The CVO AOP Data Processor

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History, Objectives, and Design Features of the CVO Processor

The CVO processor started as a joint collaboration with Stéphane Maritorena when he worked at GSFC in the 1990s. The "GSFC" processor was written in IDL and provided some of the architectural concepts of a new processor that was produced as a collaboration with Jim Brown (University of Miami) when Stéphane moved to UCSB. The new processor was written in C, and the visualization components were written in an open-source Basic language. The processor has four modules: a) data ingestion, b) raw data correction (depth offsets, timing anomalies, gain switching, etc.) and conversion to geophysical units, c) choosing extrapolation intervals, and d) processing final data products. The objectives and design features of this new "CVO" processor have remained rather similar over time and are based on the following:

- Establish a tight coupling between the data acquisition environment (custom LabView virtual instruments) and the data processing capability. This means that all execution modes used during data acquisition have documented consequences that the data processor can properly interpret. Data acquisition in this context includes normal field campaigns and laboratory experiments, plus specialized field and laboratory acquisition sequences. The latter three includes calibration (FELs, plaques, and transfer radiometers), sensor stability monitoring (SQM, SQM-II, and OCS), simultaneous instrument or sensor deployments for intercomparisons.

Self-Documenting ASCII Data Files

- Require that all data files used during data processing be self-documenting ASCII files (i.e., each file has a header block and data block, with the header block specifying all the needed information in a key-word syntax architecture:

```
/begin_header
/instrument_id=PRR-800
/serial_no=8000899105
/start_date=2004NOV26
/affiliations=GSFC
/investigators=STANFORD_B_HOOKER
/experiment=BIOSOPE
/data_type=CAST
/column_headers=Sample_No,GMT_Time_Stamp,Ed320,Ed340,Ed380,...
/calibration_filename=PRR001B1.CAL
/sequence_number=36
/sensor_1=WLR_ED_0101
/sensor_2=WLR_LU_0102
/BSI_calibration_filename=8000899105v11.cal
/end_header@
Sample_No        GMT_Time_Stamp    Ed320    Ed340    Ed380
      1  2004331180458.51  5231342  5156287  5228231  ...
      2  2004331180458.60  5214989  5239195  5213239  ...
      3  2004331180458.68  5224640  5150317  5218134  ...
   ...
```

Header block concept follows from the first implementation of SeaBASS (Hooker et al. 1994)

Tab-delimited data block

File Names Constructed from Simple Algorithms

- Specify algorithmic rules for the naming of all data files that will be part of the data processing environment, the majority of which are created during data acquisition. The previous file name `F04WD036.CHP` is decoded as follows:

```
CnnPDddd.EXT

C   is the cruise (or experiment) code                F
nn  is the cruise (or experiment) number              04
P   is the primary instrument platform:
    F = SeaFALLS (S/N 8)
    L = LoCNESS (S/N 4)
    W = Biospherical PRR-800                          W
D   is the deployment code
    C = Caps (on for dark readings)
    D = Downcast for in-water instruments             D
ddd is the deployment sequence number                 036
EXT is the file extension                             .
    E = the data rate
        C for 12 Hz (Biospherical)                    C
        S for 6 Hz (Satlantic)
    X = H (for Hertz)                                 H
    T = measurement type
        M for 7-channel in-air irradiance (MVDS)
        P for 19-channel in-water optics              P
```

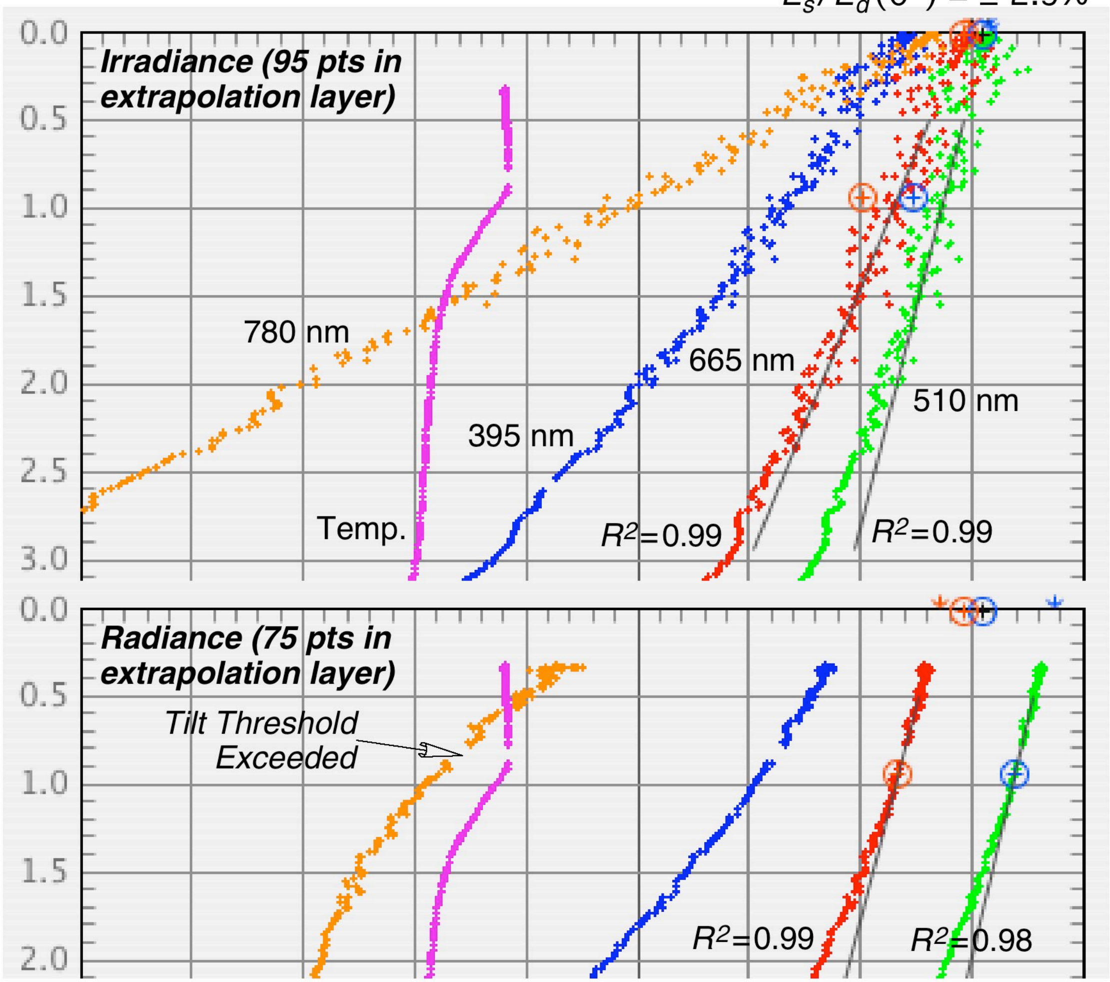
Extrapolation Intervals Chosen Based on Converging the Above- and In-Water Irradiance Fields

- Provide a GUI for choosing two extrapolation intervals (UVBGr and Red) based on converging the solar irradiance, E_s, and the extrapolated in-water downward irradiance, $E_d(0^+)$.

Additional options and displays are provided, the most important of which are as follows:

- E_s normalization of in-water light data.
- Tilt threshold rejection (5°).
- K comparisons to K_w.
- Quality-level code assigned:
  0 = suitable for all calibration and validation activities
  1 = minor flaws, suitable for validation activities
  2 = major flaws in more than one spectral component
  3 = data not useable

$E_s/E_d(0^+) = \leq 2.5\%$



Command-Line Processing

- Utilize a command-line architecture for data processing with recursive interpretation, embedded syntax, hierarchal rules, and DEFLEX (default-loaded, exception-executed) processing. When combined with the file naming algorithm, the command line provides very easy batch-mode reprocessing.

```
!
! Command line file for IWPROC: /comfil=H2IWComLines/comnum=NN
!
/comnum=1
/nsigma=2
/maxtlt=5
/inpfil=H02XD001.CHP>H02XD056.CHP{H02XD###.CHP}
/inpdir=H2DATAFIX:H2SubDAT
/caldir=H2IWResults:H2CalFil
/zoffed=0.30607/zofflu=0.00001/zofftw=0.002
/mstfil=H2MasterLog.txt
/stnfil=H2SubLog.txt
/rngfil=H2SubExtrapIntV1.txt
/etifil=IrrVal.txt/etiflg
/bioflg/biofil=Kbio.txt
/diinst=0.1016/diopti=0.0093472/ratdir=:EiEdAbsTables
/sunflg/sunana
/outdir=H2IWResults:H2SubOUT/logdir=H2IWResults:H2SubLOGs
/resdir=H2IWResults:H2SubRES/dbgdir=H2IWResults:H2SubDBG/dbgflg
```

User-Definable Syntax

- Allow the user to establish a unique (synonym) vocabulary for the standard command-line key words using a comprehensive syntax (e.g., automated decoding of physical units, angular geometries, time bases, etc.).

```
! SYN File  Angle    valued switches: a    Double   valued switches: d
!           File   pathway  switches: f    Integer  valued switches: i
!           Logical  valued switches: l    Real     valued switches: r
!           String   valued switches: s    Time     valued switches: t
!           Prompt  user  if  absent: ?    Physical units of switch: [code]
!
/CALEXT {f}             =.CAL              ! Calibration file name extension
/DSABEU {l}             =false             ! Disable processing for Eu bands
/DRKCOR {l}             =true              ! Dark correction mode: T=field
 dark_correction_mode                      !   darks, F=system darks
/DRKFIL {f}             =                  ! Dark file name
 dark_file_name
/MAXTLT {a,[deg]}       =5.                ! Maximum allowed tilt [deg]
/MSTFIL {f}             =?                 ! Master log file name
 master_log_file_name
/NPRINT {i}             =0                 ! Verbose debug output (routine
 verbose                                   !   specific; 0=standard)
/REFPRS {d,[m]}         =0.315             ! Submerged reference depth [m]
/REFTIM {t}             =1995Jan01         ! Monotonic reference time base
/SSHCOR {l}             =true              ! Self-shading correction
```

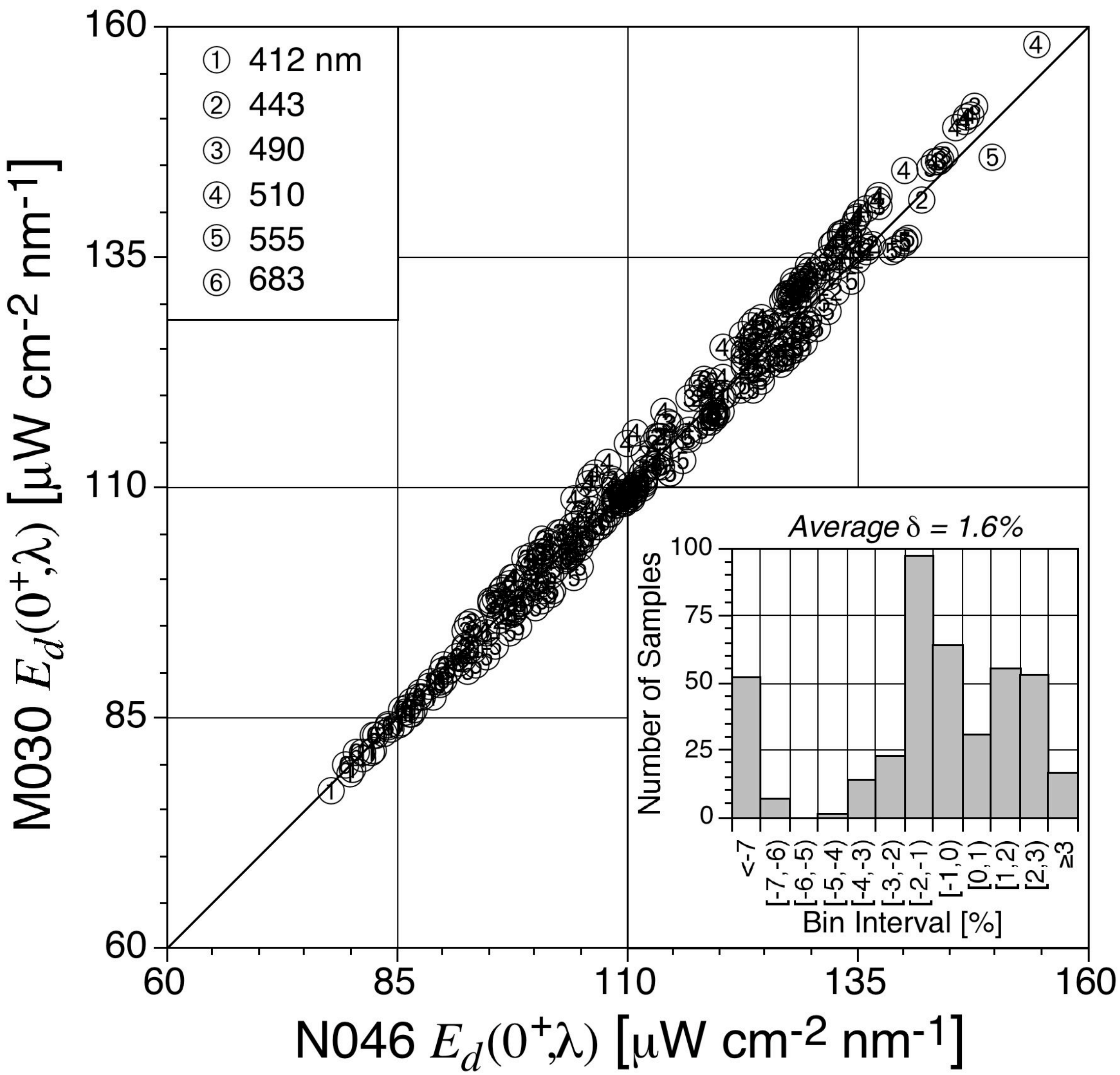
Final Corrections and Data Products

Final corrections to the data are a function of what primary variables were measured (E_d, L_u, E_u, and E_s), but L_u is almost always measured, so a self-shading correction is almost always made. Similarly, the data products depend on the light parameters that were measured, as well as any supporting measurements from a CTD profile:

- Station and cruise information, instrumentation type and attitude variables, geolocation, time, solar geometry, environmental conditions, extrapolation parameters.
- $E_d(0^-)$, $L_u(0^-)$, E_s, PAR, PAR(0^-), L_W, R_{rs}, L_{WN}, K_{Lu}, K_d, K_{PAR}, K_{SW490}, 10%LL, 1%LL, and a variety of ocean color algorithms (OCnVx).
- MLT, MLD, DCM, DFM, and TChl a.
- A variety of variables derived from CTD data, if it is available, including common ancillary sensors for CTD systems (fluorometer, PAR, etc.).
- Tabular values from look-up tables and modeled values useful for intercomparisons (F_0, K_w, Q, and K_{bio}).
- *Exact* L_{WN}, $E_u(0^-)$, and $Q_n(0^-)$.
- A number of diagnostic variables that have proved helpful over the years in terms of trouble-shooting problems with the processor.

Benefits of A Tightly Coupled Acquisition and Processing Environment

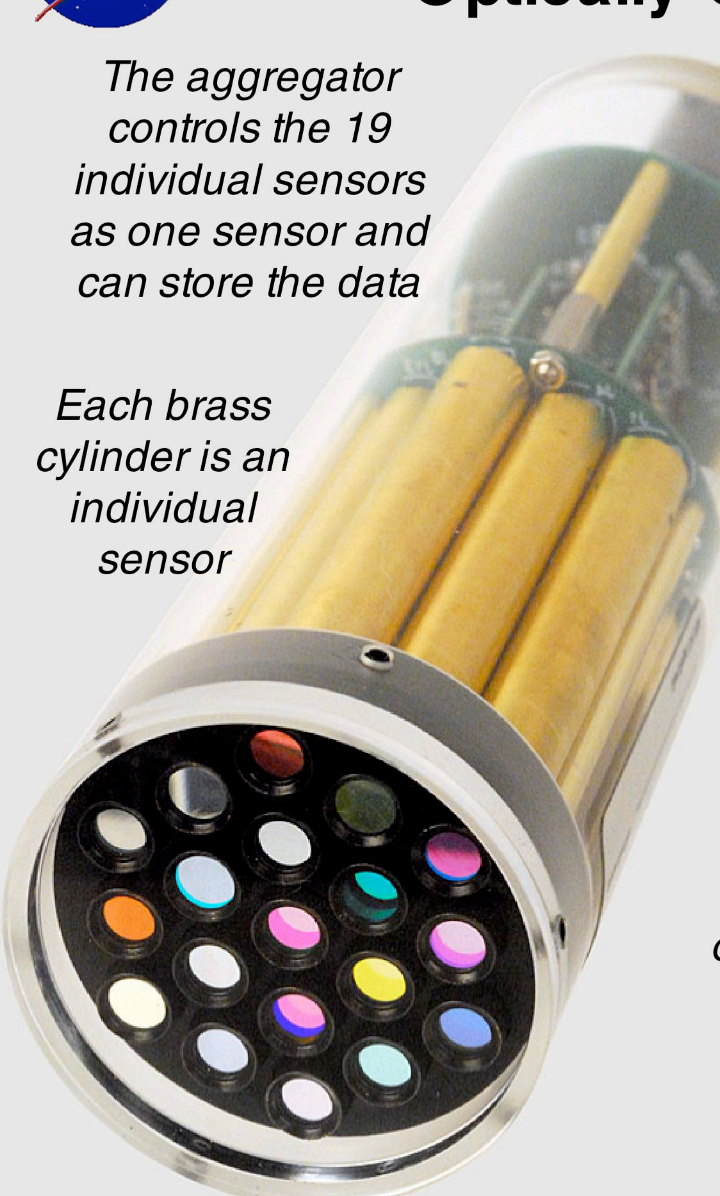
The tight coupling between the CVO data acquisition and data processing environments has been especially beneficial to maintaining the quality of the field sensors. The inquiry into immersion factors, for example, was a direct consequence of being unable to converge the various light parameters in the processing scheme, and led to the determination of new immersion factors for a large number of sensors. The latter was the result of some rather sophisticated analyses, and in most cases, simpler—but equally useful—analyses are undertaken. The plot, for example, shows the detection of an anomalous 510 nm channel.



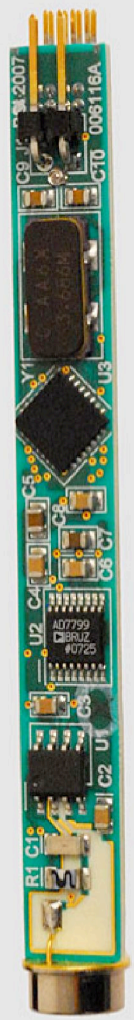
Advances in AOP Sensors for Optically-Complex Waters

The aggregator controls the 19 individual sensors as one sensor and can store the data

Each brass cylinder is an individual sensor

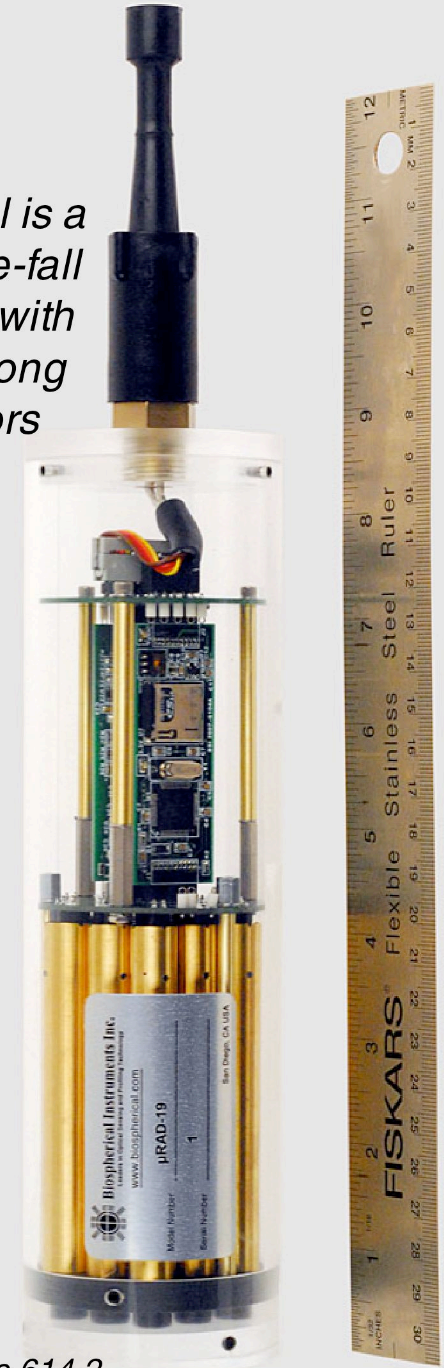


A 19-channel micro-radiometer fits in a 2.5 in (6.4 cm) cylinder—a 29% size reduction over present instruments



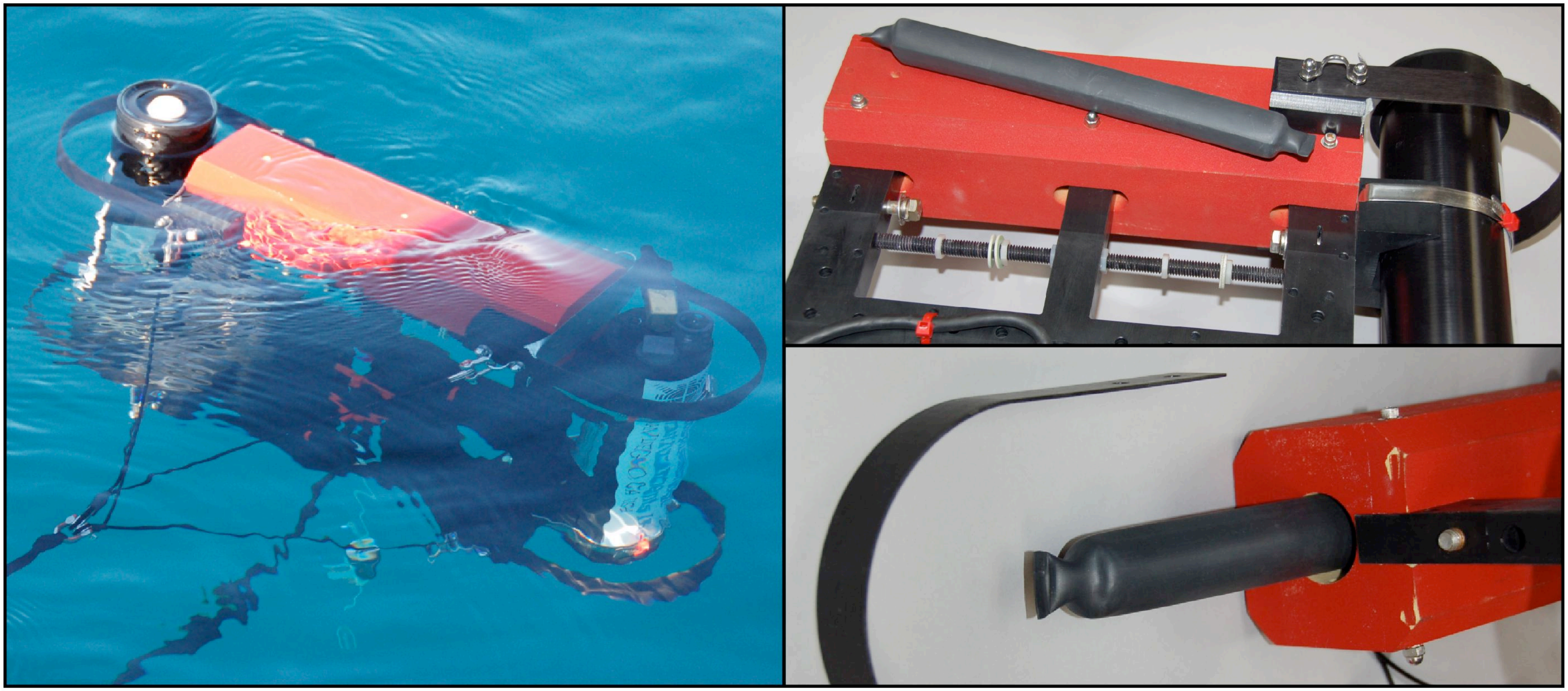
The ICs and the detector set the present size limit

The goal is a new free-fall profiler with 15 cm long sensors



A completely functional (networked) sensor with no fore-optics

Hydrobaric Descent Control of the Compact-Optical Profiling System (C-OPS)

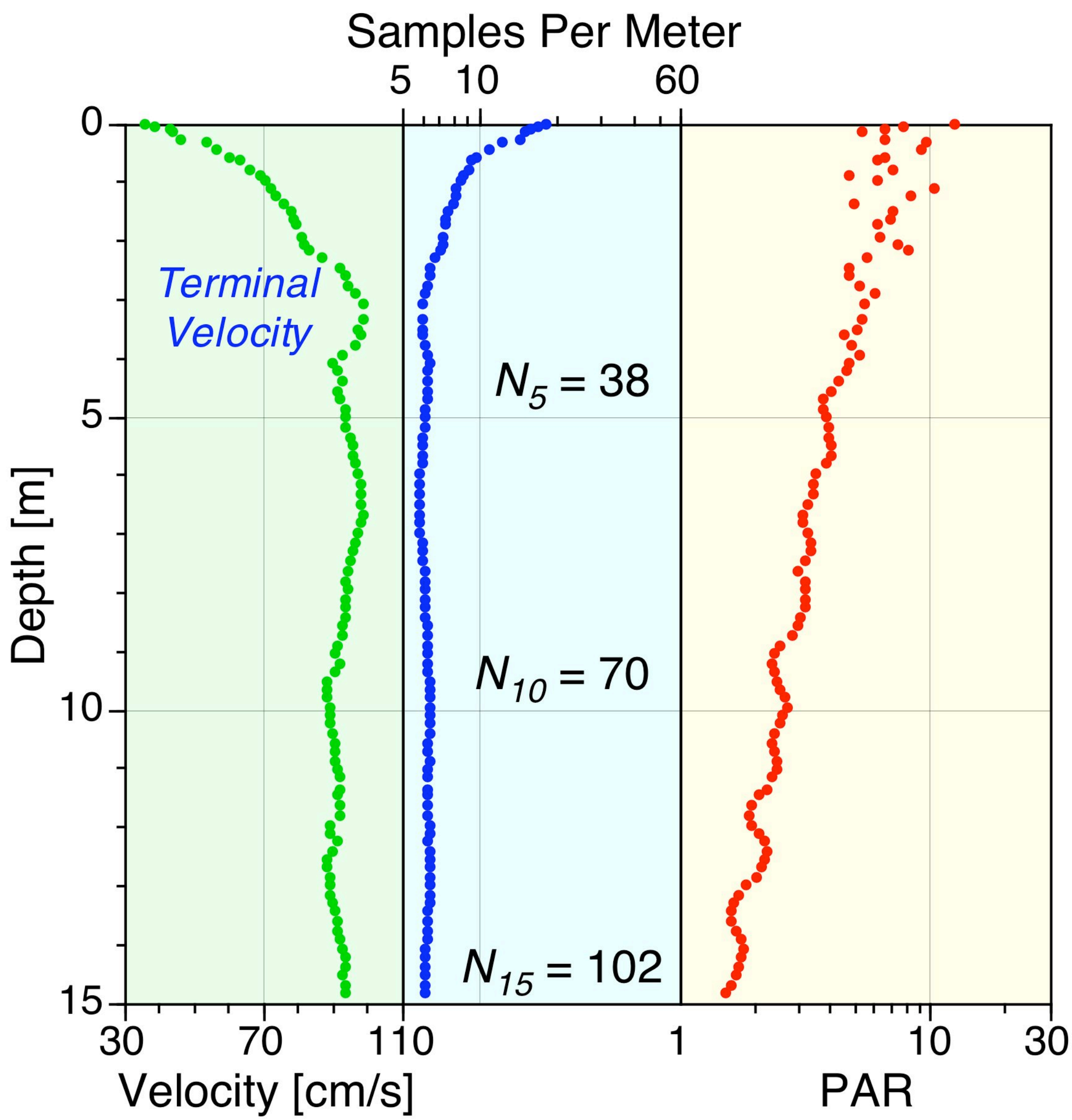


The newest version of SuBOPS uses 19-channel microradiometer sensors. The reduction in weight permits a further improvement in near-surface sampling:

The primary rigid flotation is hollowed out and an elongated bladder filled with air is inserted in the cavity. The volume of the bladder is set so the profiler barely sinks. As the depth increases, the bladder is compressed more and more and the descent rate increases, until it reaches terminal velocity.

Sampling Capabilities of a Legacy Free-Fall Profiler: SeaFALLS (SPMR)

Before investigating the sampling capabilities of C-OPS with the hydrobaric buoyancy system, it is instructive to review the capabilities of a legacy profiler, for example, a SeaFALLS (SPMR) profiler. This rocket-shaped profiler has a high descent rate which yields an average sampling resolution of about 6 samples per meter, and the total number of samples collected at 5, 10, and 15 m depth is N_5 = 38, N_{10} = 70, and N_{15} = 102, respectively. A notable consequence of this low sampling resolution is a significantly aliased sampling of wave-focusing effects during clear-sky conditions.



Sampling Improvements as a Result of the Buoyancy Control Enhancements to C-OPS

The design objective of the hydrobaric buoyancy system for C-OPS is to have a 100 or more samples per meter in the upper 2 m of the water column. The prototype system very nearly satisfies this requirement: *the vertical resolution at 2 m is almost 90 samples per meter, so some small refinement is needed*. The most tangible expression of this improved resolution is the significant improvement in capturing the high frequency perturbations associated with wave-focusing effects. The total number of samples collected at 5, 10, and 15 m depth is N_5 = 519, N_{10} = 829, and N_{15} = 1,138, respectively.