce.maine.edu/users/optics/classFTP/Portfolio/portfolio_compiled_final.pdf)

Results

Fig. 5 presents the differences in Rrs estimated with HyperSAS, HyperPRO and HTSRB. It also shows the modelled Rrs computed with Hydrolight - Ecolight 5 © based on the measured IOP's which served as inputs. In general, in situ and modeled Rrs show good agreement. In contrast, MODIS derived Rrs has significantly high values in the blue region with a spectral shape suggesting oligotrophic waters, this could be due to the atmospheric correction problem in coastal waters.

In Fig. 6 the Chla concentrations of the water samples are compared with the concentrations estimated from the ac-s and the fluorometer. Discrepancies are observed between the different methods, however the shape of the chla concentration with depth is alike for the 3 methods and exhibit a chlorophyll peak at 20m depth.

Fig 7. shows closure in estimations of Kd with depth obtained through AOPs and IOPs. Each figure represents a different wavelength in the blue, green and red. The average cosine of downwelling light (μ) is estimated for each depth by minimizing the cost function between the Kd_{AOP} and Kd_{IOP}. Note the attenuation peak at 20 m depth which corresponds with the chl a maximum peak observed in figure 6.

(a) Rrs closure derived from 3 different radiometers, MODIS and modeled with HYDROLIGHT

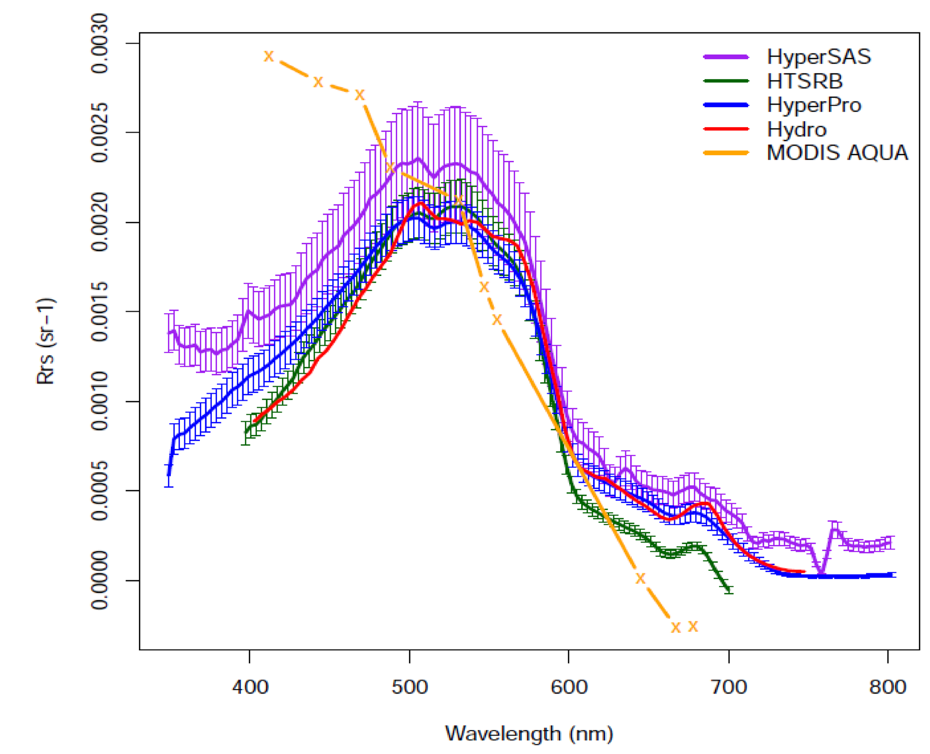


Fig. 5. Closure assessment for Rrs measured with HyperSAS, HyperPro and HTSRB, modeled with HYDROLIGHT and extracted from OC MODIS AQUA (average over a 3x3 window centered over the station).

(b) Chla concentrations from water samples compared to concentrations estimated based on fluorescence distribution

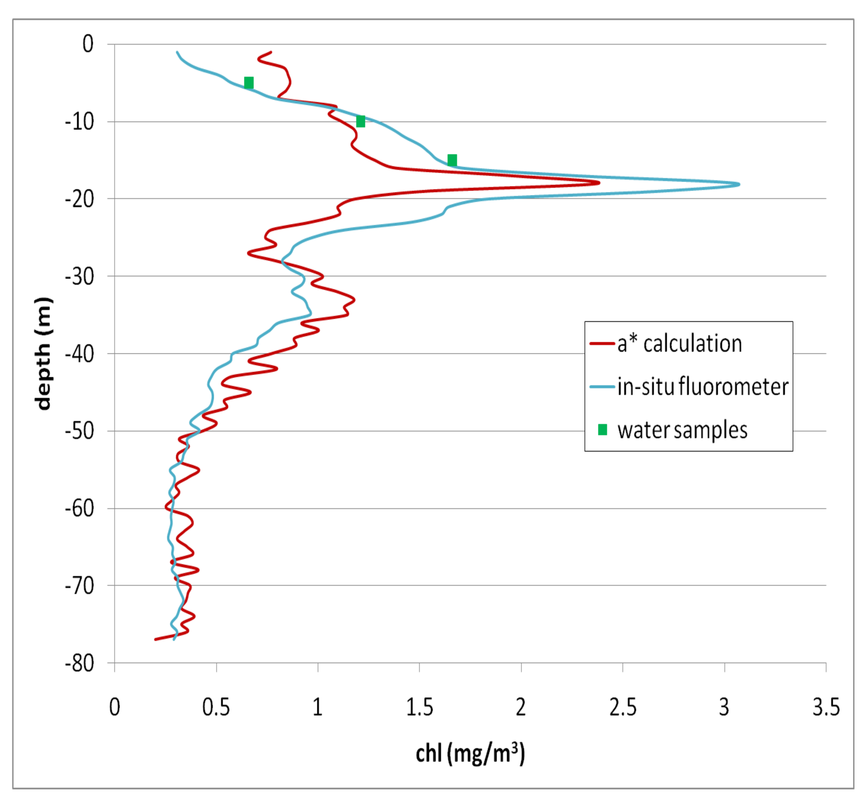


Fig. 6. Closure between Chla concentrations measured and modeled based on water samples, absorption spectrums from ac-s and fluorescence spectrums from EcoFl.

(c) Kd comparison using AOPs and IOPs

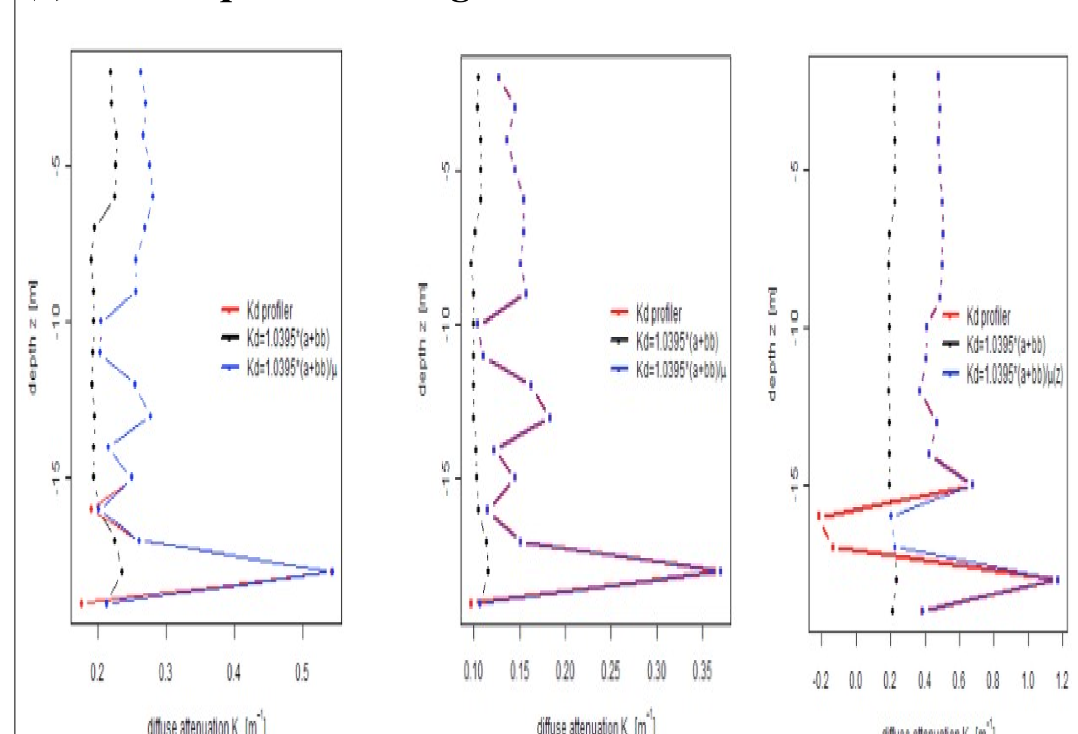


Fig 7. Comparison between Kd obtained through AOPs and IOPs for 3 different wavelengths: blue (440 nm), green (555 nm), red (686 nm), respectively from left to right.

Conclusions

- In order to consolidate results, it is important to understand the limitations and benefits of measuring the same parameter with more than one instrument.
- This comparison provides a measure for the uncertainties due to methodology.
- It is critical to document the methodology and uncertainties associated to each measurement to allow for intercomparison.
- Much effort was put into the compilation of a portfolio resuming the work done on a per-instrument basis and with a step by step protocol description. We hope that the portfolio will serve as a reference to the SeaBASS community
- In order to promote data exchange, our measurements have also been submitted to SeaBASS.
- To conclude, this type of intensive courses can have a profound impact in the participant's career and ensures that new generations of young scientists develop a critical eye to produce and identify quality data and guarantee valuable science advancements.
- Moreover, this course was not only an excellent platform to promote international networking and interdisciplinary exchanges but also a very stimulating humane and fun experience!

Acknowledgement

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