Update on the BOUSSOLE activities

V. Vellucci, B. Gentili, E. Leymarie, D. Antoine

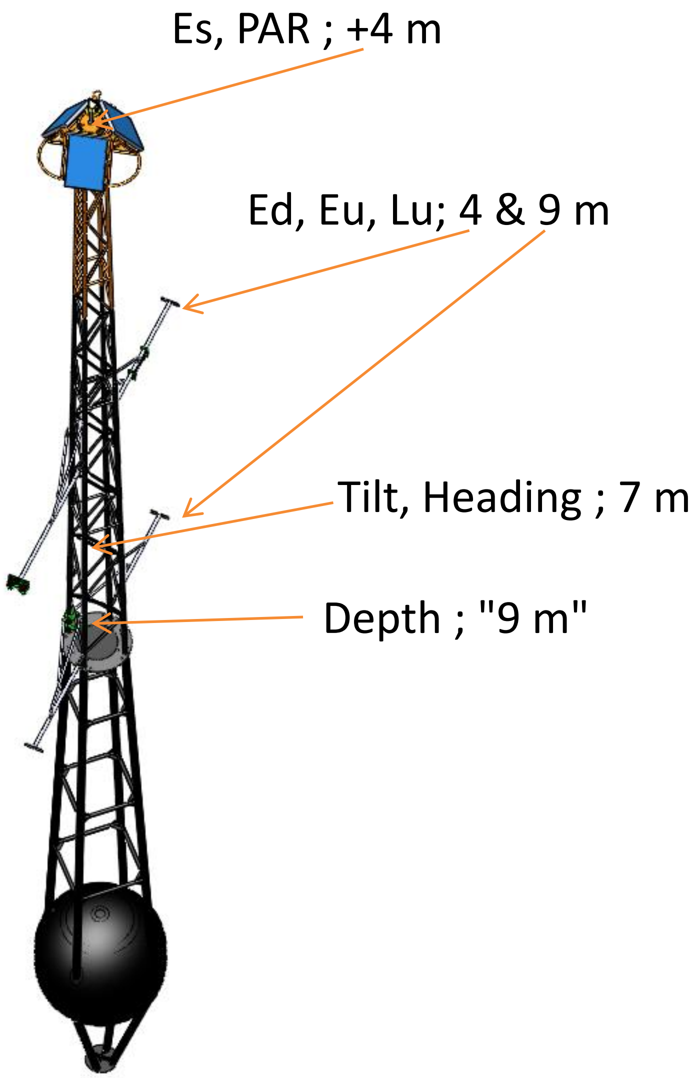
LOV – UPMC/CNRS

September 10th 2014 – MERIS QWG29

Plan of the presentation

- Introduction
- Recent processing improvements
    - tilt above water
    - tilt under water
    - shading
    - impact of corrections
- QA/QC mesures
    - biofouling correction
    - intercalibration post deployment
    - intercalibration before deployment
    - radiometers characterization and calibration budget error
- Future directions

Introduction : AOPs measurements at BOUSSOLE



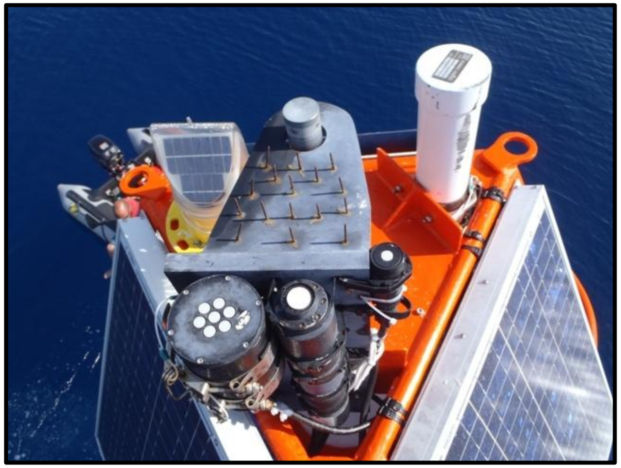
- 1’ records at 6Hz every 15’ Since September 2003.
- Instrument rotation every 6 months.

- Operational objective : provide *in situ* data for vicarious calibration of satellite OC observations and validation of geophysical products → MERMAID.

Introduction : AOPs measurements at BOUSSOLE

- 7 multi-spectral Satlantic OCI-200 series (7 λ VIS ; E_s, E_d, L_u, E_u).
- 5 hyper-spectral Satlantic HyperOCR series (150 λ UV-NIR ; E_s, E_d, L_u).
- 1 Satlantic PAR (400-700 nm ; PAR).





- Diffuse attenuation coefficients: K_d^{09} ; K_{Lu}^{49} ; K_{Eu}^{49}
- Extrapolation to surface : L_w ; $E_u(0^-)$; $E_d(0^-)$
- OC products: $R = E_u(0^-)/E_d(0^-)$; $R_{rs} = L_w/E_s$; $\rho_w = \pi \cdot R_{rs}$

$K_x = -Ln[X(Z_2)-X(Z_1)]/(Z_2-Z_1)$

$X(0^-) = X(Z_1)e^{Z_1 K_x}$; $X(0^-) = coef \cdot X(0^+)$

Introduction : AOPs measurements at BOUSSOLE

Year 2014:

Month	Days with data																														
Jan	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Feb	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28			
Mar	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Apr	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
May	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
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Jul	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
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Year 2013:

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Year 2012:

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May	1	2	3	4	5	--	--	--	--	--	--	--	--	--	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jun	1	2	3	4	5	6	7	8	9	10	11	12	--	--	--	--	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
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Year 2011:

Month	Days with data																														
Jan	--	2	3	--	5	--	--	--	9	--	11	12	13	14	15	--	--	--	19	20	21	22	23	24	25	26	27	28	29	30	31
Feb	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28			
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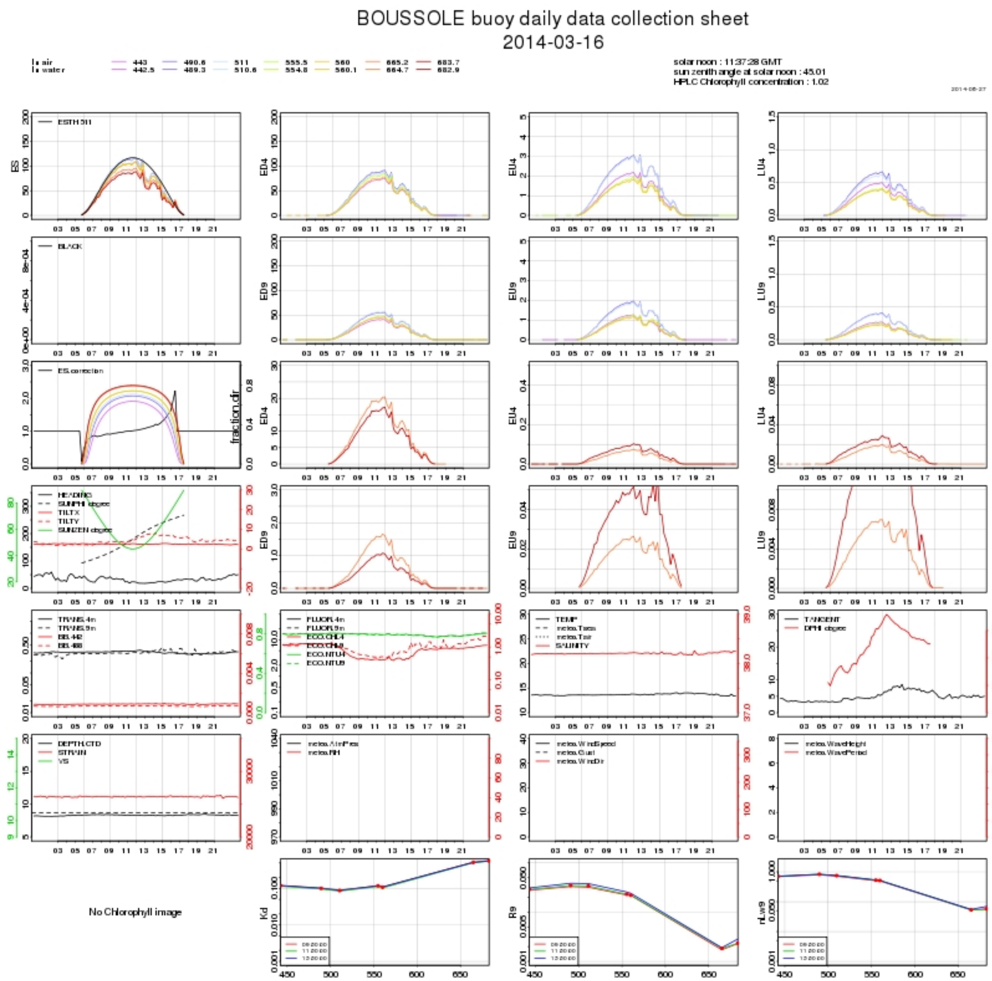

- Success rate of 95 % in the last 4 years.

http://www.obs-vlfr.fr/Boussole/

Plan of the presentation

- Introduction
- Recent processing improvements
    - tilt above water
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    - impact of corrections
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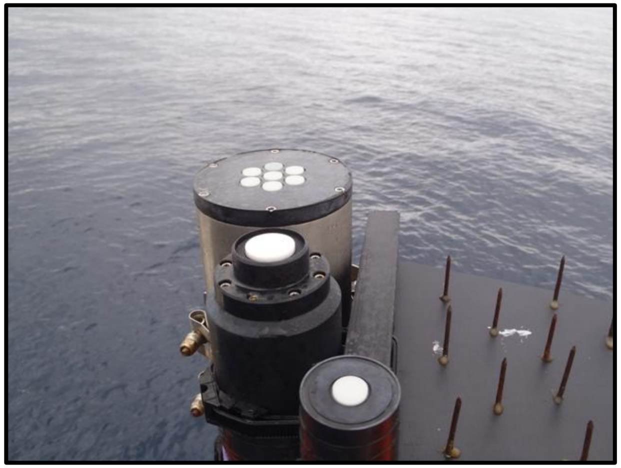
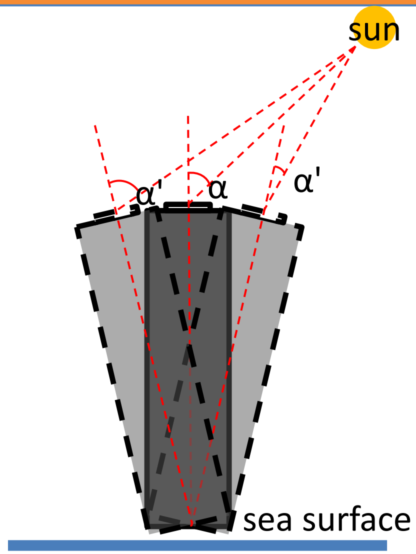
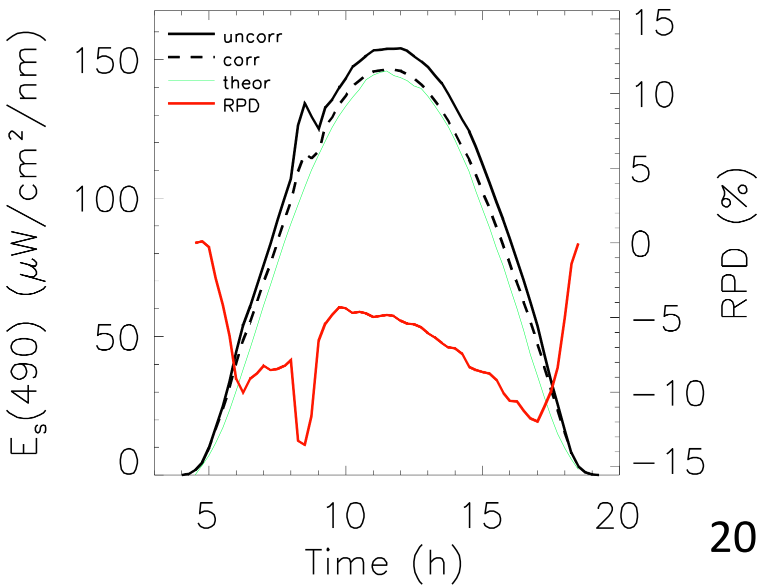
Processing improvement : tilt (cosine) correction for surface irradiance

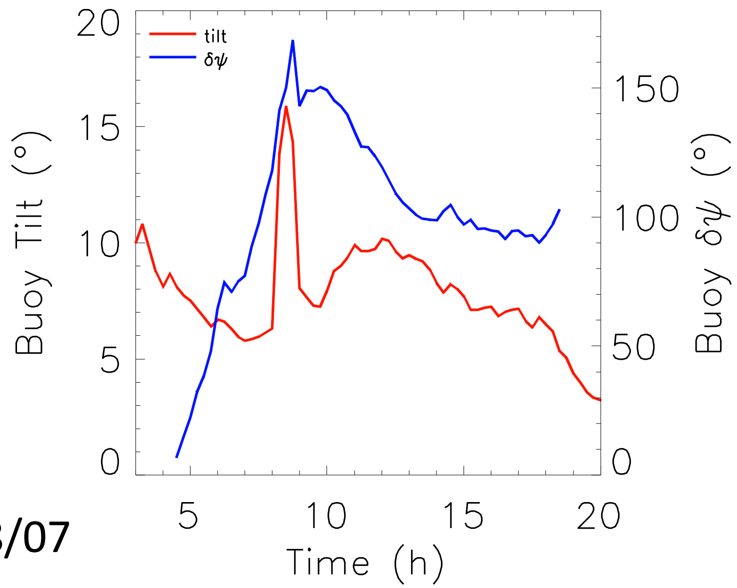
$$E_{s\_corr} = E_{s\_dir} \cos(\alpha')/\cos(\alpha) + E_{s\_dif}$$





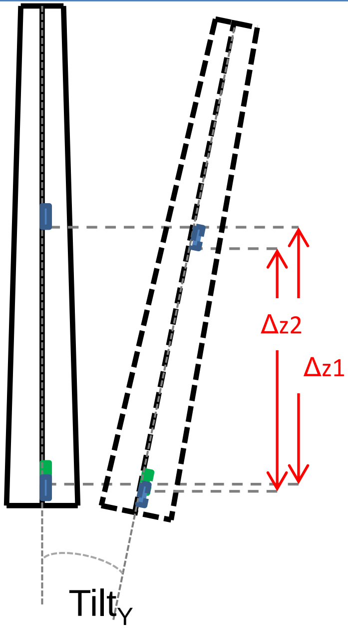


2010/08/07

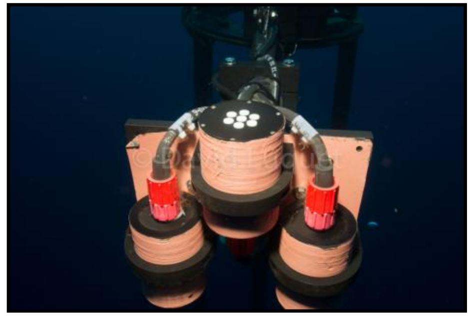


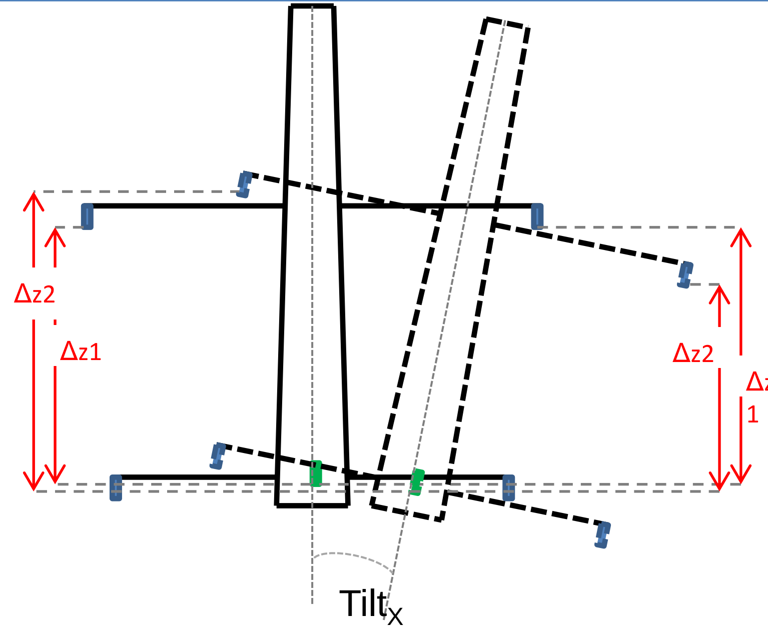
- Corrected E_s better follows the theoretical E_s curve.

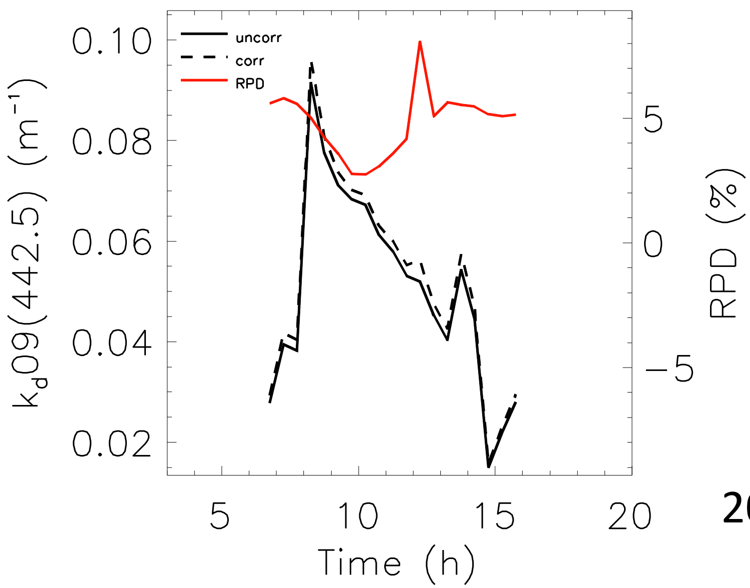
Processing improvement : tilt (depth) correction for underwater radiometry



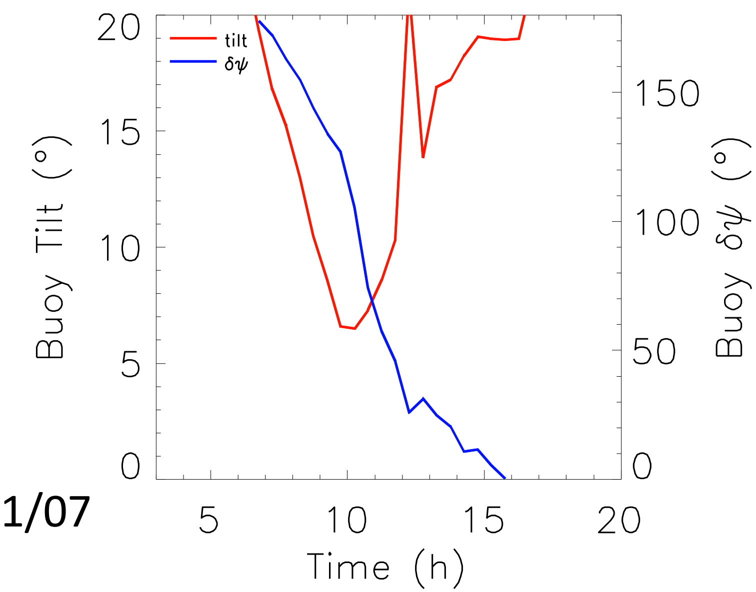
- $K_u = -Ln[E_d(Z_2)-E_d(Z_1)]/(Z_2-Z_1)$
- $E_u(0^-) = E_u(Z_1)e^{Z_1 K_u}$







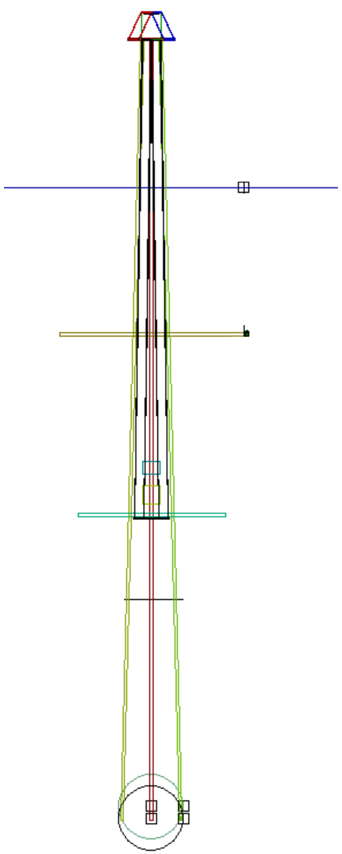
2007/11/07

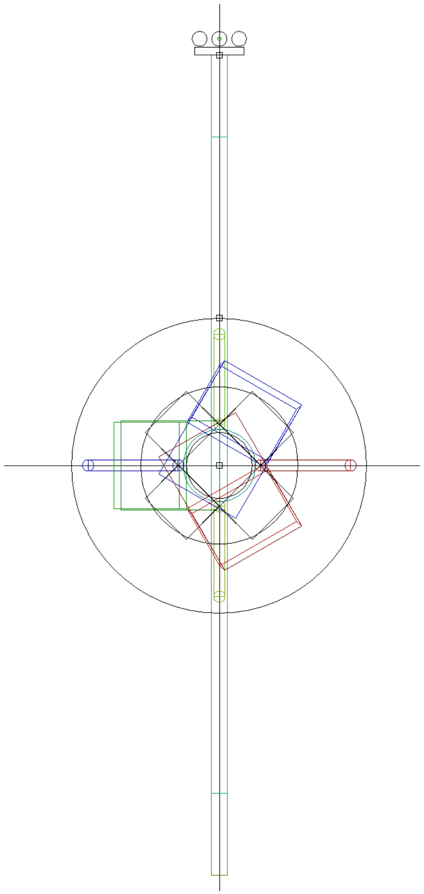


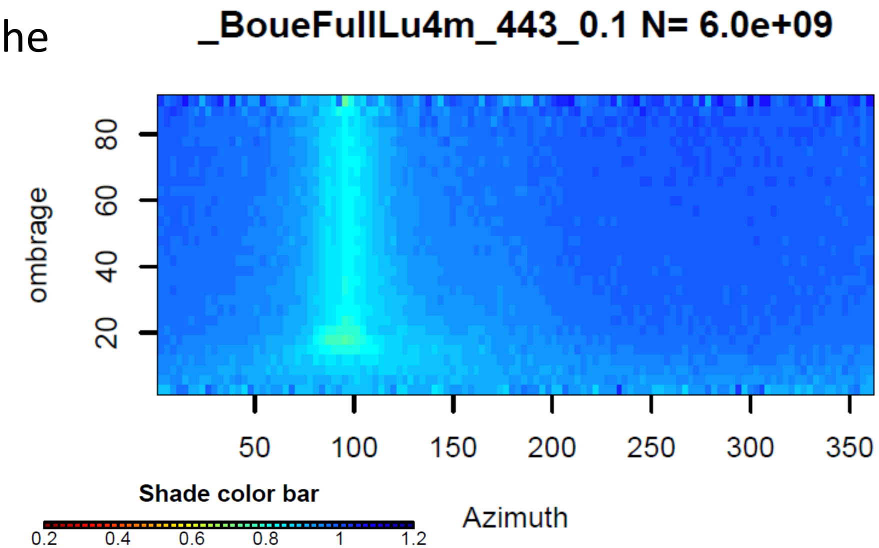
- K_d^{09} increases coherently with decreasing Δz and follows the Tilt variation.

Processing improvement : buoy structure shading and self-shading of radiometers

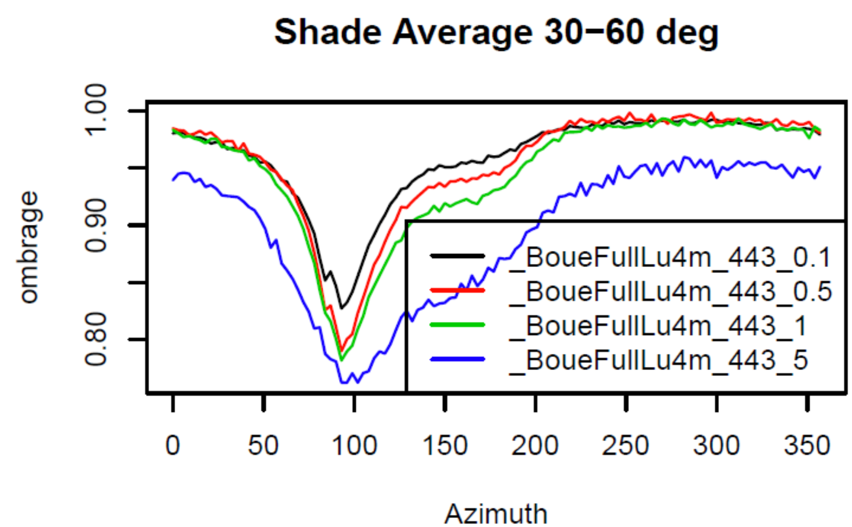
- Backward 3D *Montecarlo* simulation replaces the Gordon & Ding (1992) correction scheme.
- Chl = 0.1, 0.5, 1.0, 5.0 µg l^{-1}.
- Azimuth angle from 0° to 360°, with 5° step.
- Zenith angle from 0° to 90°, with 5° step.
- 7 wavelengths (412, 443, 490, 510, 555, 670).





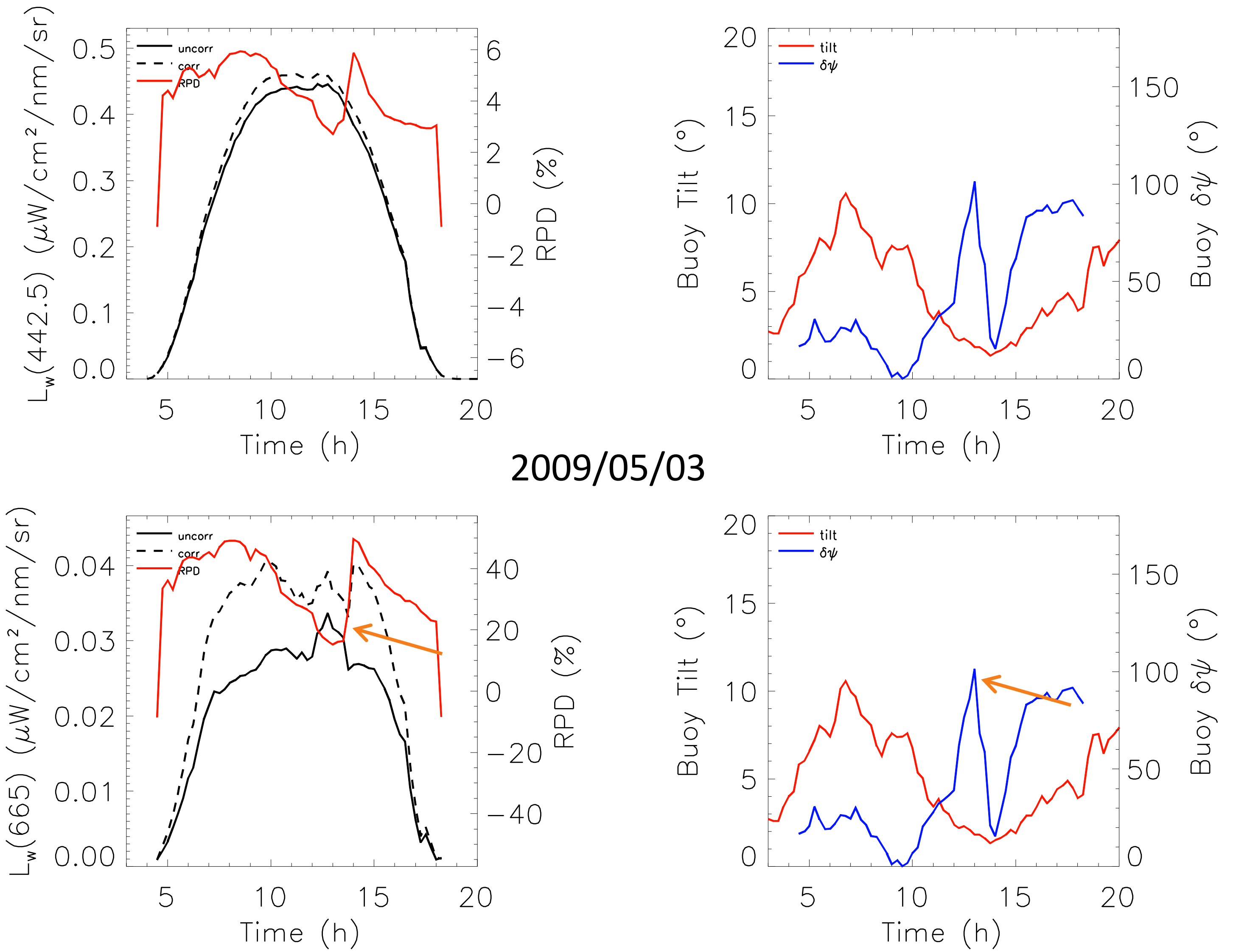


Shading coefficient matrix for L_u 4m, Chl = 0.1 µg/l



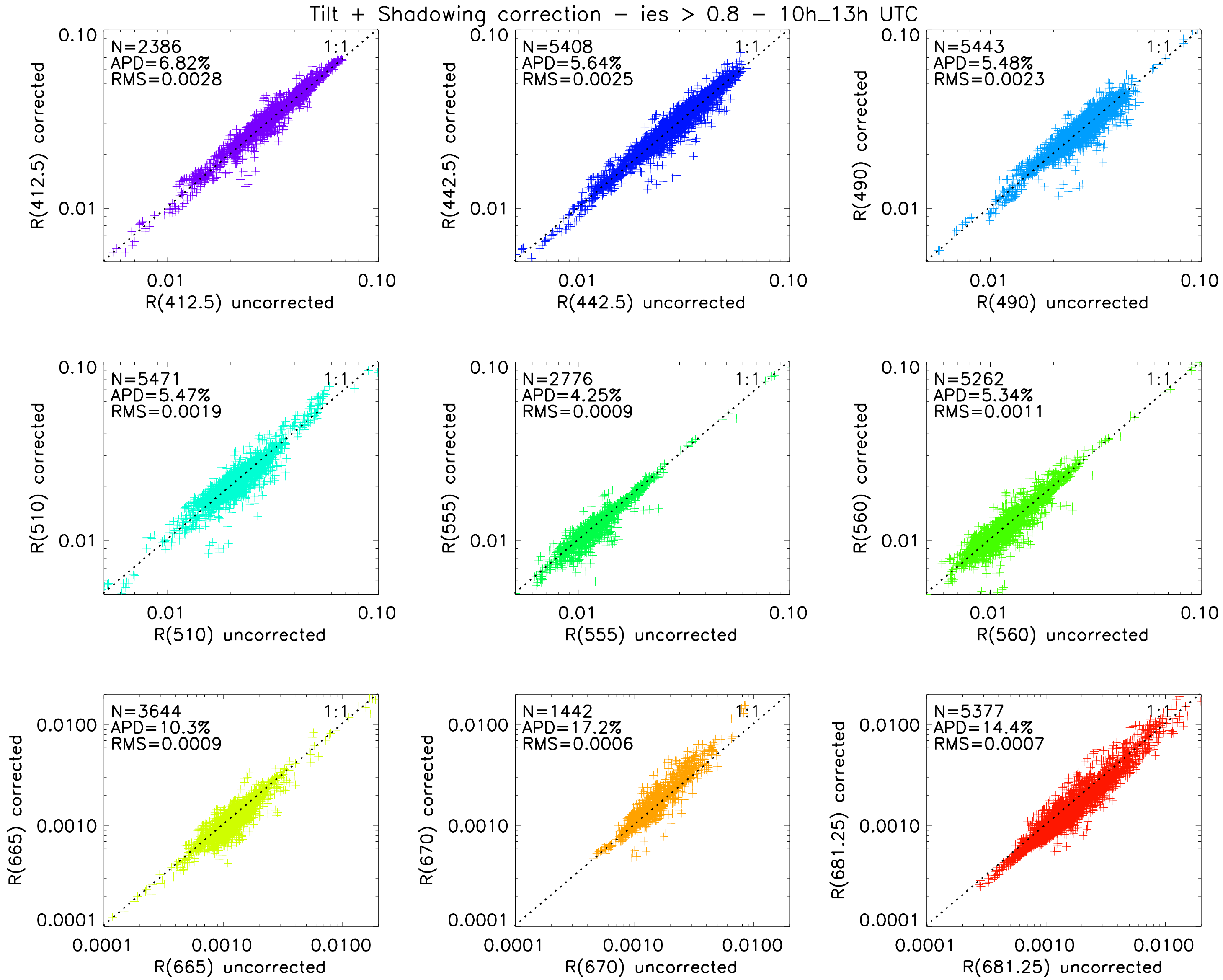
Mean shading coefficient for L_u 4m at various Chl concentrations.

Processing improvement : buoy structure shading and self-shading of radiometers



• L_w shading correction is more important in the Red than in the Blue and well reflects the variations of the azimuth angle.

Processing improvements : combined tilt and shading corrections



- The historical data set has been reprocessed with tilt + shading correction.
- For R the impact of corrections is of the order of 5 % in the Blue/Green and 15 % in the Red.

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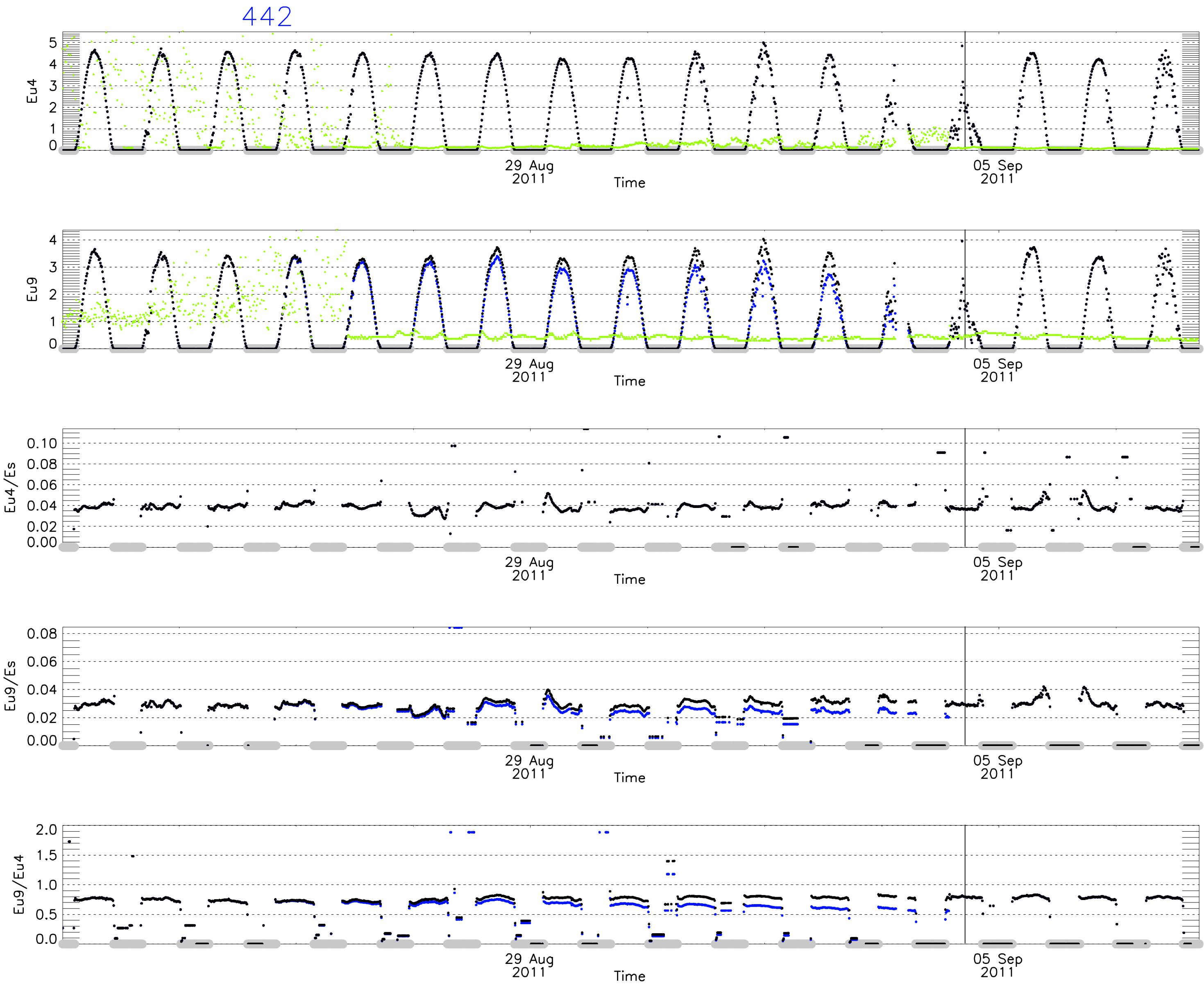
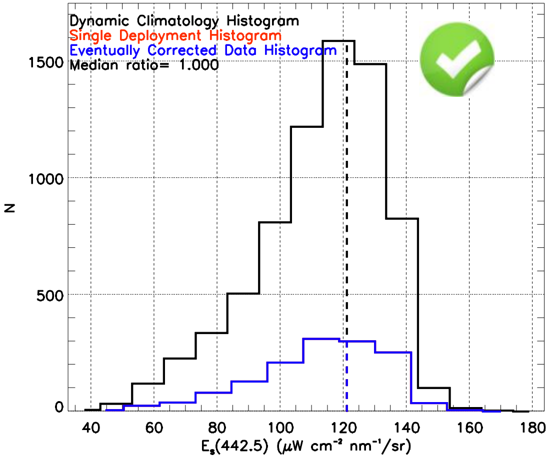
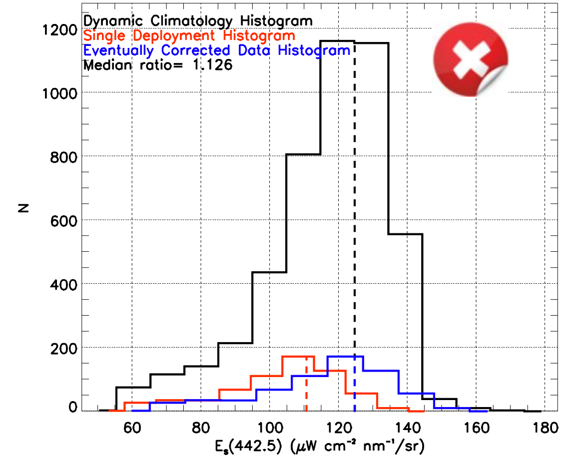
QA/QC : biofouling corrections

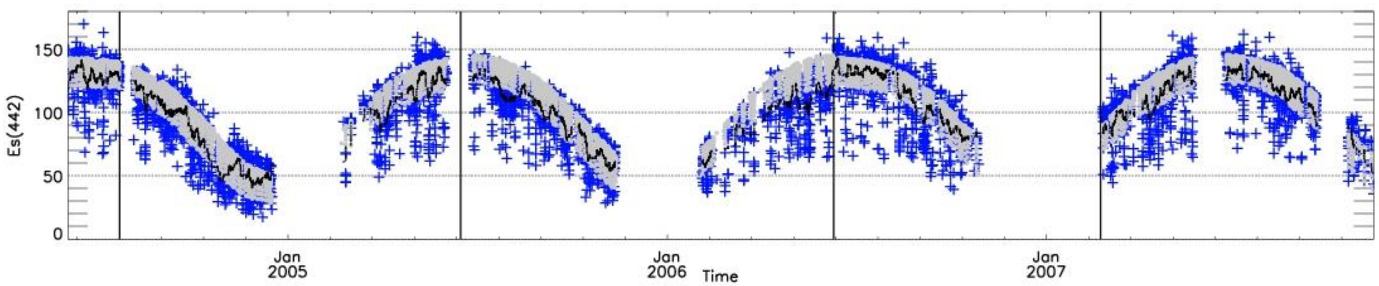


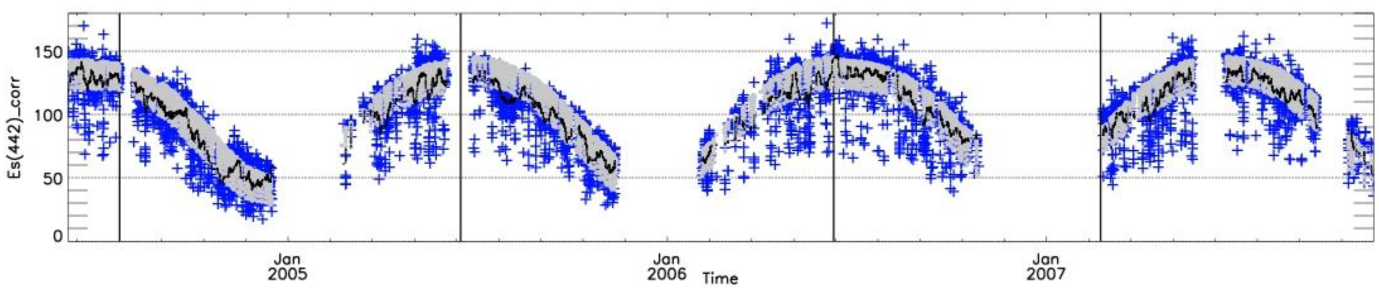
- Biofouling corrections are subjectively determined relying on objective criteria.
- Reanalysis of the entire dataset (only multi).

QA/QC : intercalibration post deployment



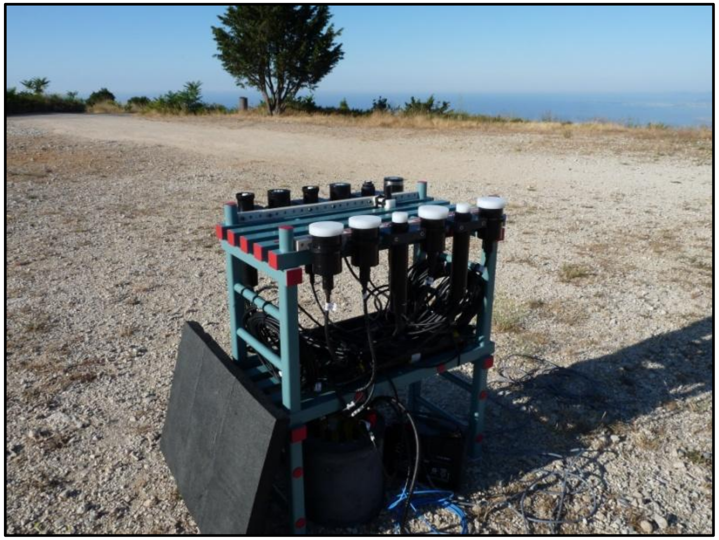






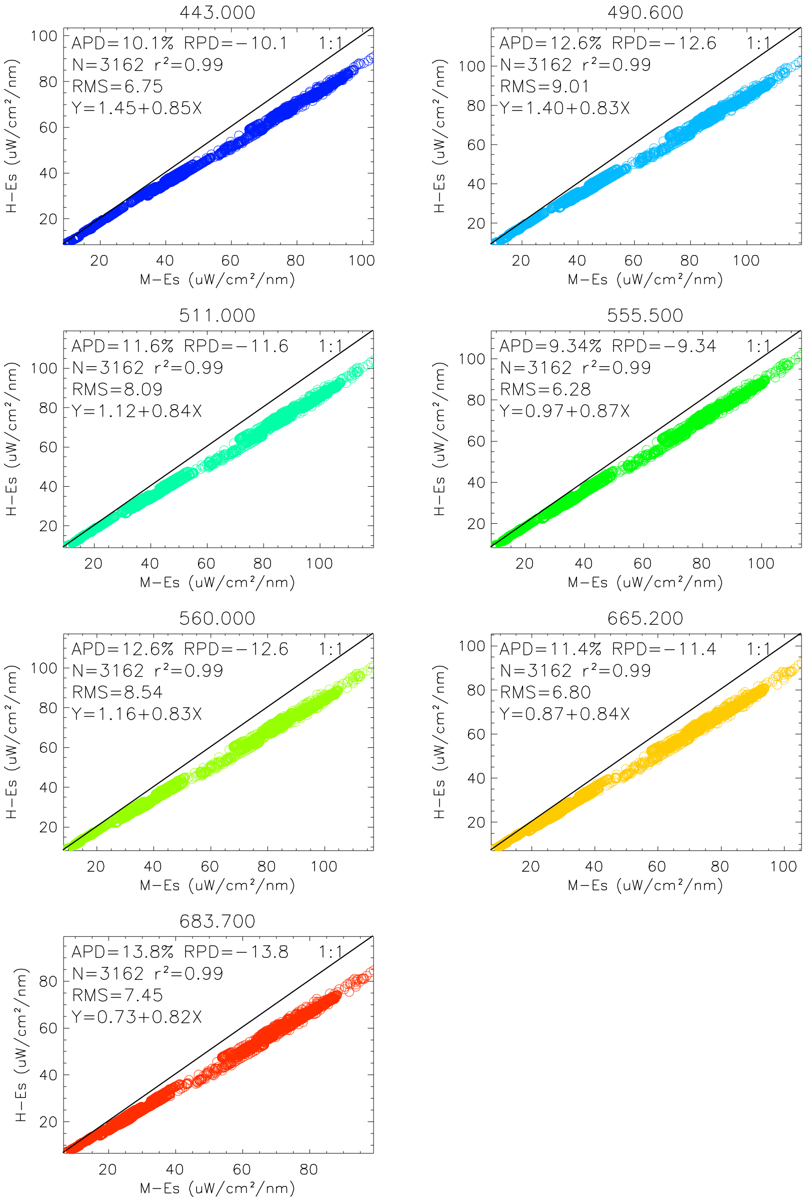
- Establishment of a climatology of “good” radiometric measurements.
- Reanalysis of the entire dataset (only multi).
- Correction of “wrong” series based on the climatology (previously discarded).

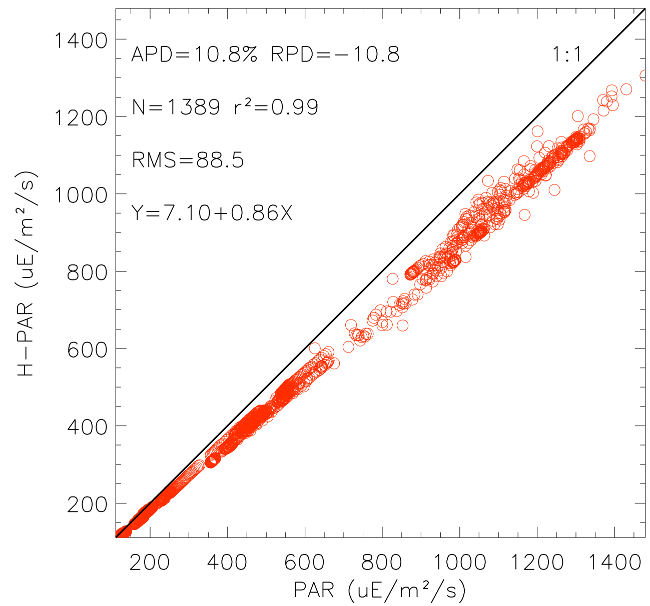
QA/QC : intercalibration before deployment (since 2011)



- A fine example.

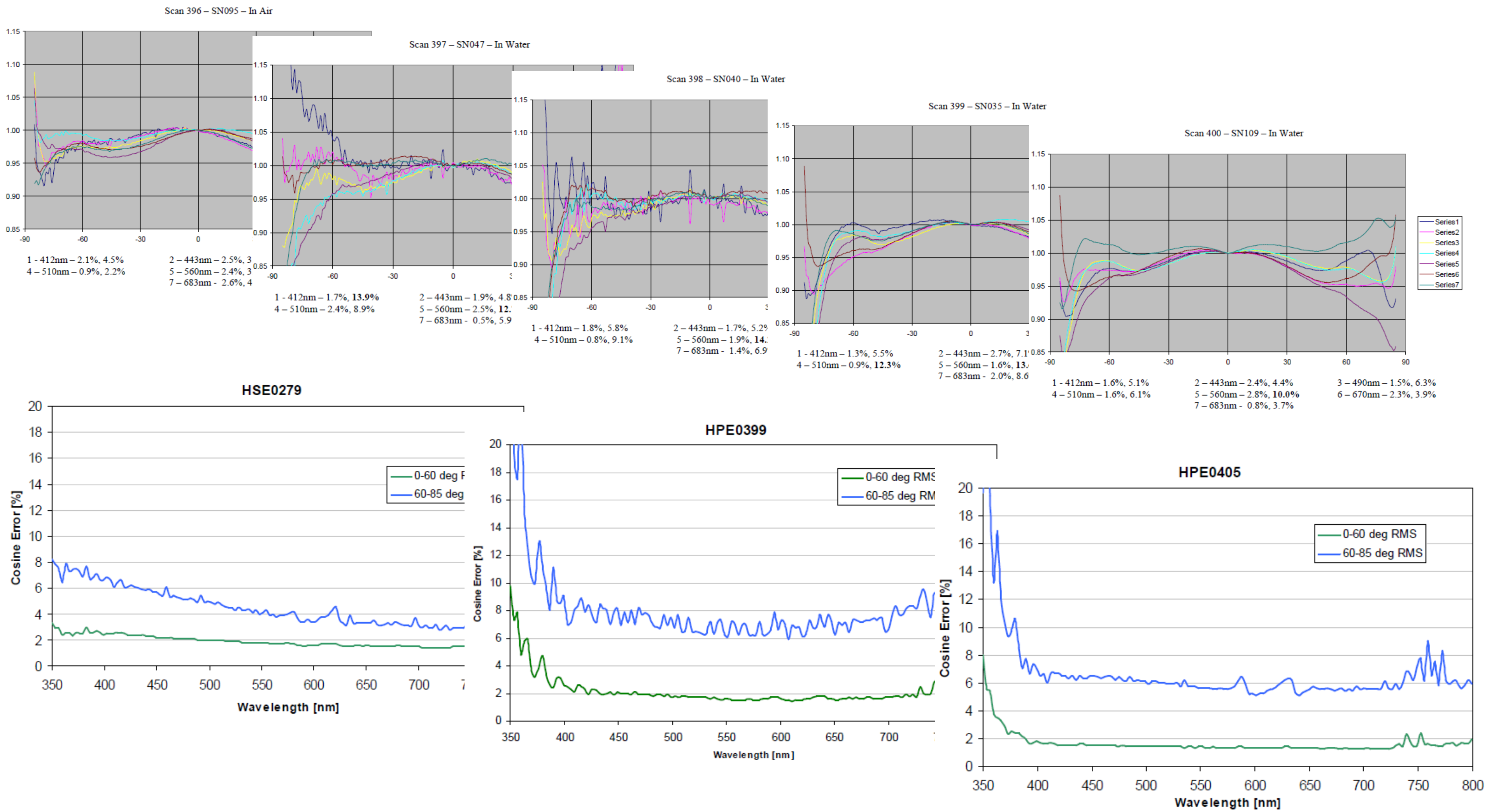
QA/QC : intercalibration before deployment





- A bad example.
- Instrument sent back to factory for verification : collector replacement and recalibration.

QA/QC : cosine response scan



- In this example, few λ out of specs and needed components replacement.
- Regular verifications of cosine response : tentative.

QA/QC : radiometers characterization and calibration budget error (by NPL)

- WP4 of QA4EO : Development of Action Plan and Future Operational Cal/Val Strategy (ESA).

Table V: List of the tests performed at NPL

			Operations performed at NPL					
Inst. Type	**Product**	**Nominal depth**	**Cosine response**	**Linearity**	**Multi-centre calibration**	**Single-centre absolute calibration**	**Stray-light**	**Temperature dependence**
OCI-200	Es	0+		■	■	■		■
OCI-200	Ed	4			■	■		
OCI-200	Eu	4				■		
OCR-200	Lu	4		■		■		
OCI-200	Ed	9			■	■		
OCI-200	Eu	9				■		
OCR-200	Lu	9				■		
HOCR-ICSA	Es	0+	■	■		■	■	■
HOCR-ICSW	Ed	4				■	■	
HOCR-R08W	Lu	4		■		■	■	
HOCR-ICSW	Ed	9				■	■	
HOCR-R08W	Lu	9				■	■	
PAR	PAR	0+				■		■

In July 2013 two additional hyperspectral radiometers were sent to NPL (*hyper 422* and *hyper 277*) for additional tests such as stability, detector linearity and stray light.

- Uncertainty budget of radiometers absolute calibration (< 2%).
- Characterization of 1 set of buoy radiometers.
- Work to be continued :
    - to extend the uncertainty budget to the *in situ* and processing levels;
    - to characterize the 2^{nd} set of radiometers.

Future directions

- Improve the long-term operational traceability of the BOUSSOLE radiometers.
- Establish a revised uncertainty budget.
- Provide Flags associated to final products.
- Definitive transition to Hyperspectral radiometers.
- Intercalibration campaign with MOBY.
- Improve the buoy capabilities by:
    1. adding 2 Lu at 1m depth

    and/or

    2. establish a set of reference radiometer to inter-calibrate the two sets of radiometers.

Thank you for attention

enzo@obs-vlfr.fr