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Measuring Radiometric Variables for the AOPs: An Instrument Manufacturer's Perspective

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Typical Research Applications (Who talks to us?)

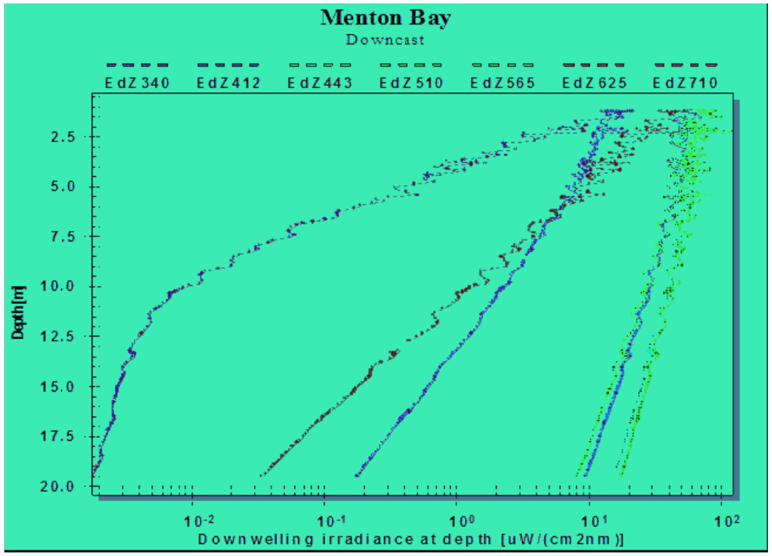
- Phytoplankton Ecology and Aquaculture
- Environmental Monitoring (Eutrophication, Corals, Water Quality)
- Remote Sensing (and Cal/Val)
- Physical Modelers
- Photochemists (especially UV)

Typical Radiometric Variables Sampled in the Field

- Downward Irradiance at the Surface (filter /photodetector -based)
- Downward Irradiance with Depth
- Upwelling Radiance with Depth

Supporting Variables

- Pressure /Depth
- Water Temperature
- 2-Axis Tilt (Pitch and Roll)
- Supply Voltage, Photodiode Temperature



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Software Data Processor

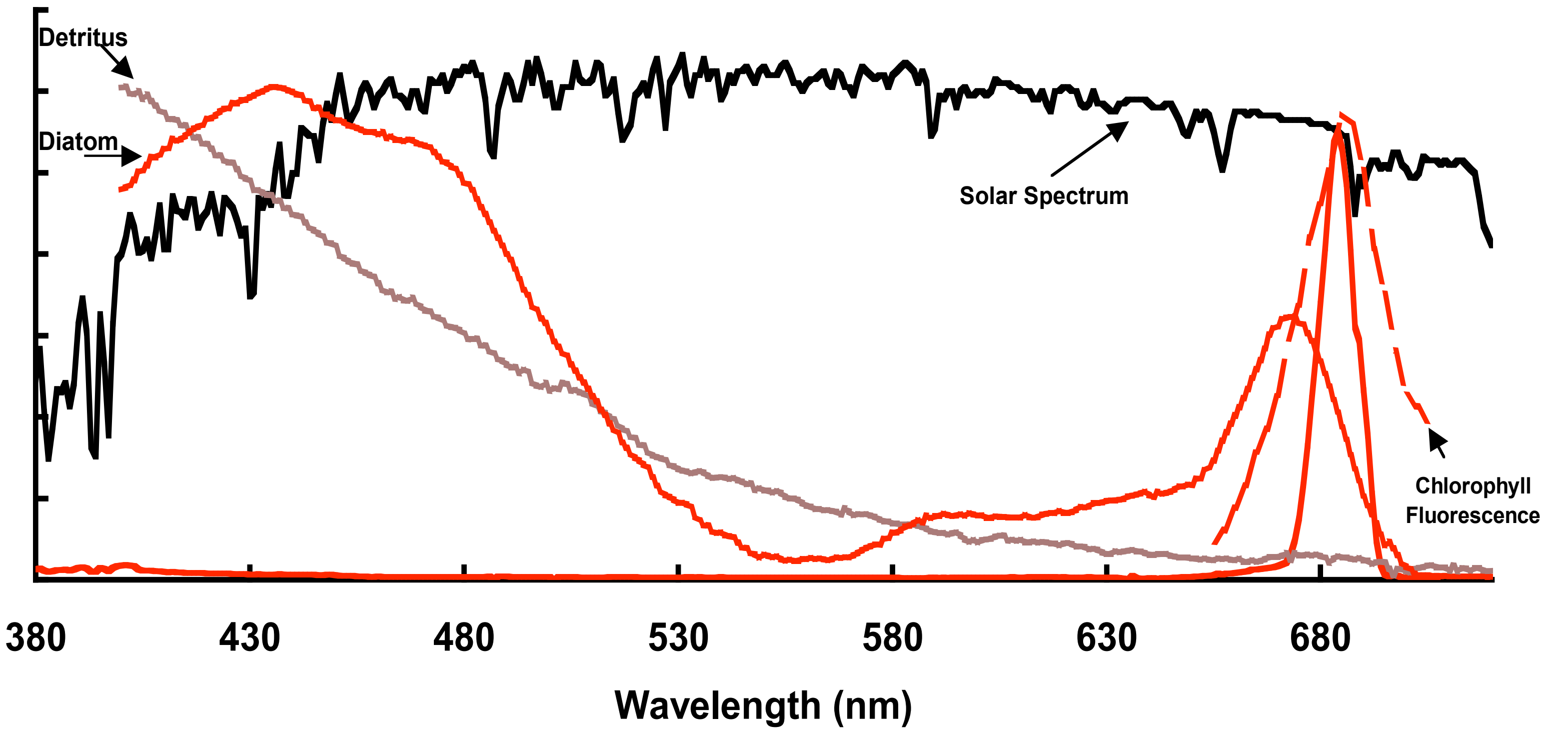
Custom Windows -based integrated with data acquisition ;
Excel worksheets

Data Products

User-selectable downcast, upcast, cast limits
Tables of calibrated , dark-corrected measurement variables (Access or ASCII)
Vertical Profile Plots and Spectra with depth
Diffuse Attenuation Coefficient (selectable smoothing interval and bin)
Chlorophyll concentration and primary productivity (Kiefer et al. algorithm)

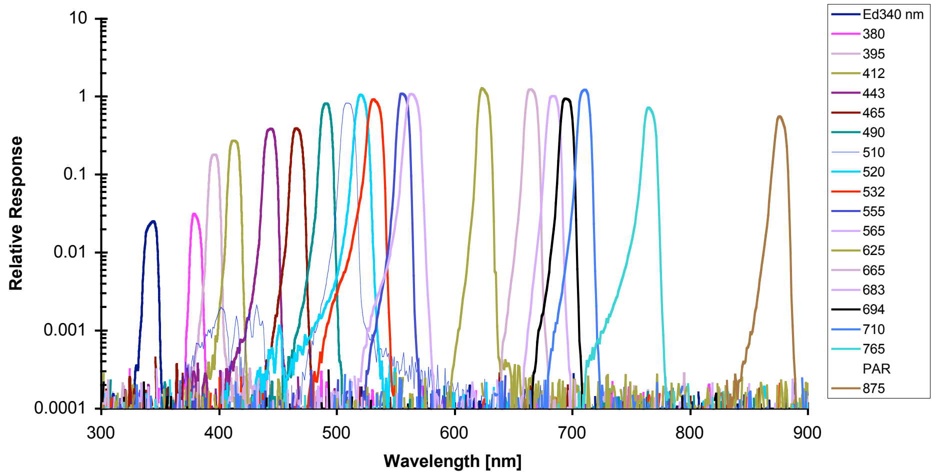
Additional Capability

Time and Position (microradiometer -based GPS)
Shadowband Accessory

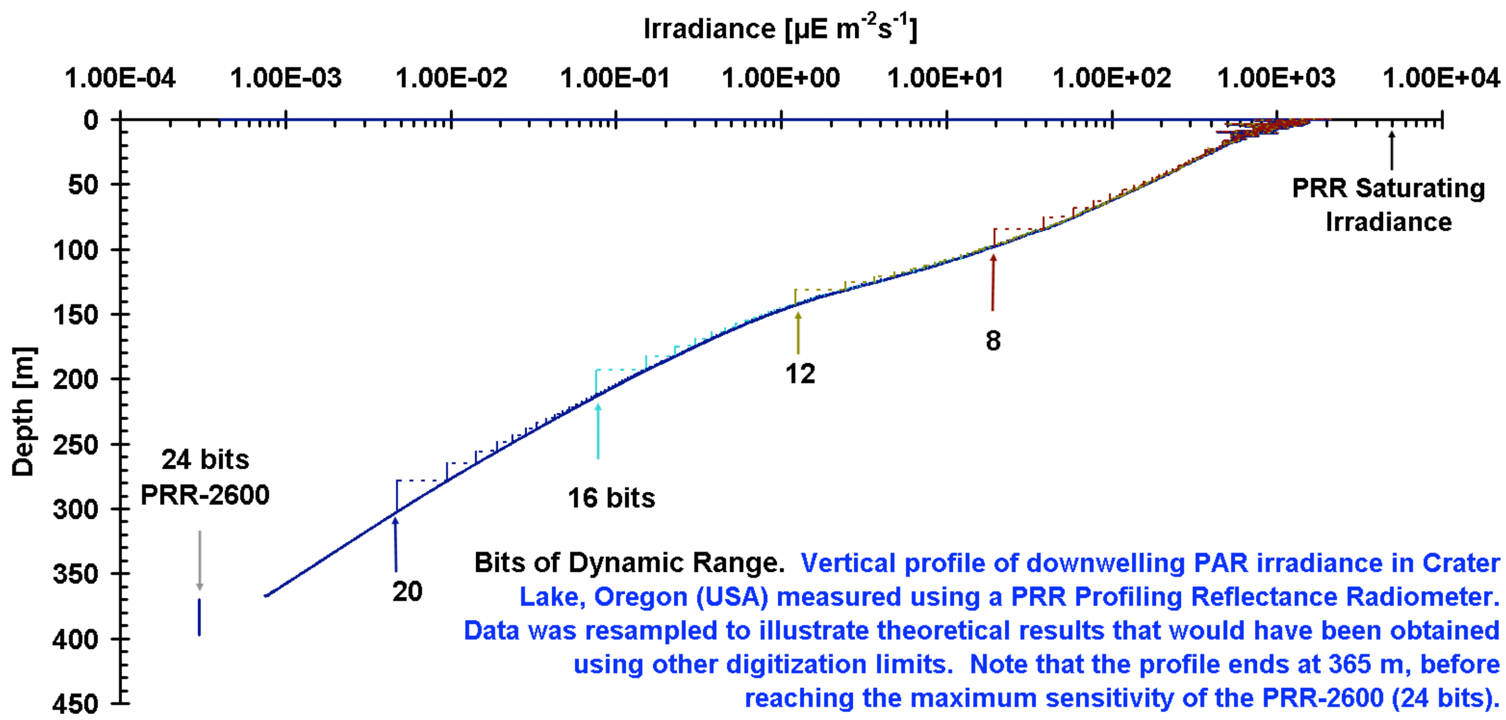


Varying impacts from biogenic and non-biogenic sources, as well as transformations such as chlorophyll and Raman fluorescence, all contribute to variability in the light field with depth.

Multi-wavelength Filter Radiometer

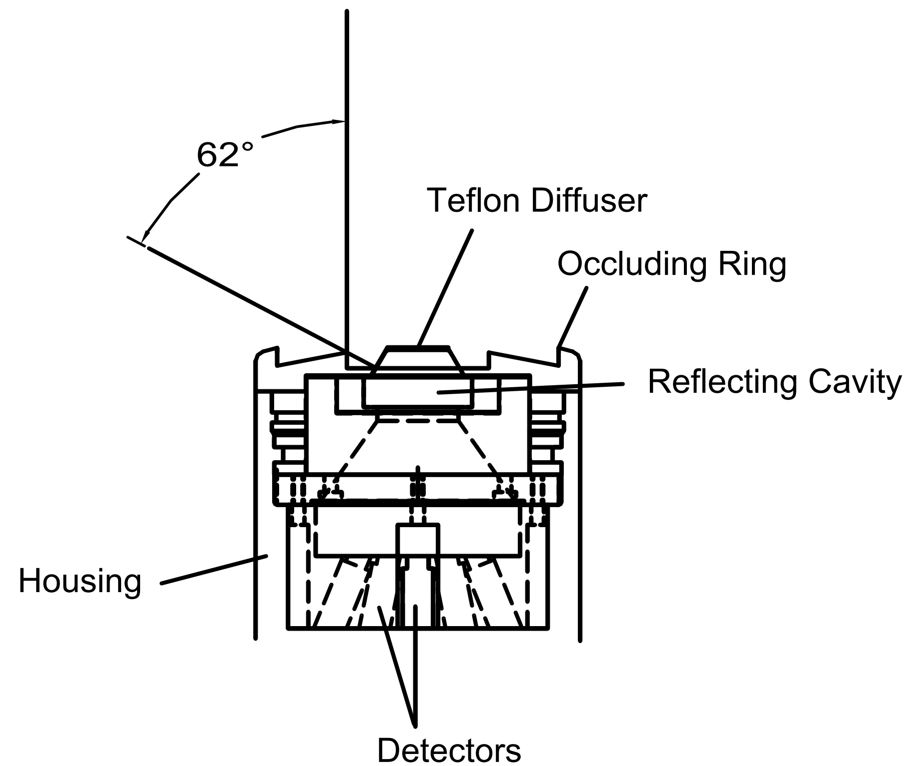


Dynamic Range



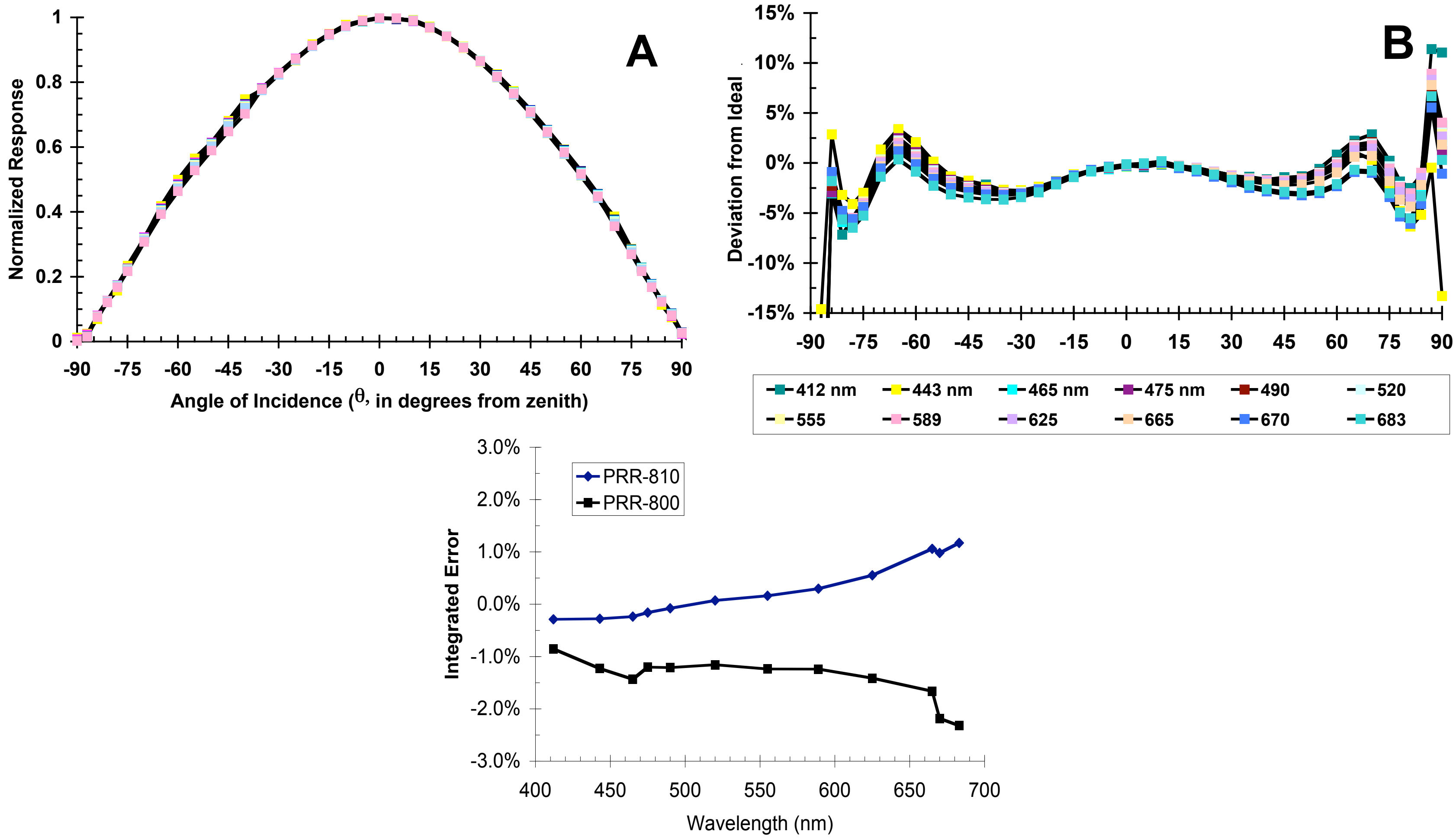
Bits of Dynamic Range. Vertical profile of downwelling PAR irradiance in Crater Lake, Oregon (USA) measured using a PRR Profiling Reflectance Radiometer. Data was resampled to illustrate theoretical results that would have been obtained using other digitization limits. Note that the profile ends at 365 m, before reaching the maximum sensitivity of the PRR-2600 (24 bits).

Cosine-Collector Design for In-water Irradiance



Measured irradiance will be proportional to the cosine of the angle of incidence in a properly designed cosine collector. For designs using multiple photodetectors, wavelength detuning as the view angle of the photodetector moves off-axis is also an issue.

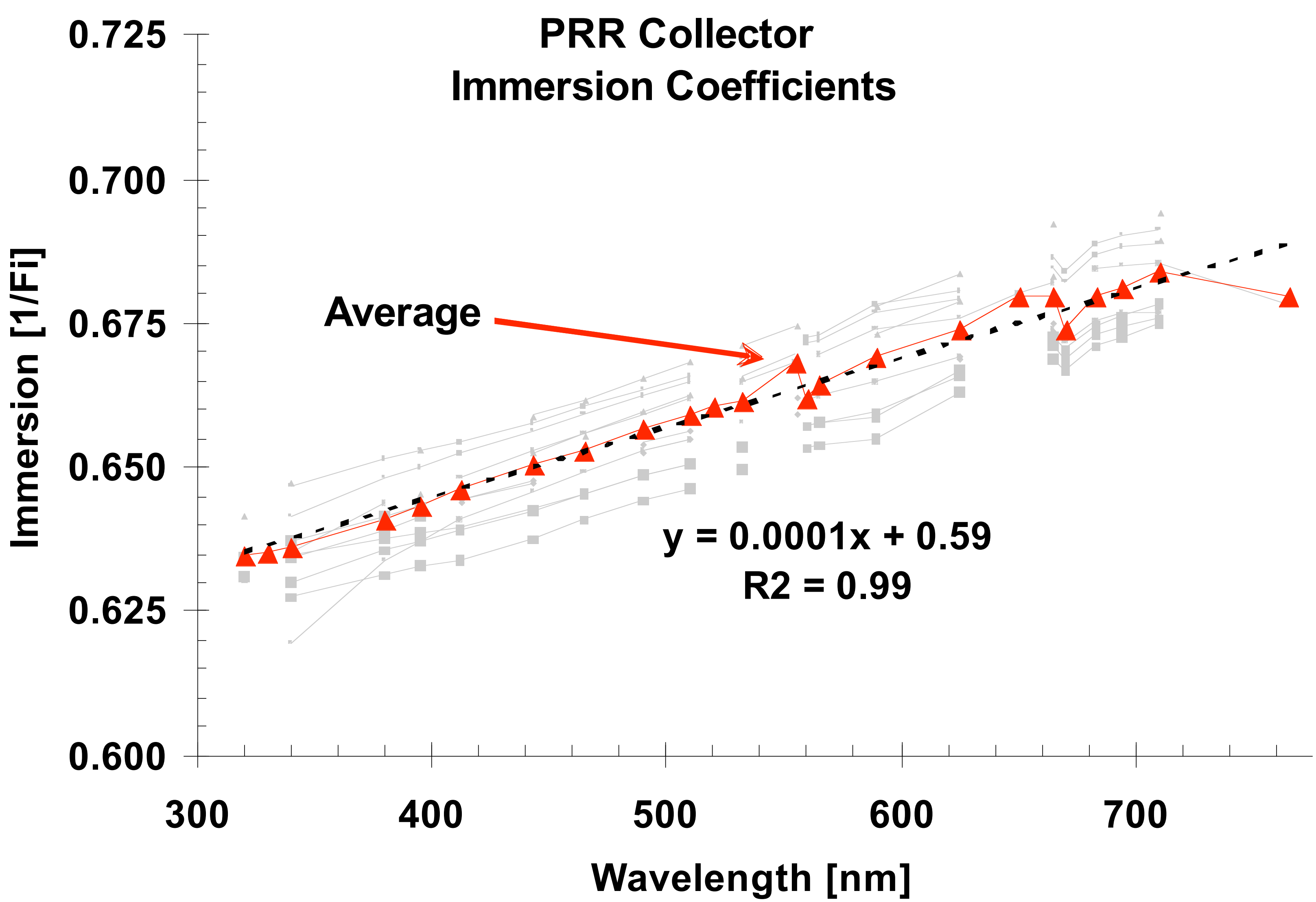
Angular Response of In-water Irradiance Collectors



Typical results for PRR cosine collector, in water, normalized to the response at θ=0º. Panel A shows the normalized response from –90º zenith angle to +90º. Panel B panel displays the % deviation from ideal over the same range. Bottom panel is a calculation of the percent error due to departures from true cosine for a theoretical uniform diffuse light field.

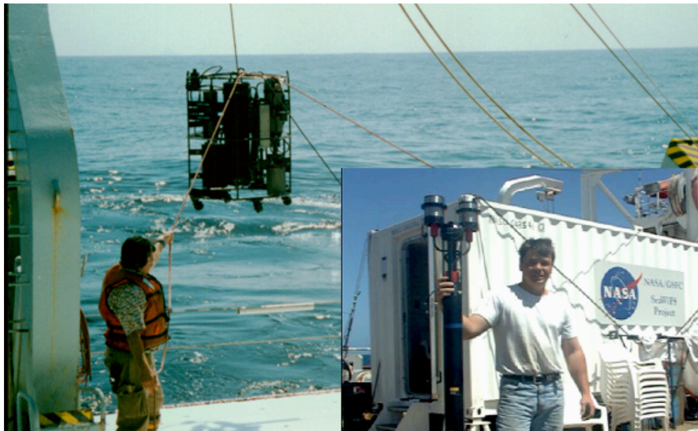
Manufacturer's Sidebar: temporary "repairs"

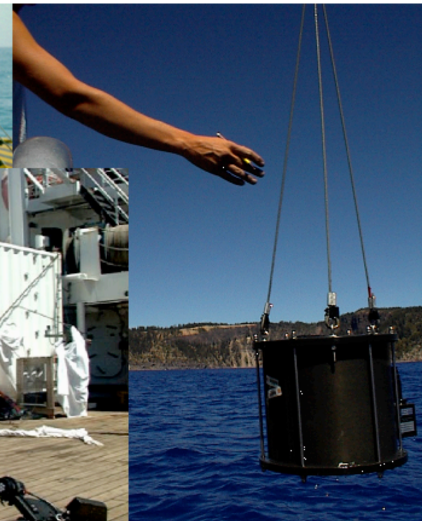
Maybe it stopped leaking, but what about calibration, immersion coefficient and cosine response?



PRR Collector
Immersion Coefficients
Average
y = 0.0001x + 0.59
R2 = 0.99
Immersion [1/Fi]
Wavelength [nm]
0.725
0.700
0.675
0.650
0.625
0.600
300
400
500
600
700

There are a number of challenges that need to be overcome as we move into coastal waters





Legacy Instruments

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.

Adequate laboratory space is hard to get…

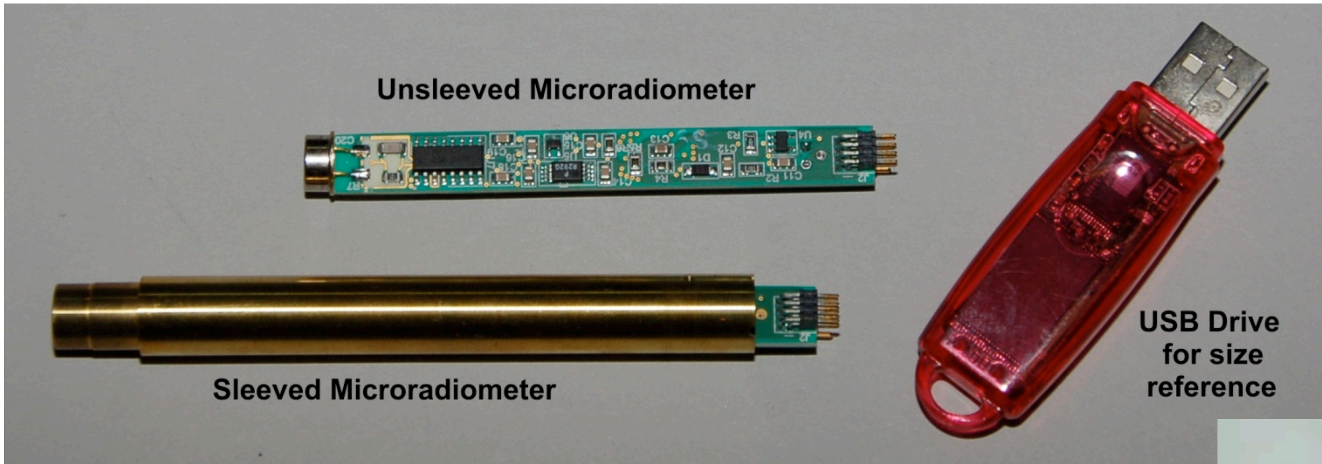
laptop computers remain difficult to see …

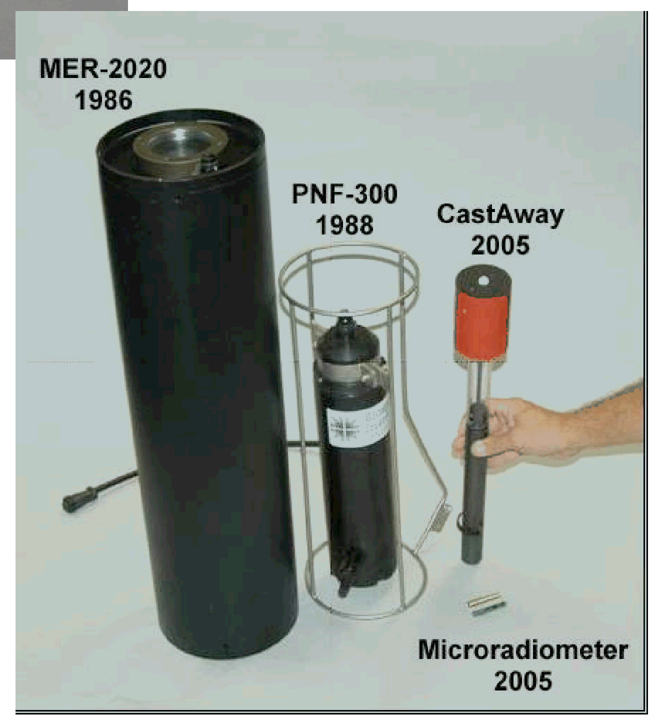
long hours on small boats…

less-than-ideal instrument placement…

and reduced funding

Smaller and faster





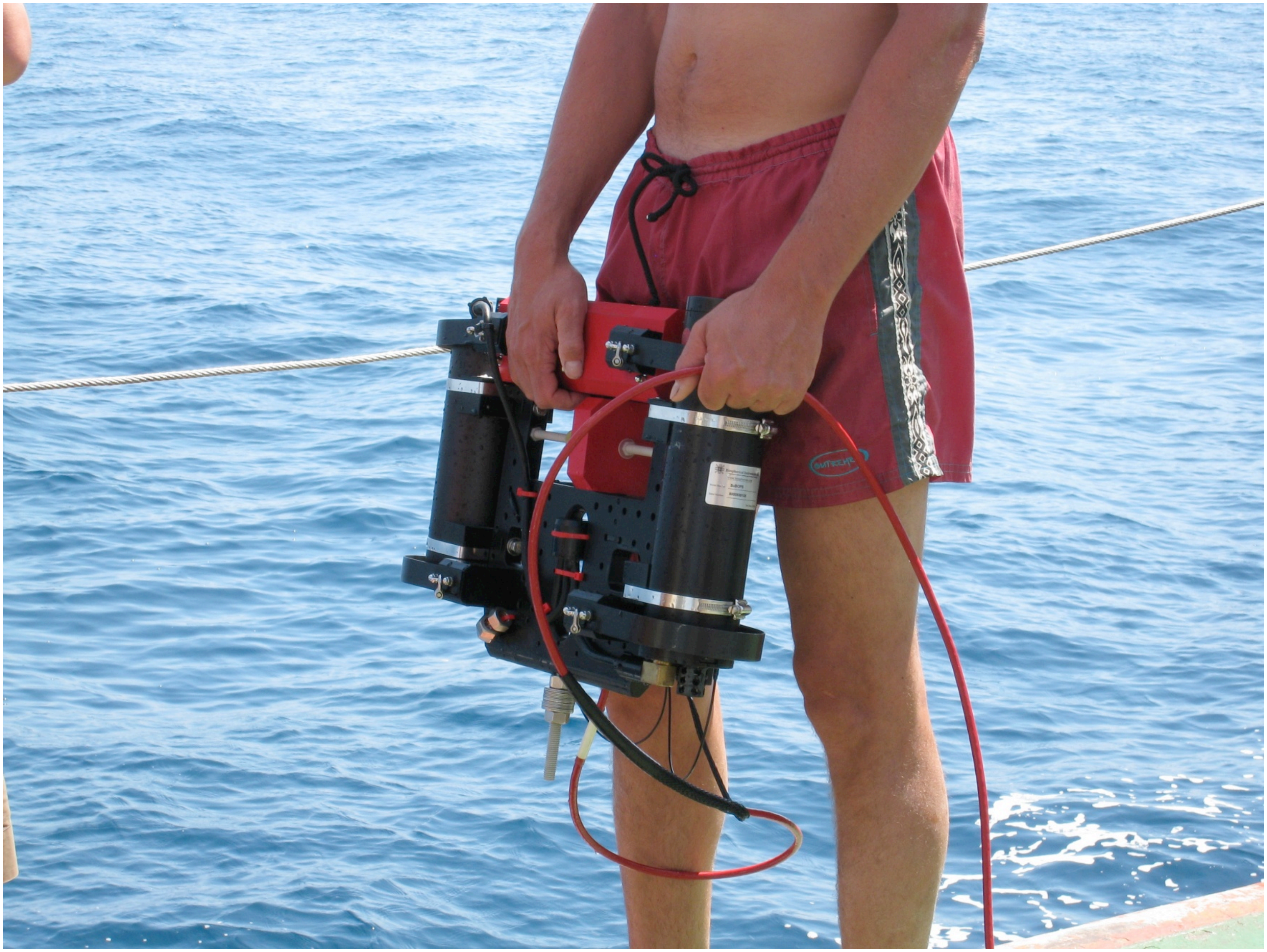
Microradiometer technology. A microradiometer is an "intelligent" photodetector -- filter/photodetector, DAS, microprocessor and RS485 communications in a single small package. Clusters of microradiometers can be ganged together in simple hierarchical "networks" to produce small, high-speed multiple wavelength radiometer systems.

19 channel microradiometer radiance head
6.3 cm diameter

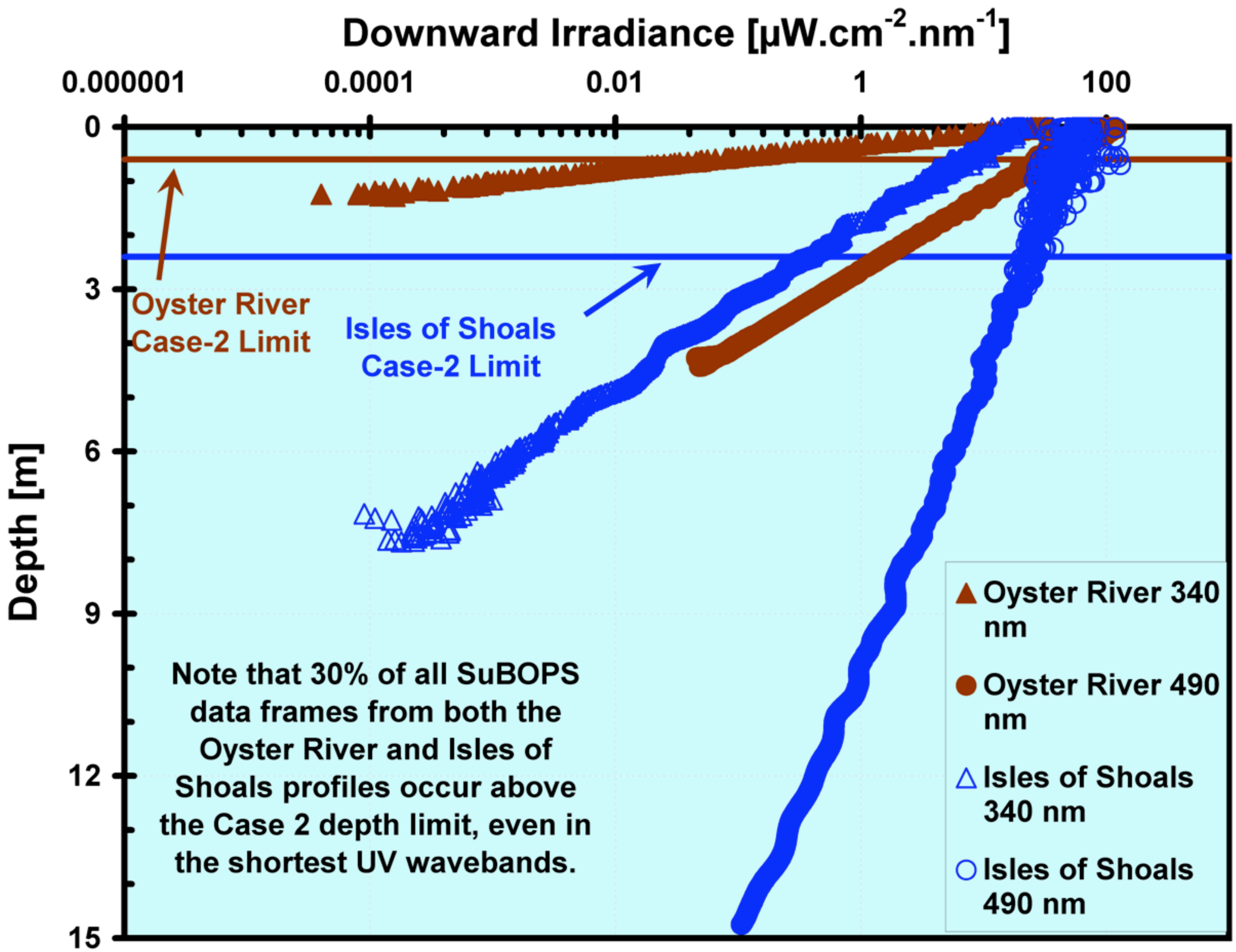
C-OPS 19 channel radiometers in 7 cm pressure housing

In-water irradiance   Surface irradiance   In-water radiance

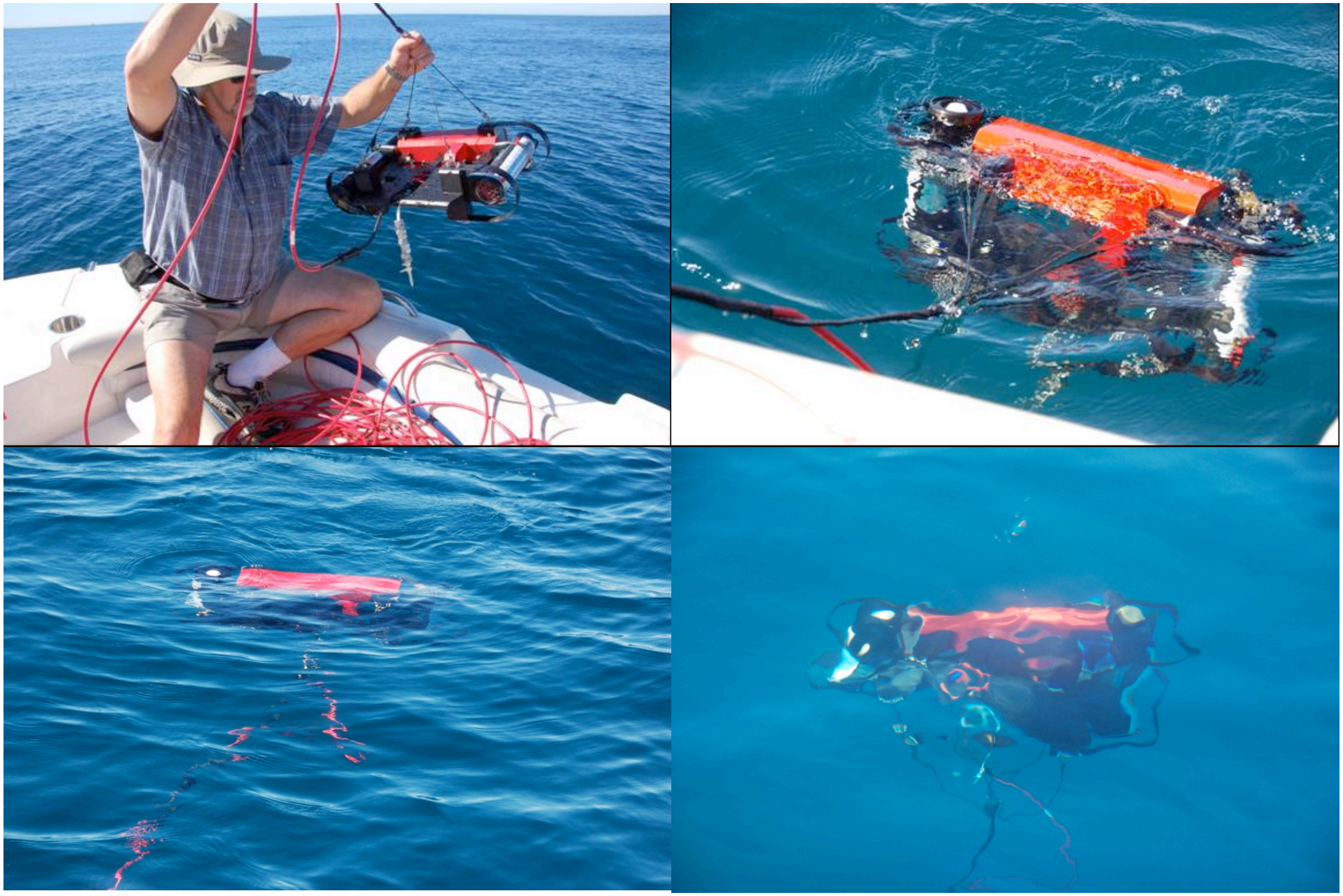
SuBOPS Deployment



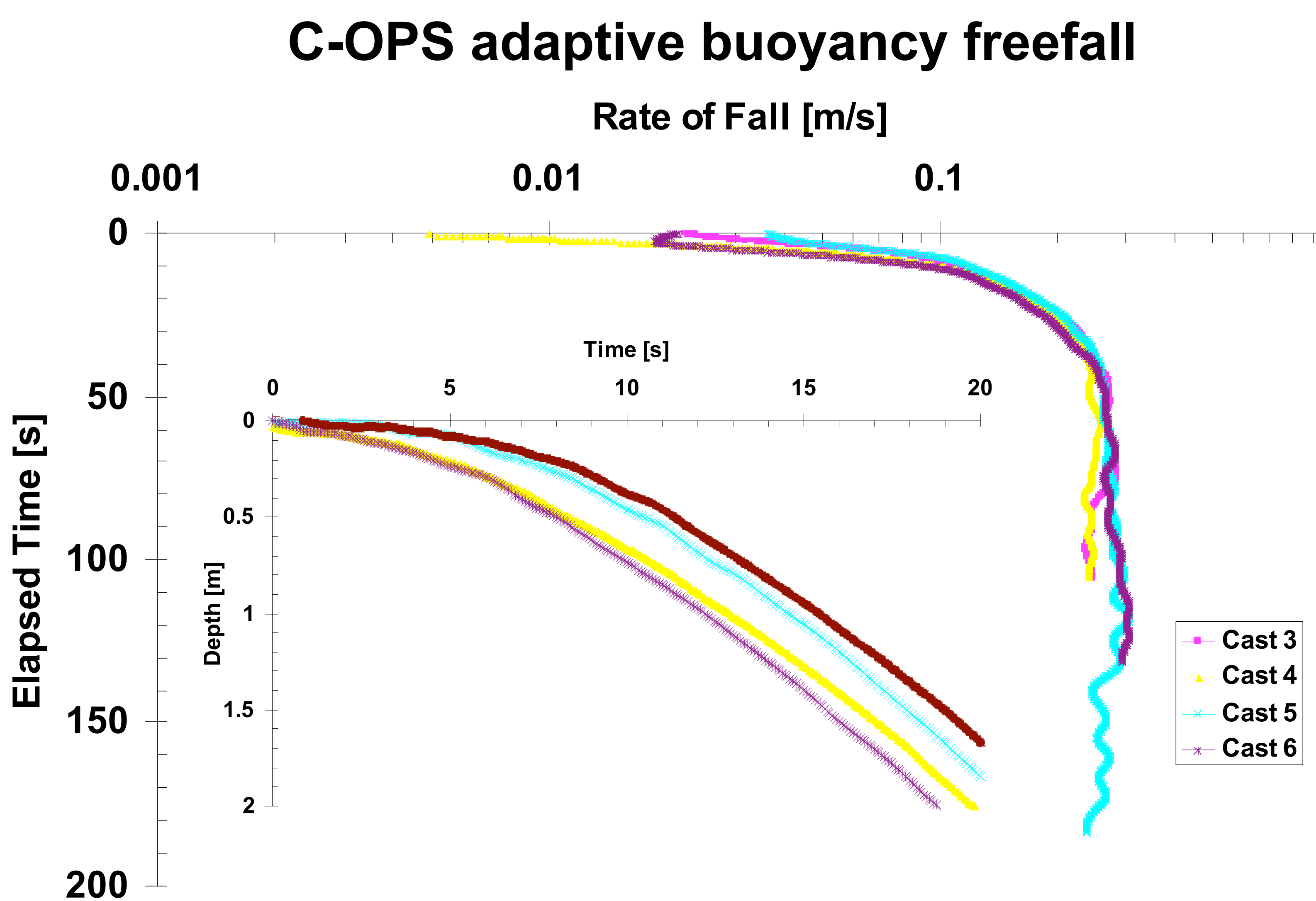
SuBOPS constant buoyancy freefall



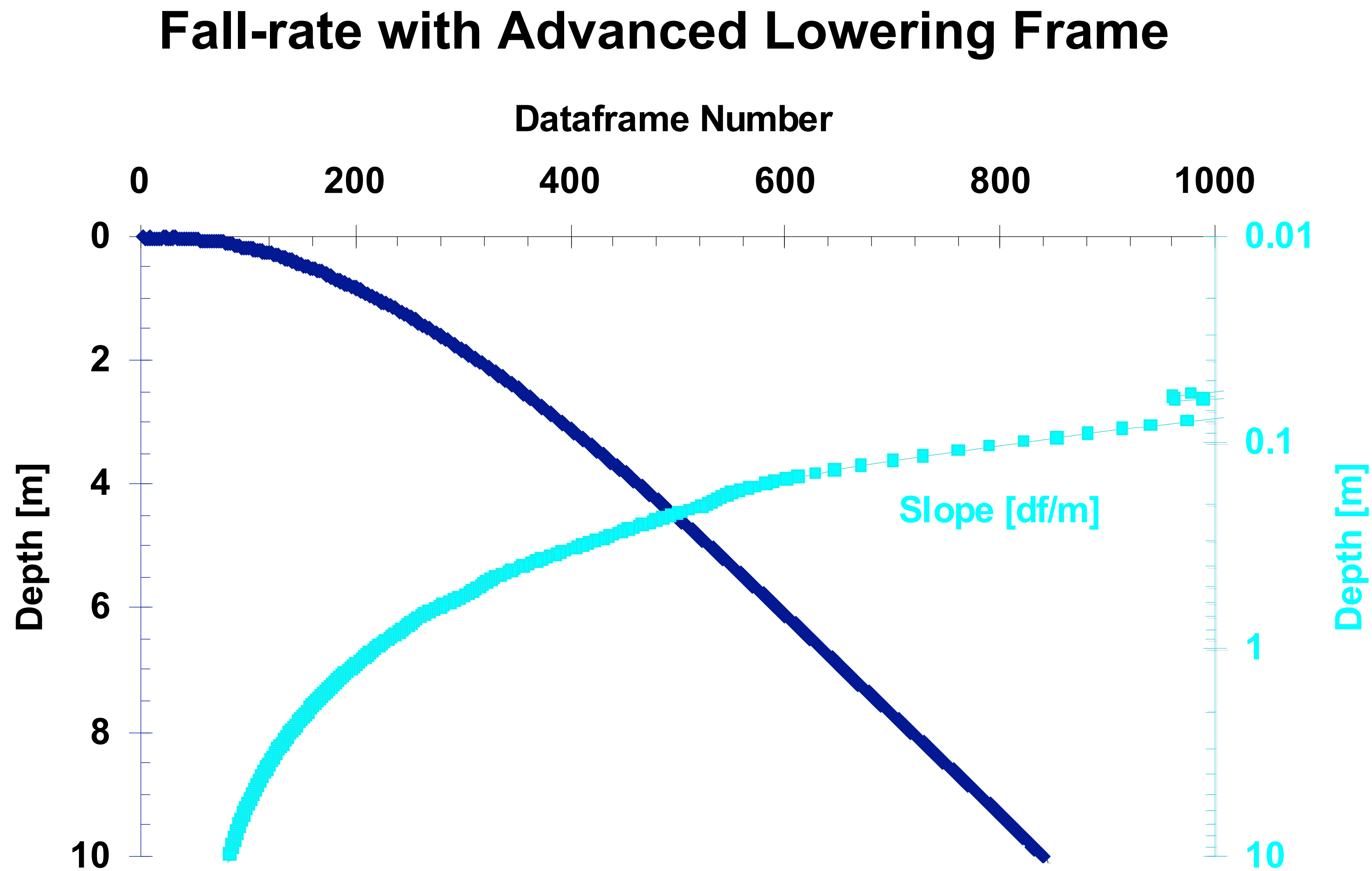
C-OPS Deployment



C-OPS adjustable freefall system



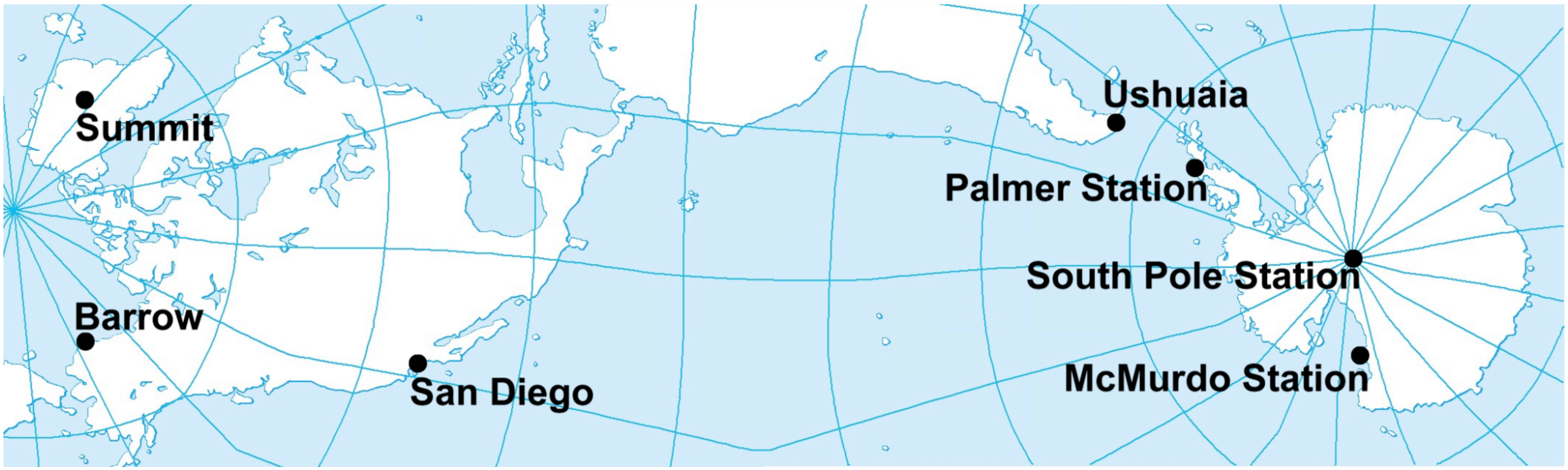
C-OPS adaptive buoyancy freefall
Rate of Fall [m/s]
0.001
0.01
0.1
1
Elapsed Time [s]
0
50
100
150
200
Time [s]
0
5
10
15
20
Depth [m]
0
0.5
1
1.5
2
Cast 3
Cast 4
Cast 5
Cast 6



Fall-rate with Advanced Lowering Frame
Dataframe Number
0
200
400
600
800
1000
Depth [m]
0
2
4
6
8
10
Slope [df/m]
Depth [m]
0.01
0.1
1
10

National Science Foundation's UV Monitoring Network Operated by Biospherical Instruments

Network Sites



Data Products

- Spectra of global (sun and sky) irradiance between 280 and 600 nm
- Integrated irradiance (e.g., UV-B, UV-A, and visible irradiance)
- Biologically effective dose-rates (>15 action spectra, e.g., UV Index)
- Actinic flux and photoloysis rates (e.g., $O_3 \rightarrow O(^1D) + O_2$)
- Total ozone - Effective albedo - Cloud optical depth - Modeled spectra

NSF UV Monitoring Network
Where to get data?

Official site:
www.biospherical.com/NSF

SeaBASS*:
http://seabass.gsfc.nasa.gov
(Data from all sites have been submitted, data from Palmer are online)

WOUDC†:
www.woudc.org
(In March 2009)

* SeaWiFS Bio-optical Archive and Storage System
† World Ozone and UV Data Center

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Selected Software Lessons Learned

- Data acquisition and data processing have different, sometimes competing goals
- Acquisition software needs to provide enough data processing in (almost) real time to help assure the best dataset
- Acquisition software needs flexibility in data output and storage formats
- Acquisition software needs to be able to report as much detail as the researcher desires
- All stages of the process requires document (time, frame counts, raw data, darks, calibrations, etc.), document (what went in the water when?), and document (where were we?)