Calibration and data processing for the Satlantic Profiler

Instrument:	Satlantic Profiler II with HyperOCR
Model/SN:	HyperOCR (SNs 355, 452 and 453), Profiler II (SN 162)
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I. Description

The Satlantic Profiler is a free-falling instrument platform equipped with two HyperOCR sensors to measure *in situ* downwelling irradiance (E_d, μW cm^{-2} nm^{-1}) and upwelling radiance (L_u, μW cm^{-2} nm^{-1} sr^{-1}) along with pressure and instrument tilt. The drop rate for our profiler was typically 0.3 to 0.5 m s^{-1}. A third HyperOCR mounted on deck provides concurrent above-water irradiance (E_s, μW cm^{-2} nm^{-1}). E_d, L_u and E_s are resolved at 137 wavelengths ranging between 350 and 800 nm. A more detailed description of specific Profiler setup and OCR sensor design can be found in the Profiler and HyperOCR Operation Manuals (Satlantic 2011a and 2012). All instruments are connected through the manufacturer's on-deck control box and power supply. Data capture and instrument control are carried out via the manufacturer's software (SatView, v. 2.9.4_2). Further information on software setup can be found in the SatView Manual (Satlantic 2008).

II. Calibration and Maintenance

Sensors are rinsed with ultrapure water between cruises to keep them clean and free from residue. Factory calibration files provided by the manufacturer are applied during data processing to convert binary data files to real units; no other calibration is required. These files are instrument specific and are not included in the posted dataset.

III. Sample collection and processing

Prior to each deployment, the instrument is pressure tared on deck. At each station, the Profiler is deployed in three modes:

1) Surface – The manufacturer's float collar is fixed to the Profiler and data collected at the surface for 5 min,
2) Multi – Five successive free-fall casts from the surface to 10 m are recorded,
3) Full – A single free-fall cast from the surface to 1% light saturation or to within 10 m of the bottom, whichever is shallower, is recorded.

For each mode, the Profiler is deployed off the sun-facing stern or side of the ship and allowed to drift a minimum of 10 m away prior to starting data capture to avoid potential artifacts created by ship reflection or shadow. For those cases where local currents dictate instrument deployment occur on the sun-opposite side of the ship, the profiler is allowed to drift farther away prior to data capture to avoid ship-shadow affects. Meta-data provided in the dataset include ship-relative

angles of profiler deployment and sun position along with sea-state, cloud cover and estimated wave height.

IV. Data Processing

Profiler data are first processed with the manufacturer's software (ProSoft, v. 7.7.19) from binary data files to Level 2 (Step 1 below). All further data processing is carried out using a custom set of MATLAB scripts as described below. Data are analyzed following the protocols of Mueller 2002; all steps are applied spectrally.

1) Data are processed from binary to Level 2 via ProSoft:
Separate "Instrument Contexts" are created for the Profiler in Surface and Multi/Full cast modes as directed in the ProSoft Manual (Satlantic 2011b) specifying appropriate factory calibration files to convert binary data to real units. In all modes, data are pressure tared and corrected for shutter-darks. Level 2 data returns time-resolved E_s, E_d and L_u along with a separate record of time-resolved Profiler depth, drop rate and tilt.

2) Data are quality controlled and depth corrected:
Multi/Full casts: Data are excluded where instrument tilt exceeds 4°. Only down-casts are utilized; up-casts are detected via negative drop rate and excluded.

Surface deployments: Tilt is ignored and all data utilized.

All deployment modes: Depth is retrieved by interpolating each light sensor's time field with the Profiler's instrument time field. Interpolated depths are adjusted for the distance from the light sensor to the pressure sensor mount. Data retrieved at negative depths are excluded. Negative values of E_s, E_d and L_u are excluded.

3) E_d and L_u are corrected for variability in above-surface irradiance:
The E_s time-series is smoothed over a continuous 15 s interval. In-water optics for all deployment modes (Surface, Multi and Full) are corrected for observed variability in incident irradiance:

$$E_d(t,\lambda) = E_d(t,\lambda) \cdot \frac{E_s(t_0,\lambda)}{E_s(t,\lambda)}$$

$$L_u(t,\lambda) = L_u(t,\lambda) \cdot \frac{E_s(t_0,\lambda)}{E_s(t,\lambda)}$$

where E_s is the smoothed above-water time series, t is elapsed time and t_0 is the start of the deployment.

4) Data are binned to 1-m using the global mean for all data within a given bin. For Multi-cast mode, data from all casts are combined during this process. For Surface deployments, all data are combined into a single bin at the surface.

VI. References

Mueller, J.L. (2002) In-Water Radiometric Profile Measurements and Data Analysis Protocols. In: Mueller, J.L., G.S. Fargion, and C.R. McClain [Eds.] *Ocean Optics Protocols for Satellite Ocean Color Sensor Validation, Revision 4, Volume III: Radiometric Measurements and Data Analysis Protocols.* NASA/TM-2003-21621, NASA Goddard Space Flight Center, Greenbelt, MD, Chapter 2, pp 7-20.

Satlantic (2008) *SatView Data Logging/Display Program Users Guide v2.9.*

Satlantic (2011a) *Operation Manual for the HyperOCR.*

Satlantic (2011b) *ProSoft 7.7 User Manual.*

Satlantic (2012) *Operation Manual for the Profiler II.*