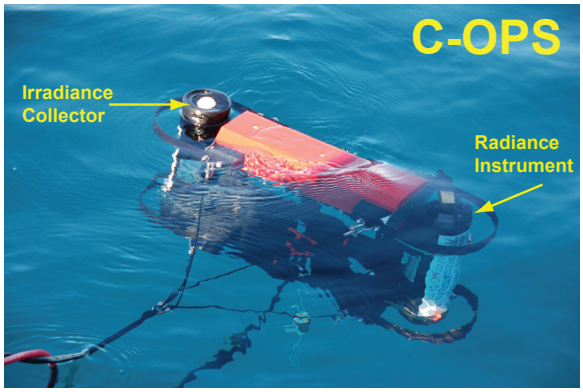
Biospherical Instruments Inc.

Your Source for Optical Sensing and Aquatic Profiling Technologies

C-OPS: Compact Optical Profiling System

WHAT IS C-OPS?

C-OPS is a radiometer system for determining apparent optical properties in the ocean. It consists of two radiometers: one measuring in-water upwelling radiance, and the other either downward irradiance or upward irradiance. Both radiometers are equipped with 19 wavebands and are mounted on a free-fall frame. The frame can be optimized for either slow descent rates for work in very shallow coastal waters, or faster descent rates for observations in the open ocean. Available accessories include above-water reference irradiance sensors to measure incident irradiance, the "BioShade" shadowband assembly for making diffuse measurements, and the "BioGPS" for providing position and time.



WHY C-OPS?

In-water legacy systems are not always well suited for properly resolving the optical complexity of shallow waters, principally because of overall instrument size, proximity of the sampling platform, or rate of descent. C-OPS does not have any of these problems.

C-OPS is so lightweight it can be hand deployed, so the system can be operated from either small or large vessels. In addition, its free-fall system precludes any influence from the shadow of the ship.

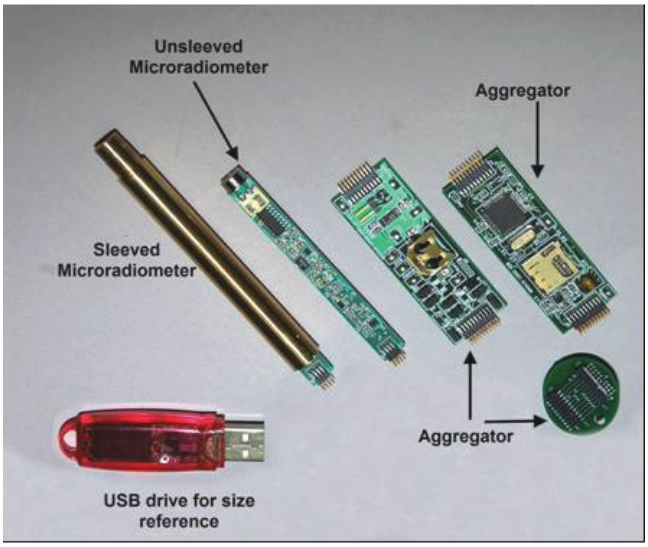
WHAT'S DIFFERENT ABOUT C-OPS?

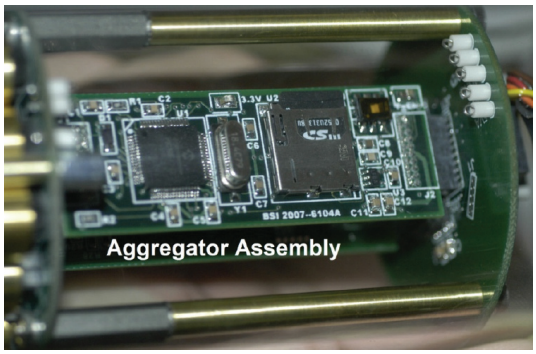
- Ideal for both ocean color, and satellite calibration and validation, in shallow water
- Complete, integrated system for measuring radiometric variables in coastal waters with submersible and above-water instrumentation (for both turbid coastal and clear oceanic waters)
- Submersible instruments are optimized for measuring vertical profiles of radiance and irradiance at depth
- It features rapid sampling (15 Hz); slow, free-fall descent; adjustable buoyancy; it is hand deployed; and has a 300 m maximum depth
- Based on microradiometer technology
- Developed in partnership with NASA

Microradiometers

The heart of the new C-OPS profiling system, and all of its accessories, is the microradiometer—a revolutionary new approach to photodetector integration.

The Biospherical Instruments Research and Development Group has perfected a miniature, stand-alone photodetector called the "microradiometer." The microradiometer consists of a filtered photodiode with a microprocessor, a preamplifier with controllable gain, a 24-bit analog-to-digital converter, and a serial port—all on one small circuit board assembly the size of a pen. The brass outer sleeve provides support and isolation from electronic noise.

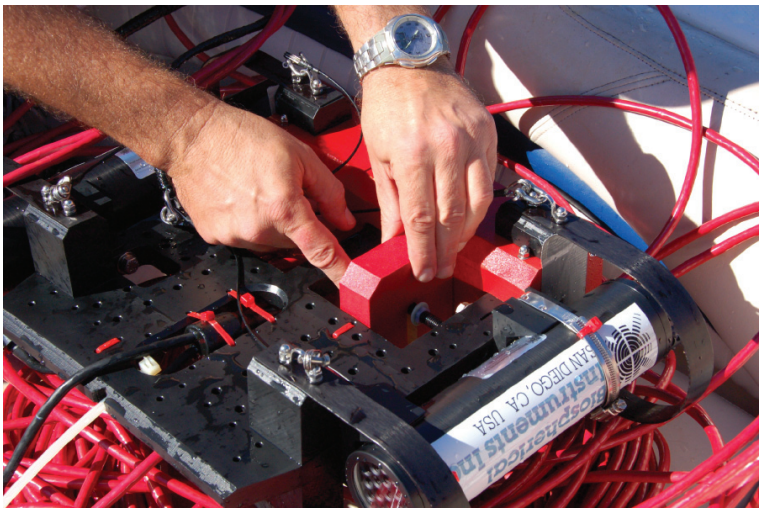




Although every microradiometer is an independently functioning photodetector, multiple microradiometers can be clustered together to form multiple wavelength radiometers. Aggregator assemblies (left) are used to bundle clusters of microradiometers with auxiliary sensors. Aggregators control the data flow to and from microradiometers. Aggregators also feature power conditioning; additional sensors including tilt angles, temperature, input voltage and current; and onboard removable data storage for specialized applications (microSD).

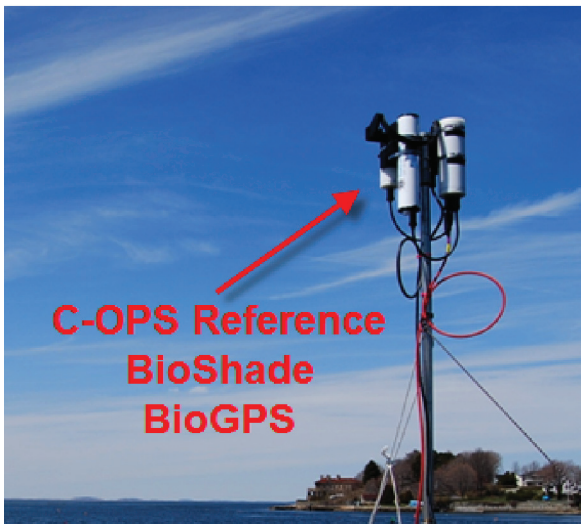
A cluster of 19 microradiometers in a pressure housing, allied to an aggregator assembly (above) forms a stand-alone multichannel radiance ocean color sensor that is small enough to hold in one hand (right).

C-OPS



The C-OPS near-surface buoyancy is easily adjustable using a combination of air filled and rigid foam floats. As the system descends, the increasing water pressure compresses air-filled bladders, which reduces buoyancy and increases the descent rate from <3 cm s^{-1} at the surface, to over 30 cm s^{-1} below 10 m.

The above-water reference sensor measures incident global irradiance. Optional accessories include shadow band for measurements of diffuse irradiance to support atmospheric correction schemes (BioShade), and GPS integration for position and time (BioGPS).



The battery-powered master aggregator deck box, the “Microradiometer Master Controller,” provides power and telemetry to a Windows-based laptop computer (supplied), or other PC. Biospherical Instruments custom software is provided. The deckbox also contains an output port controller, which allows both the surface reference and in-water sensors to adapt to different cable lengths, while supplying optimum power to the sensors. The deckbox displays an inventory of attached sensors on power up, which is helpful in troubleshooting cable and connection problems in complicated shipboard environments.

C-OPS Microradiometer Based Sensor Specifications

Each microradiometer contains its own complete control and acquisition system composed of a microprocessor, 24-bit analog-to-digital converter (ADC), voltage reference, temperature sensor, and electrometer front end. The electrometer is configured with three gains controlling the conversion of current to voltage. A collection of microradiometers, typically sampling different wavelengths, is aggregated into a microradiometer cluster, or instrument, where an electronics package ("aggregator") controls polling and acquisition of signals from each of the microradiometers. All microradiometers are synchronized to ensure simultaneous sampling at all wavelengths. The aggregator also contains the power conditioning circuitry and data communications interfaces, and may also be equipped with internal data storage (microSD Card—1 gigabyte) to support remote data logging.

Specifications

Microradiometer Specifications:

Detectors: Si (13 mm^2), InGaAs (7 mm^2), or GaAsP (7 mm^2)

Photocurrent-to-Voltage Conversion: Electrometer amplifier with three gain stages—1, 200, and 40,000.

ADC: 24-bit bipolar: 4–125 Hz data rates.

Dynamic Range (usable): 9 decades

Linearity: Measured on all microradiometers over a signal current range of 1×10^{-12} to 1×10^{-5} A using a programmable light source. Typically, errors are < 1% compared to a reference system electrometer. Gain ratios are individually measured using a computer controlled optical source and programmed into each microradiometer.

Speed: ADC sample rate is programmable from 4–125 Hz, and is normally set to 125 Hz, with averaging over the sampling period performed internally by the microradiometer.

Response Time: Exponential change with a time constant of < 0.01 s. Time required for gain change is < 0.1 s.

Electronic Sensitivity: ADC resolution is 0.5 µV with a current resolution of $< 10^{-15}$ A. The saturation current is 160 µA. The 3-gain signal-range is 1.6×10^{11}, defined as the saturation signal divided by minimum resolvable signal.

Noise: Si detector typically has 15–20 fA of noise when ADC is sampling at 125 Hz with the internal microradiometer averaging of 25 samples, resulting in a data rate of 5 Hz.

Optical Sensitivity: Sensitivity depends on the spectral region and the entrance optics (irradiance or radiance). It is expressed as Noise Equivalent Signals at 5 Hz for radiance ($\mu W\, cm^{-2}\, nm^{-1}\, sr^{-1}$) and irradiance ($\mu W\, cm^{-2}\, nm^{-1}$):

Channel	Radiance	Irradiance
320 nm	2.9×10^{-6}	9.0×10^{-5}
395 nm	5.0×10^{-6}	6.9×10^{-5}
490 nm	1.8×10^{-6}	2.3×10^{-5}
683 nm	9.9×10^{-7}	1.1×10^{-5}
780 nm	6.8×10^{-7}	8.0×10^{-6}

Note: Radiance is adjusted for immersion in water. Note also that radiance sensors may be pointed directly at the solar disk without saturating.

Dark Offsets: Dark offsets are measured and set at the time of calibration for each gain level. Offsets can also be automatically measured and applied in the field to accommodate different temperature regimes.

Microradiometer Power: ± 5 VDC at 4 mA total.

Optical Filters: 10 nm full width at half maximum multicavity ion-deposited interference filters selected for greatest out-of-band blocking and minimum fluorescence and maximum long term stability

Spectral Range: 250–1650 nm. (Range of 1100–1650 nm requires InGaAs detectors.)

C-OPS Assembly Specifications:

Cluster Sizes: Microradiometers are assembled into collections of 13 and 19 wavebands in a single housing. The following applies to 19-channel sensors:

Diameter: 2.75 inches

Depth: 125 m maximum depth rating standard; 300 m versions are available.

Wavelength Selection: Wavelengths are selectable from 250–1650 nm

Speed: A single, 19-waveband optical instrument can be operated at rates greater than 30 Hz. Complete systems composed of three 19-waveband radiometers can operate at rates greater than 15 Hz.

Data Rate: Optical instruments communicate at 115,200 baud, using RS232 or RS485 (full or half duplex). Deck box communicates at 115,200 baud using RS232.

Power Requirements: Optical instrument with 19 channels: 7.5 V at 90 mA. Three instrument system, 19 wavebands, 0.30 A typical at the deckbox.

Field-of-view Radiance Instrument**:** 7° half-angle in water (SeaWiFS specification)

Cosine Error Irradiance Instrument**:** ± 3% for zenith angles smaller than 60°; ± 5% for zenith angles 60–70°, and ± 10% for zenith angles from 70–80°.

Free-fall Speed: < 1 cm depth resolution; adjustable terminal velocity 6 cm to 35 cm s-1; manually adjustable pitch and roll

Ancillary Sensors: Water temperature, water pressure transducers, and pitch and roll.

Available Accessories:

BioShade: Marine shadowband accessory for surface irradiance reference sensor.

BioGPS: GPS accessory; custom adaptable free-fall frames; individual characterizations.

Custom cable lengths, cable reels, and shipping containers. Details available upon request.

Biospherical Instruments Inc.
5340 Riley Street
San Diego, CA 92110-2621, USA
Telephone: (619) 686-1888
Fax: (619) 686-1887
E-mail: support@biospherical.com