Update on the BOUSSOLE activities

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Plan of the presentation

• Introduction
• Recent processing improvements
  • tilt above water
  • tilt under water
  • shading
  • impact of corrections
• QA/QC measures
  • 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:
\[R = E_u(0^-)/E_d(0^-); R_{rs} = L_w/E_s; \rho_w = \pi \cdot R_{rs}\]

\[K_x = -\ln[X(Z_2)-X(Z_1)]/(Z_2-Z_1)\]
\[X(0^-) = X(Z_1)e^{Z_1K_x}; X(0^+) = \text{coef}\cdot X(0^+)\]
Introduction: AOPs measurements at BOUSSOLE

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

http://www.obs-vlfr.fr/Boussole/
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• Summary
• Future directions
Processing improvement: tilt (cosine) correction for surface irradiance

\[ E_{s\_corr} = \frac{E_{s\_dir} \cos(\alpha')}{\cos(\alpha)} + E_{s\_dif} \]

Corrected \( E_s \) better follows the theoretical \( E_s \) curve.

- Corrected \( E_s \) better follows the theoretical \( E_s \) curve.
Processing improvement: tilt (depth) correction for underwater radiometry

- $K_u = -\ln[E_d(Z_2) - E_d(Z_1)]/(Z_2 - Z_1)$
- $E_u(0^\circ) = E_u(Z_1)e^{Z_1K_u}$

$K_d^{09}$ increases coherently with decreasing $\Delta z$ and follows the Tilt variation.
• 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).
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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• Future directions
• Biofouling corrections are subjectively determined relying on objective criteria.
• Reanalysis of the entire dataset (only multi).
• 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.
• In this example, few $\lambda$ out of specs and needed components replacement.
• Regular verifications of cosine response: tentative.
QA/QC : radiometers characterization and calibration budget error (by NPL)


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<th>Inst. Type</th>
<th>Product</th>
<th>Nominal depth</th>
<th>Cosine response</th>
<th>Linearity</th>
<th>Multi-centre calibration</th>
<th>Single-centre absolute calibration</th>
<th>Stray-light</th>
<th>Temperature dependence</th>
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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\textsuperscript{nd} set of radiometers.
• 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