ProVal

A profiling float dedicated to radiometric measurements

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Summary

In-situ high quality measurements of radiometric quantities are mandatory to enable a "system vicarious calibration" (SVC) of satellite sensors dedicated to Ocean Color Radiometry (OCR) as well as to validate their derived products. High density of acquisition is particularly critical during the early stages of an OCR satellite activity. The ProVal float measures downward irradiance and upwelling radiance at seven wavelengths on two arms that allow radiometer redundancy and shading mitigation. We analyzed more than 500 profiles sampled in the Southern Ocean and Mediterranean Sea to date. We find that 45% and 85% of data in the surface layer exhibit tilts lower than 10° in the Southern Ocean and Mediterranean Sea respectively. Floats deployed in the Mediterranean Sea were recovered allowing post-deployment calibrations of radiometers that confirmed the low sensor drift. In addition, platform shading, estimated from the difference between the two radiometers, shows good agreement with Monte-Carlo simulations. Finally, comparisons of Remote Sensing Reflectance with the OLCI sensor (Sentinel-3A) show results in agreement with other sources of in-situ data but with extended coverage capabilities.

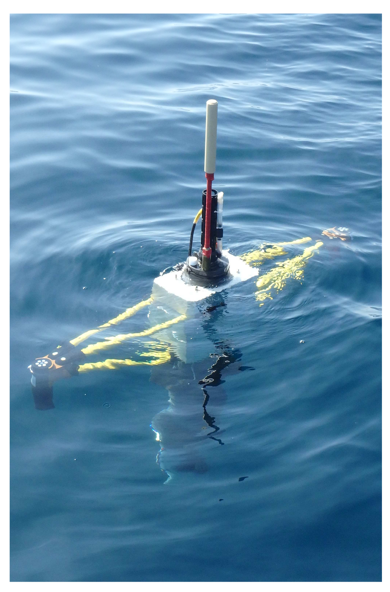
The ProVal float

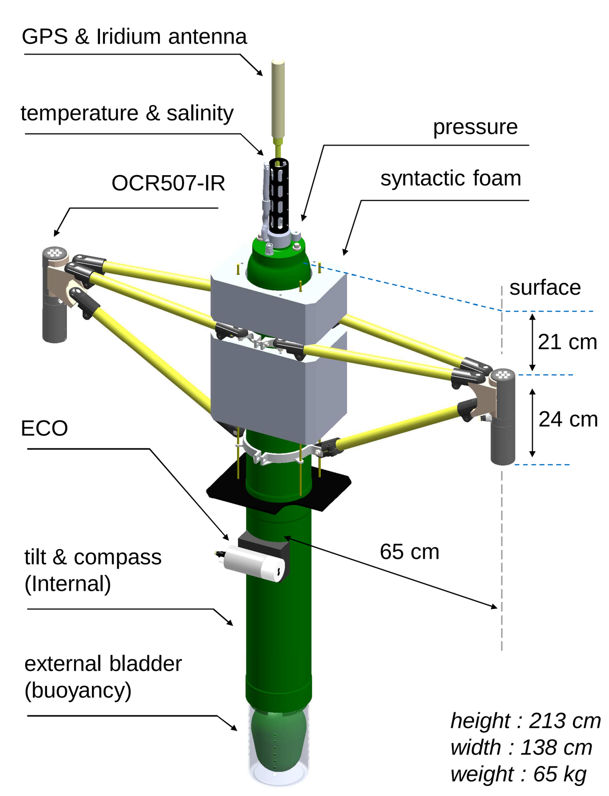
ProVal is a PROVOR CTS5 instrumented with

- ✓ 2 E_d-L_u 7λ (380*, 412*, 443, 490, 510, 560, 665 nm + PAR)
- ✓ Fluorimeter (Chla and CDOM) and backscattering
- ✓ CTD, Compass and tilt

Key features

- ✓ Sensors close to the surface
- ✓ Sensors redundancy
- ✓ Self-shading mitigation

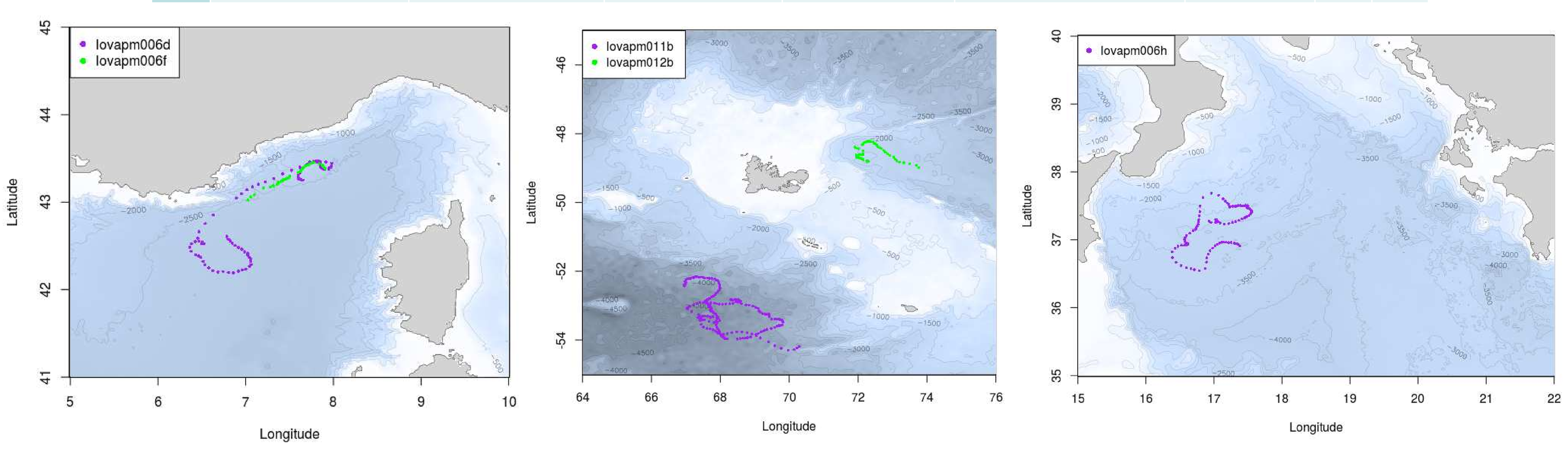




(*) Irradiance measurement @ 380 and 412 nm only on one arms to have PAR on two arms

More than 550 profiles from 5 deployments

	float name	Area	Start Date	End Date	Status	N. Profiles	Lat	Lon
1	lovapm006d	NW Med	08/07/2015	30/08/2015	recovered	53	43	7
2	lovapm012b	E Kerguelen	17/10/2016	01/01/2017	mission completed	68	-49	72
3	lovapm011b	SW Kerguelen	19/10/2016	13/02/2018	mission completed	247	-53	68
4	lovapm006f	NW Med	09/06/2017	21/09/2017	recovered	81	43	7
5	lovapm006h	Ionienne	10/06/2018	-	recovery planned	110	37	17



Navigation performances and data sampling

Fig 1 : ProVal allows more than 800 points over a 300m profile plus 1 min of acquisition at surface.

Fig 2a : percentage of the data point below 5° (solid lines) and 10° (dashed lines) as a function of depth for the Southern Ocean (black) and the Mediterranean Sea (red). Arrows represent values during "buoy" mode.

Fig 2b : median of the tilt within the shallowest 5 m as a function of waves height derived from a meteorological mooring (Mediterranean Sea only, float *lovapm006d*).

Fig 2c : median profile of ascent velocity for the Mediterranean Sea (red) and Southern Ocean (black) floats. Only shallowest 50 m are shown as velocity at depth is stable.

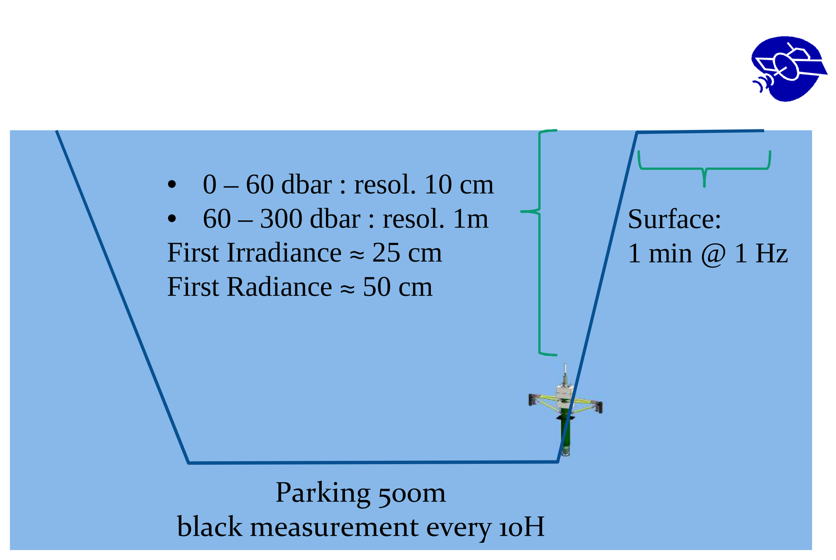


Fig. 1 : data sampling

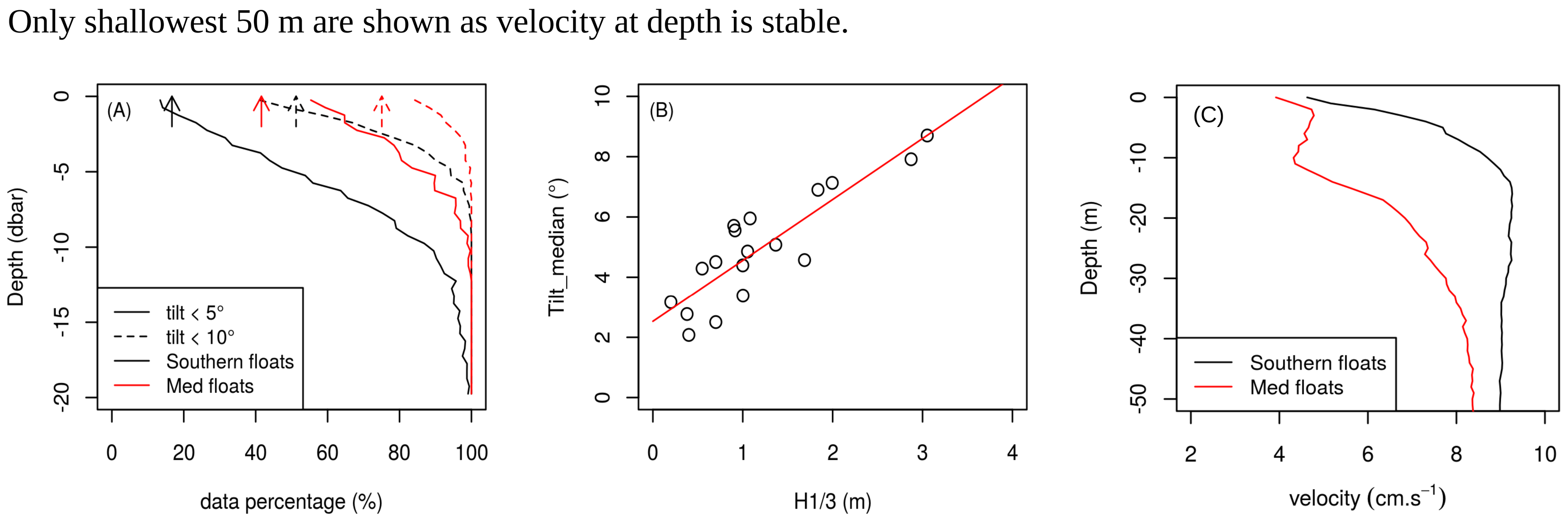


Fig. 2 (a, b, c) : navigation performances

Data processing and results

Basic Data Processing

- ➢ Dark signals are estimated from night profile.
- ➢ Data are filtered for tilt<10° then smoothed and extrapolated to the surface by using a Local Polynomial Regression Fitting.

Rrs Processing

Marine reflectances (Rrs) were derived from E_d and L_u extrapolated to the surface by (Morel1996 [2])

$$R_{rs}(\lambda) = \frac{L_w(\lambda)}{E_S(\lambda)} = 0.523 \frac{L_u(0^-,\lambda)}{E_d(0^-,\lambda)} \ (sr^{-1}).$$

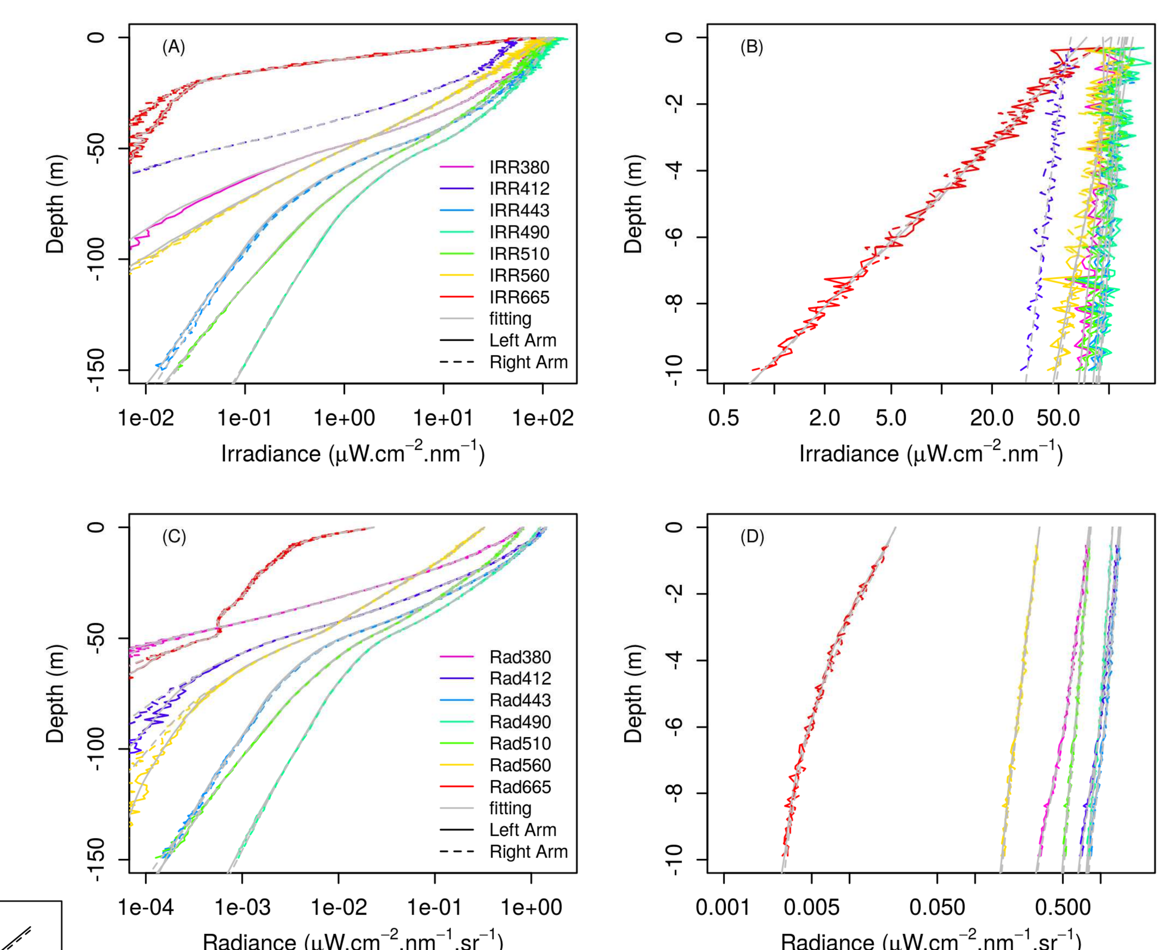
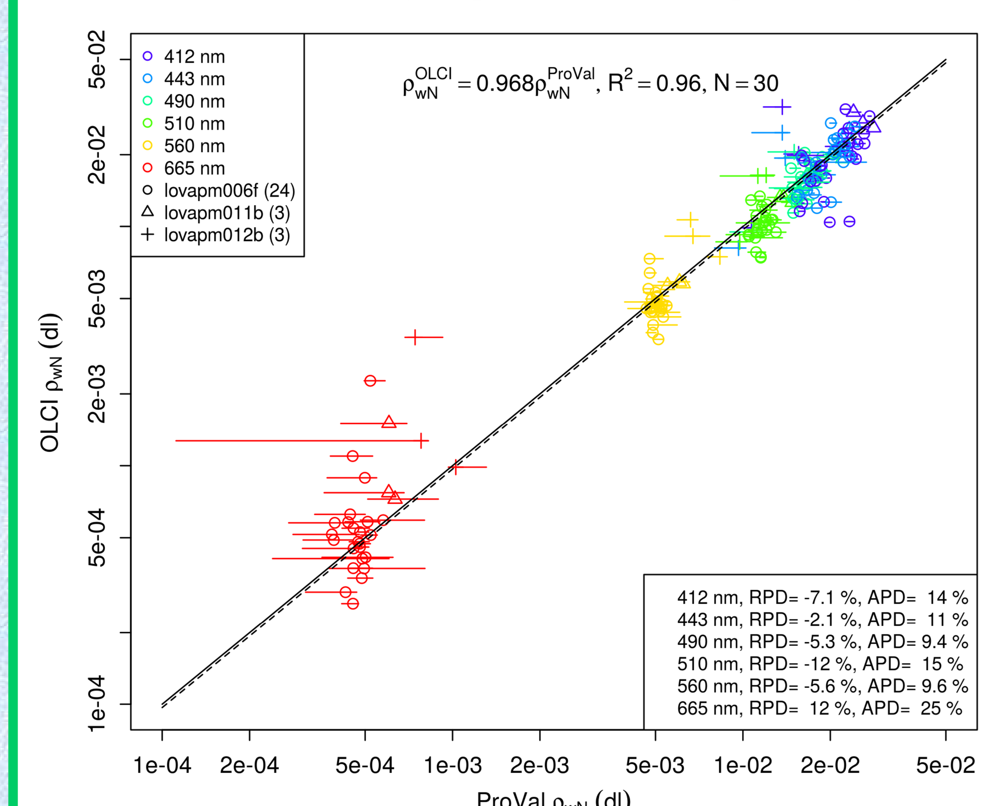


Fig. 4 : Example of data, float lovapm006f (profile 57, 2017−08−02)

Fig 3 : normalized reflectance ρ_{wN} from OLCI and ProVals for both Mediterranean (*lovapm006f*) and Southern Ocean floats (*lovapm011b* and *lovapm012b*).



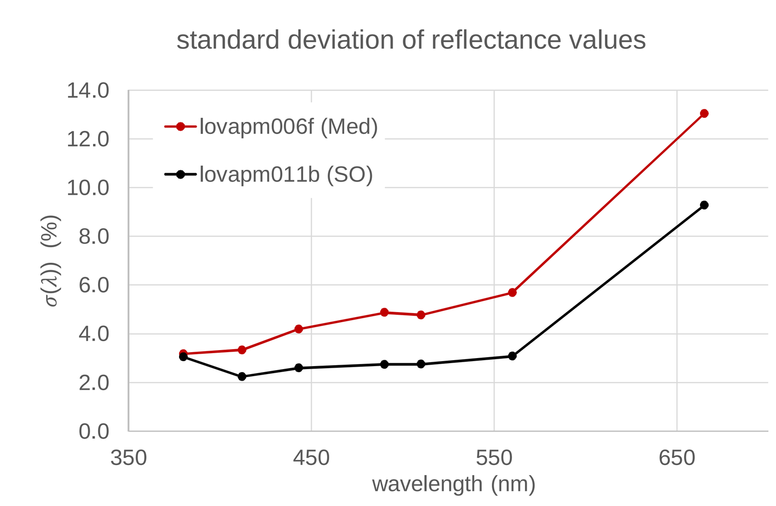


Fig 5 : standard deviation of Rrs normalized values for all profiles of floats *lovapm006f* and *lovapm011b*.

Data quality (shading and sensor drift)

Sensor Unbiased Relative Difference (SURD)

The two arms configuration of the ProVal allows a direct sensor inter-comparison

$$SURD_S(z) = \frac{2 * [S_1(z) - S_2(z)]}{[S_1(z) + S_2(z)]}$$

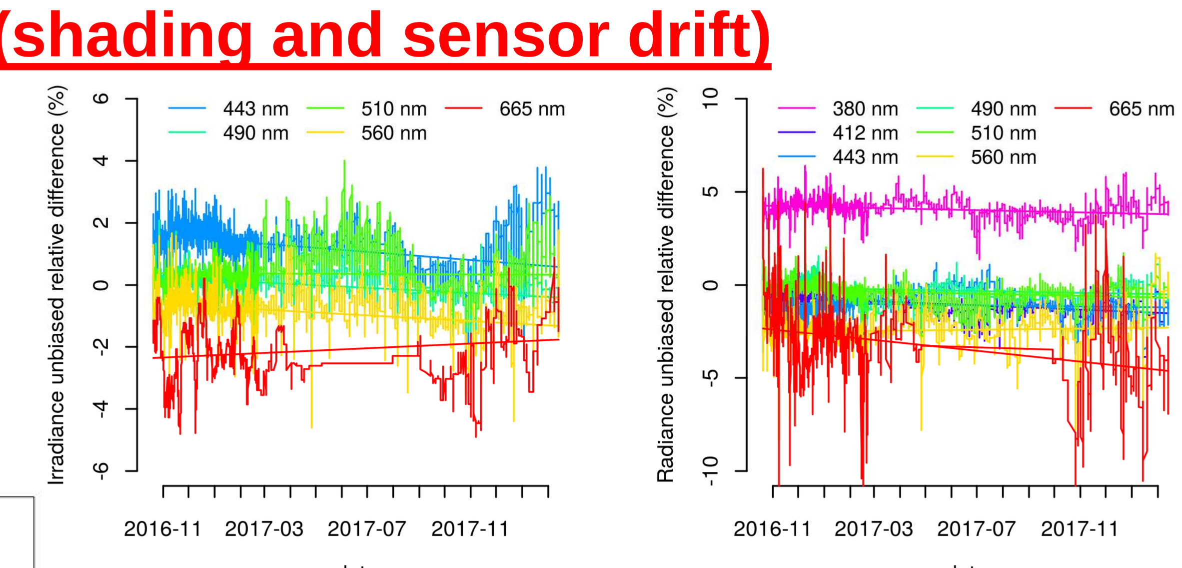


Fig. 6 : sensor relative difference between arms (E_d and L_u, lovapm011b)

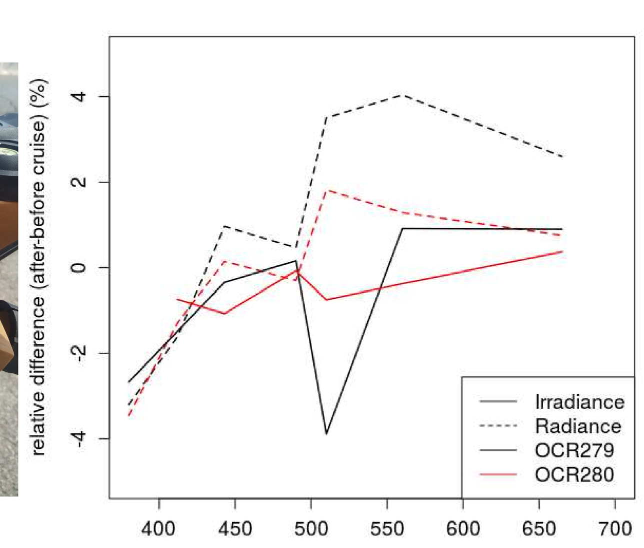


Fig 7 : Sensors were calibrated before and after lovapm006d deployment. Sensor drift after 2 months in the med sea stays reasonable. Pictures of the sensor just after the recovery and without any cleaning.

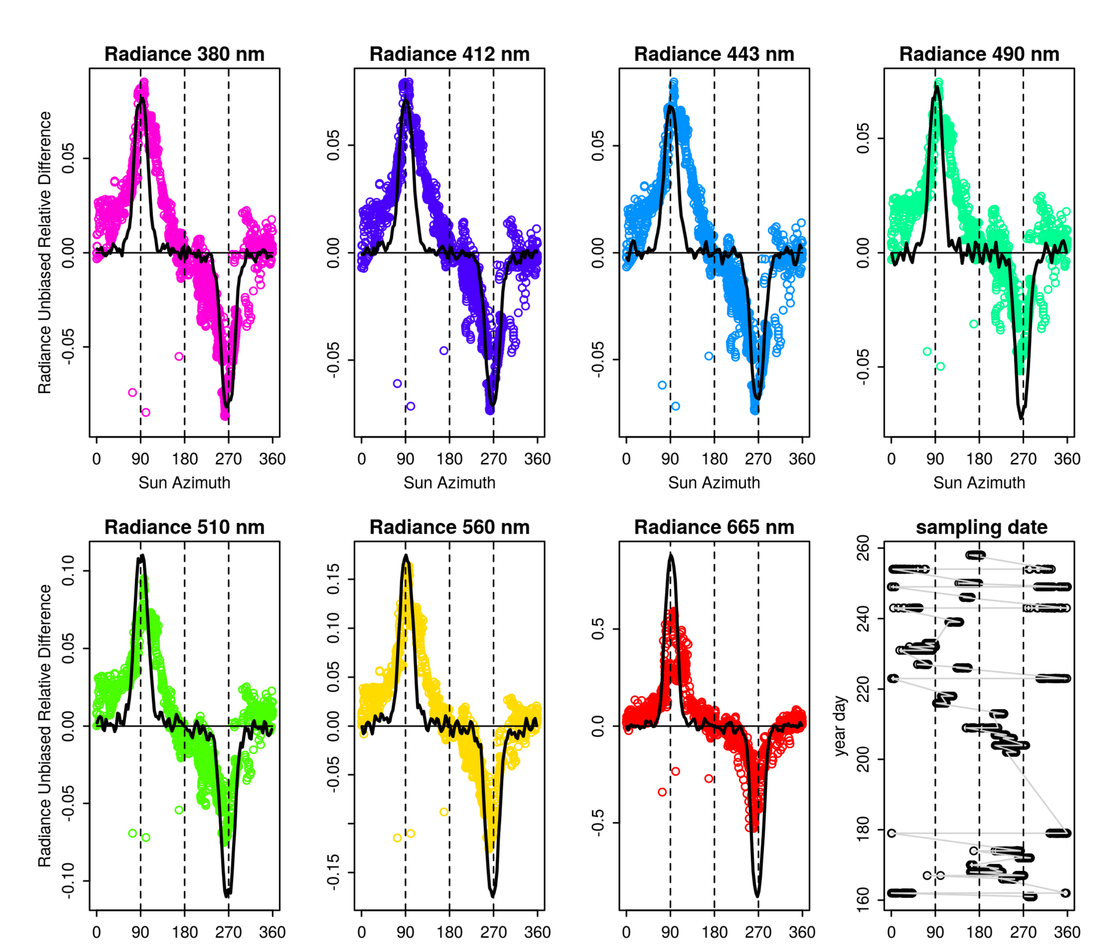


Fig 8 : SURD is computed for the radiance, close to the surface, and plotted in function of the sun's azimuth angle (90° = Sun aligned with one arm). 3D Monte Carlo Simulation of the self shading is also plotted (SimulO [3]). **The two arms configuration of the ProVal allows to have always one arm not affected by shading.**

References:

[1] IOCCG Report Number 11, (2011). Bio-Optical Sensors on Argo Floats. www.ioccg.org/reports/IOCCG_Report11.pdf
[2] Morel, A., and B. Gentili (1996). Diffuse reflectance of oceanic waters. 3. Implication of bidirectionality for the remote-sensing problem. *Applied Optics*, **35**, 4850-4862.
[3] SimulO. http://omtab.obs-vlfr.fr/SimulO/index.htm

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