

Calibration report of the profiling reflectance radiometer

Instrument Details

Name: Satlantic

Model: Profiler II (MicroPro)

Serial Number: 069

Purchase date: 01-May-2002

Contact Information

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I) Instrument Overview

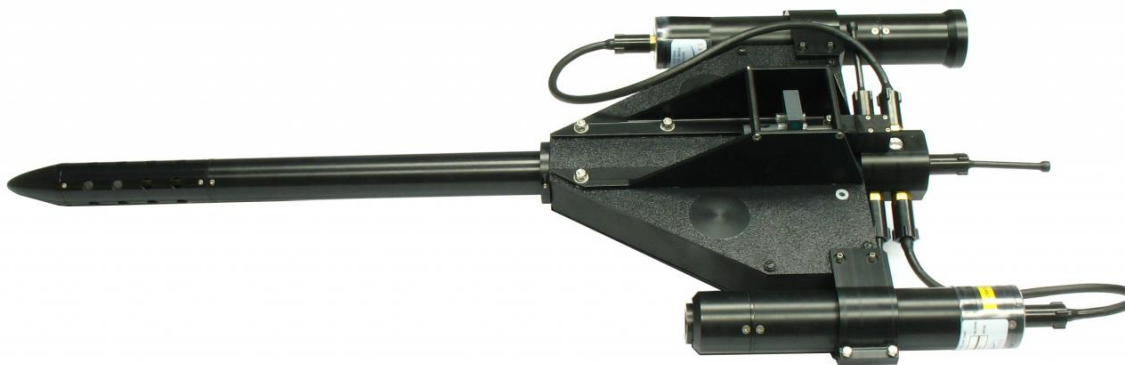
The Profiler II is specifically designed to allow the interchangeable use of Satlantic's high-resolution multispectral OCR-500 series optical sensors and hyperspectral HyperOCR sensors.

The Profiler II made for the Bermuda Bio-Optics Project (BBOP) uses two multispectral OCR-500 series sensors, each measuring eleven channels – one for upwelling radiance (Lu) and the other for downwelling irradiance (Ed). The Lu sensor includes the following channels: 305.5, 325.1, 339.6, 380.3, 411.5, 442.8, 489.4, 509.7, 554.6, 664.7, 682.5. The Ed sensor includes: 305.0, 324.6, 340.2, 379.5, 411.6, 443.1, 490.8, 509.6, 555.0, 664.6, 682.5. All wavelengths are measured in nanometers (nm).

A precision Druck PMP 4000 series pressure sensor is placed within the extension piece of the instrument and provides an analog signal to the ancillary module's converter. A miniature biaxial clinometer (tilt sensor) is also found within the extension and provides pitch and roll measurements with a linear operating range of $\pm 25^\circ$ and an accuracy of 0.2° .

Figure 1 illustrates the instrument with its upwelling radiance sensor (Lu) and downwelling irradiance sensor (Ed) at each side of the instrument body. The tilt and pressure sensors are located mid-way within the extension piece and the ballast weights are placed inside a coupler at the nose of the extension.

Figure 1: Illustration of the Profiler II



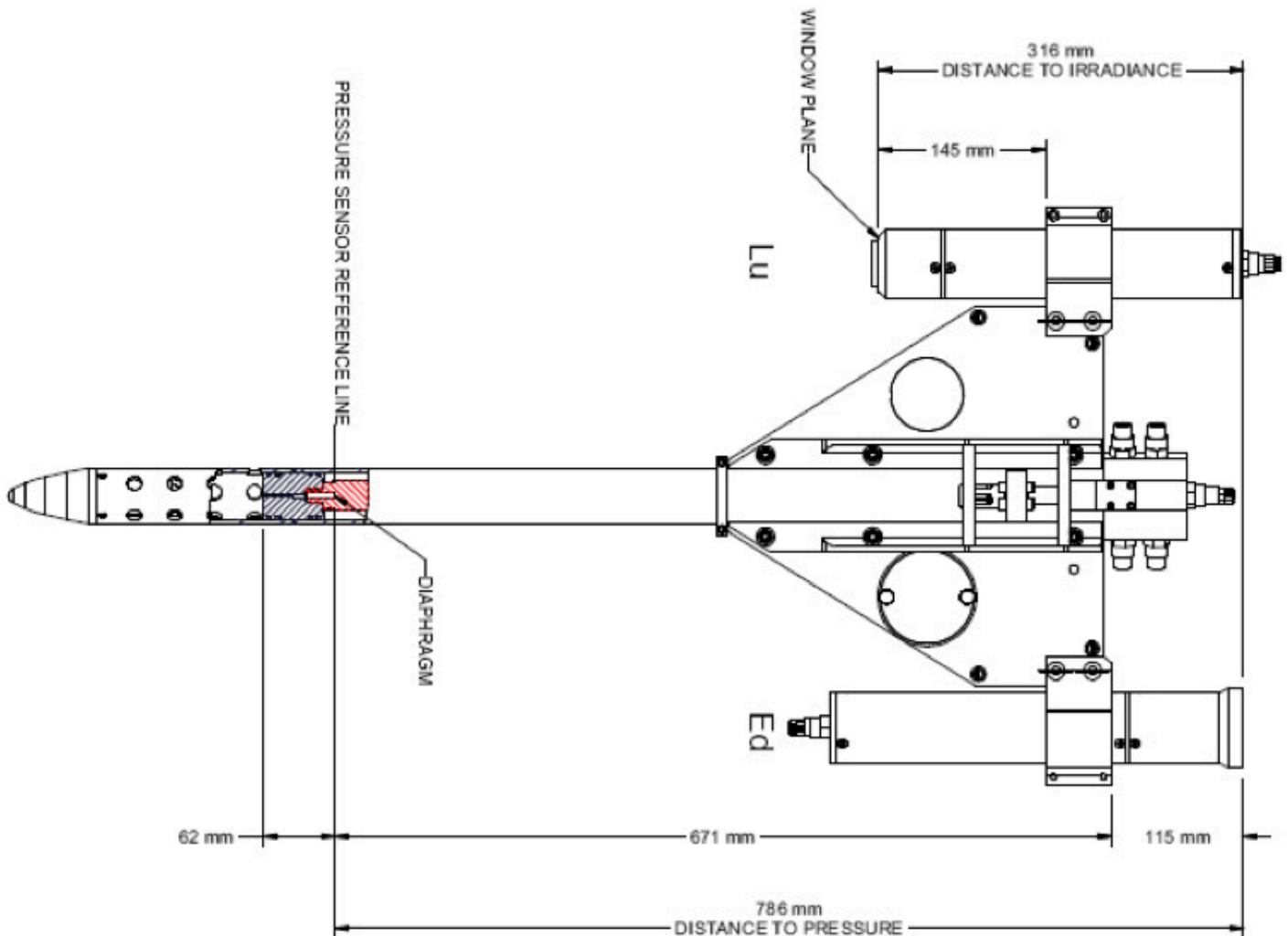
Two important distance offsets need to be measured and documented so that processing can be done correctly. These are based on the depths for each radiometer mounted to the profiler.

The first measurement required (*Distance to Pressure*) is the distance between the irradiance sensor and the pressure reference line. The distance from the cosine collector face of the irradiance radiometer to the face of the lower end-cap containing the pressure sensor is measured. The pressure sensor reference line is a fixed distance above the face of the lower end-cap containing the pressure sensor, as shown in the figures. Subtracting that fixed distance from the measurement to the end-cap face gives the distance of the irradiance sensor to the pressure reference line.

The second measurement (*Distance to Irradiance*) is the distance between the radiance sensor and the irradiance sensor. The distance from the cosine collector face of the irradiance radiometer to the glass window face of the radiance radiometer is calculated by adding the distance from the cosine collector face to the top of the sensor clamp, the thickness of the clamp, and the distance from the bottom of the clamp to the radiance sensor front guard and subtracting the fixed distance that the window is recessed from the guard.

Satlantic factory mounted the sensors such that the distances are 0.786 m and 0.316 m respectively. Figure 2 illustrates the distances.

Figure 2: Sensor position measurements



II) Calibration and Maintenance

A. Our Facility

The Satlantic Profiler II sensor heads are calibrated once each year on an optical table in our own climate-controlled lab. Our calibration lamps are attached to a rail mounted to the table and can easily slide back and forth in order to provide calibration distances from 50 cm to over 2 m. The Optical Table and all hardware are black in nature or painted flat black. The Table is surrounded by Black-out curtains including a overhead curtain. NIST standard FEL Lamp holders and shunt are used to secure all lamps. An alignment laser is mounted and used to align all sensors mounted on the table.

B. Calibration Lamp History

Five lamps were used for calibrations of the Profiler IIs since 2008 — F-475, F514N, F-1101, F-1102, F-1103, — all of which are traceable to the National Institute of Standards and Technology (NIST). Lamp F475 was purchased in 2002 and was used for all routine calibrations at UCSB from 2002–present (BBOP started using Unit S/N113 in 2008 and changed to unit S/N069 in 2015). Lamp 514N is a NIST Calibrated lamp that all other lamps are inter-compared too. Lamp F-1101, 1102 & 1103 are seasoned, uncalibrated FEL lamps, purchased in 2011, and calibrated by Optronics and put into use for routine calibrations at UCSB.

NIST-traceable Optical Calibrations

Traceability of lamps, the calibration set up (e.g.shunts, voltmeters, power supplies) and calibration procedures follow recommendations published by the National Bureau of Standards (US), specifically “NBS Special Publication 250-20 Spectral Irradiance Calibrations (1987)” and “NBS Publication 594–13 Optical Radiation Measurements: The 1973 Scale of Spectral Irradiance (1977).”

Irradiance Calibration

Irradiance calibrations are performed on our Optical table. The instrument to be calibrated is placed on an optical rail with the plane of measurement (normally the surface of the irradiance diffuser) located 50 cm from the plane of the lamp as defined using a NIST-specified alignment fixture. This fixture is also used with a laser to determine the optical axis of the system; the device being calibrated is aligned to be normal to this axis.

A 1,000 W FEL tungsten-halogen lamp is the irradiance source and it is powered by a High precision regulated power supply that can regulate the nominal 8 A of current to better than 100 μ A accuracy and stability.

Radiance Calibration

Radiance calibrations are performed on our Optical table. The instrument to be calibrated points to a Spectralon plaque that is in turn illuminated by a 1000 W FEL standard lamp, mounted 200 cm away from the plaque. The plaque's reflectivity is regularly being calibrated by Labsphere.

The Optical table features a Black aperture, this is mounted between the lamp and plaque to minimize stray light. An instrument holder with fine adjustable mounts point to the center of the plaque at a 45° angle. The lamp is mounted on an optical rail to permit accurate determination of the calibration distances. Depending on the application, other distances can be configured.

C. Procedure

Using our optical table Measurements are recorded over all wavelengths in $\mu\text{W}/\text{m}^2$. The Optical table is surrounded by black-out curtains and all outside light is isolated from the calibration room. Measurements are recorded through an open aperture as a Light value (L), obstructed by a Black lollipop giving a Shadow (S) value and then with a closed aperture giving a Dark value (K). Using the transfer value Between the Calibration Lamp and our NIST Standard Lamp e.g. (X) at the differing standard distances of 50cm and 200cm we then calculate a Calibration coefficients using: $X/(L-S)$.

These Instrument Wavelength Calibration coefficients are tracked and inter-compared for each FEL lamp used over time. This allows us to monitor both degrading lamps and the changes in instrument wavelength responses.

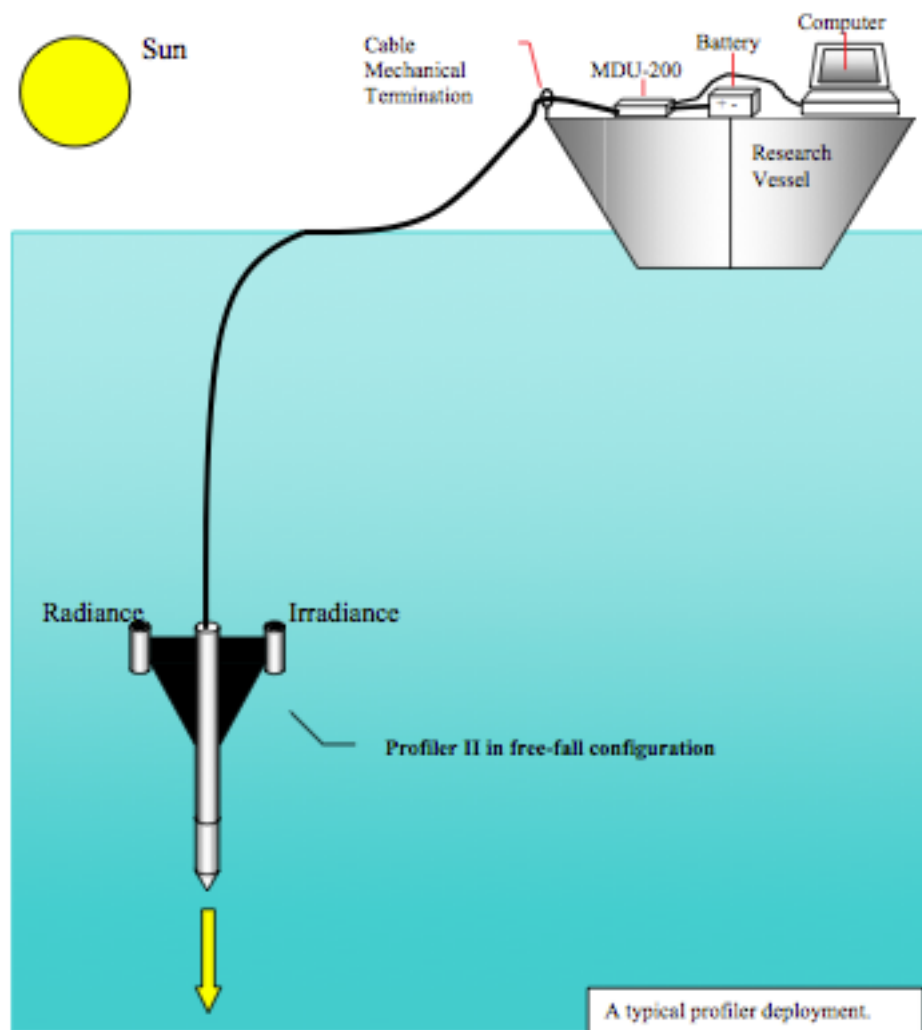
A certificate is created after each calibration event and includes information about the following references:

- Dark readings
- In-house calibration factors
- Manufacturer's original calibration coefficients
- Percent change for each sensor

III. Deployment / Sample collection

The Profiler II is used as a free-falling profiling device. This design provides a straightforward method of making measurements away from the ship. With a main pressure-housing diameter of only 48mm and a weight of about 8.2kg (with two OCR sensors attached), this design minimizes the size and weight of the profiler, allowing rapid deployment and retrieval. The free-fall descent rate of the instrument is set to 1.0m/sec through the use of lead ballast. The ballast is located within the flooded coupler and can be easily adjusted by removing the parabolic nose cone and adding or removing weight as required.

When the instrument is ready to deploy, a dry pressure tare is performed on deck. The instrument is then carefully lowered to the water by slowly releasing the cable hand over hand with the goal of maintaining a constant velocity with tilts as close to zero or vertical as possible (typically less than 5 degrees is acceptable; less than 2 degrees desirable). Maximum depth is typically 200m.



IV. Data Processing

Data are processed with Satlantic's ProSoft. The processing is segmented into 4 main levels:

Level 1

Binary data is extracted from raw data under the control of the instrument (calibration) files. Extracted information is grouped along with its calibration information and is placed into Level 1a HDF files.

Level 1b

Level1b data is calibrated. CAL, BIN or NULL dark correction is applied.

Level 2

Level 1b data is further modified:

1. Reference and dark data deglitching is applied.
2. If selected, SHUTTER dark correction is applied.
3. If a profiler instrument exists, profile editing is performed.

Level 2s

Level 2 data is interpolated onto a common co-ordinates vector, which is either depth or time.

Level 3a

Includes averaging of Level 2s data as defined by the processing parameters.

Level 4

Includes higher level data products calculated from level 3a data. This includes products such as normalized water leaving radiances, reflectance profiles, photosynthetically available radiation etc.

V. Additional Information

A. Factory Specifications:

- Optical Features: Measures 11 wavelengths of downwelling irradiance (305.0, 324.6, 340.2, 379.5, 411.6, 443.1, 490.8, 509.6, 555.0, 664.6, 682.5 nm) and 11 wavelengths of upwelling radiance (305.5, 325.1, 339.6, 380.3, 411.5, 442.8, 489.4, 509.7, 554.6, 664.7, 682.5 nm).
- Housing: 48mm
- Weight: 8.2 kg (in air).
- Other Sensors: Pressure, temperature, WET Labs ECO-BB2F, HyperOCR (Eu)
- Operating System: Microsoft Windows®
- Communication Software: Satlantic Satview
- Power Requirements: 12V converted to a regulated 48 VDC
- RAC to Mooring: A power/telemetry cable runs from the deck unit to the instrument body.
- Frame-Rate (Hz): 1m/sec.