Calibration and data processing of Satlantic Hyperpro system used on the deployment cruise:
CLIVEC 7
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NAME: Satlantic Hyperpro System
S/N: MPR-149, HED-410, HPL-331, HPE-409κ

1) Introduction and Summary

The Satlantic Hyperpro System is a matched set of 3 hyperspectral radiometers and a profiling frame, which also contains instruments to measure conductivity, temperature, and pressure. On the profiler, one radiometer is pointed upward, to measure downwelling irradiance (E_d), while the another is pointed downward, to measure upwelling radiance (L_u). The third radiometer is mounted on the ship, to measure incoming solar irradiance (E_s). The profiling package is deployed behind the ship, and free-falls at approximately 30 cm/sec.

The three radiometers have a spectral range from 300 to 900 nm, with wavebands every 3-4 nm. They are calibrated at the factory from 350 to 800 nm. Each features a spectrometer with 16 bit digital to analog converter and 25 bit dynamic range (HyperOCR operator's manual).

2) Calibration/Maintenance

2.1) Manufacturer calibrations/coefficients

The radiance radiometer (HPL-331) and the CTD attached to the profiler (MPR-149) were calibrated on Aug 12, 2011. The two irradiance radiometers (HPE-409 and HED-410) were calibrated on May 10, 2012 after having their diffusers replaced. All calibrations were performed at Satlantic, Inc., in Halifax, Nova Scotia.

2.2) Self calibration methods and results

The radiometers were not calibrated in the field.

3) Deployment

3.1) Measurement methods

Profiles were made at each station, conditions permitting, three times per day: morning, noon, and evening. The deployment coincided with IOP measurements and water collection using the CTD rosette, happening either immediately before or after the rosette deployment. The ship would first be positioned such that the sun was over the starboard rear quarter, then the profiler would be cast into the water and positioned 15 to 25 meters behind the ship before profiles were made. A burst of the ship's propeller was often needed to establish the distance between the ship and the profiler.

A series of free-fall casts would begin, using the multi-cast method (Zibordi, et al 2011). The solar reference radiometer was mounted on a telescoping mast above the flying bridge to ensure that the ship's superstructures did not interfere with the measurement of E_s.

3.2) Package design

The profiling package is designed to maintain a stable orientation through the water when in free-fall. It has a weighted nose-cone and syntactic foam near the instruments. The ballast was adjusted to maintain a ~30 cm/sec descent rate.

Figure 1: Profiling portion of the Hyperpro system. Ballasted nose-cone at the bottom, E_d radiometer on upper left, L_u radiometer upper right. Between the radiometers are the conductivity and temperature sensors and the power/data conversion unit.

4) Data processing

4.1) Data analysis

The data was first processed to level 2s using Satlantic's ProSoft software, version 8.1. The appropriate calibration files were loaded, and the parameters shown in table 1 were chosen. The result is time- (E_d, E_s) and depth- (E_d, L_u) matched radiometric values.

Table 1: ProSoft parameters used in processing files

Thermal Correction	On
Surface Edit	On
Profile Edit	On
Multicast Profile	On
Min Wavelength	350 nm
Max Wavelength	750 nm
Auto Dark Correction	Shutter
Dark Bins	N/A
Shutter Dark Deglitch	On
Deglitch Profiler Data	Off
Profiler Noise Threshold	N/A
Upper Depth Level	0 m
Lower Depth Level	250 m
Deglitch Reference	Off
Reverence Noise Threshold	N/A
Auto Edit	On
High Tilt	5°
Low Velocity	0.1 m/sec
Minimum Pressure	0 m
Maximum Pressure	250 m
Depth Resolution	0.05 m

The level 2s files were processed further using Matlab to eliminate data near the noise level of the in-water radiometers: 0.025 μWcm^{-1} for E_d, 0.0006 μWcm^{-1} for L_u, determined empirically. Most of the data eliminated were in the UV and NIR range.

Salinity was calculated from conductivity, temperature, and pressure using the equation of Fofonoff and Millard (1983). The individual successive downcasts were combined, and the timestamp was configured for Seabass input.

Solar zenith angles were calculated, and are included in the header file of each cast. The morning and evening casts often had angles greater than 60°, and therefore have decreased expected accuracy: 10% cosine response instead of 3% (HyperOCS operation manual).

5) References

Fofonoff, P. and Millard, R.C. Jr. Unesco 1983. “Algorithms for computation of fundamental properties of seawater”. Unesco Tech Pap. In Mar. Sci., No. 44

HyperOCS Operation Manual. Retrieved from: http://satlantic.com/sites/default/files/documents/HyperOCR-Manual_0.pdf

Zibordi, G., Berthon, J.-F., Mélin, F., D'Alimonte, D, “Cross-site consistent in situ measurements for satellite ocean color applications: The BiOMaP radiometric dataset”, Remote Sensing of Environment 115 (8) , 2104-2115, (2011).