

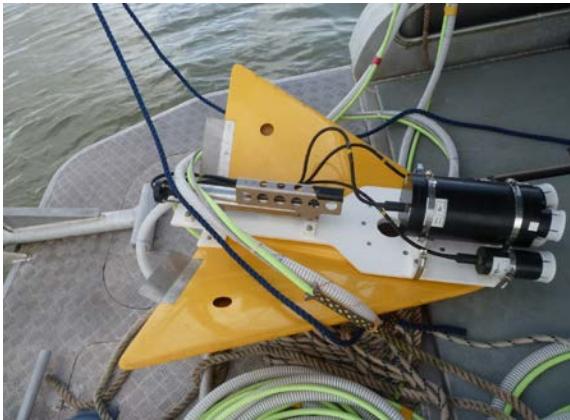


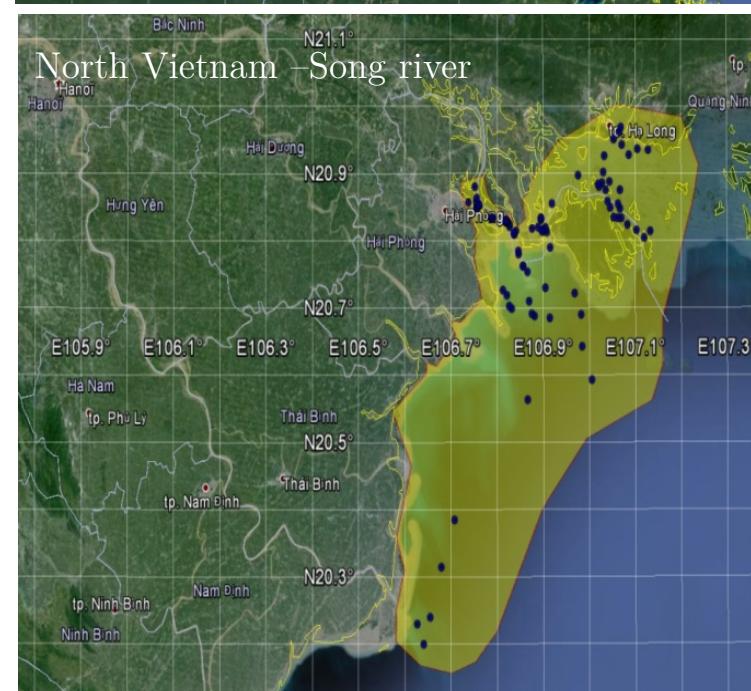
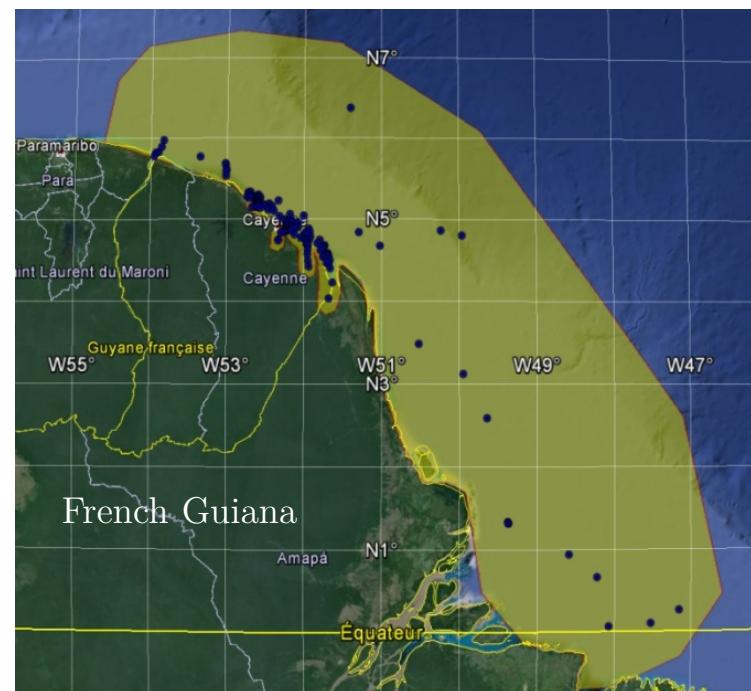
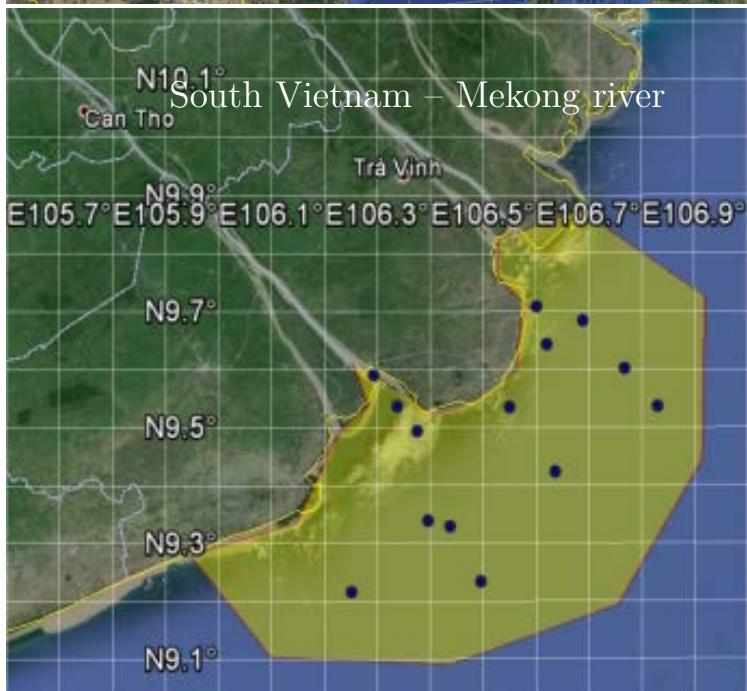
Evaluation and improvements of MERIS, OLCI and SLSTR Rrs in contrasted turbid waters

Jamet, C., H., Loisel, M.A. Mograne, D., Dessailly, X., Mériaux and A., Cauvin
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*Validation Copernicus Sentinel data using FRM
21st June 2017
Plymouth, UK*







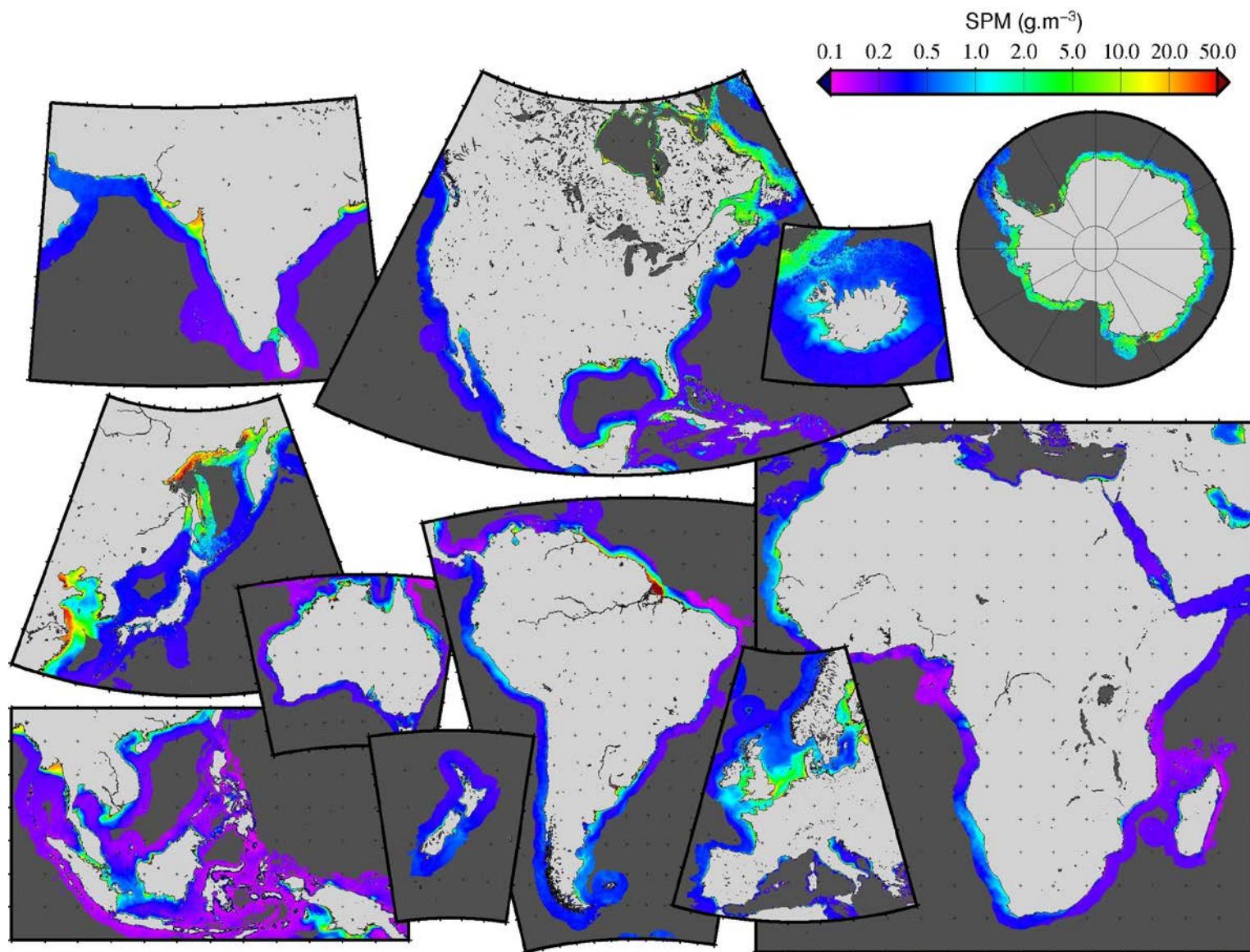
Location of the in-situ datasets from the LOG partner: a) West European coastal waters; b) French Guiana, c) South Vietnam –Mekong river; d) North Vietnam – Song river

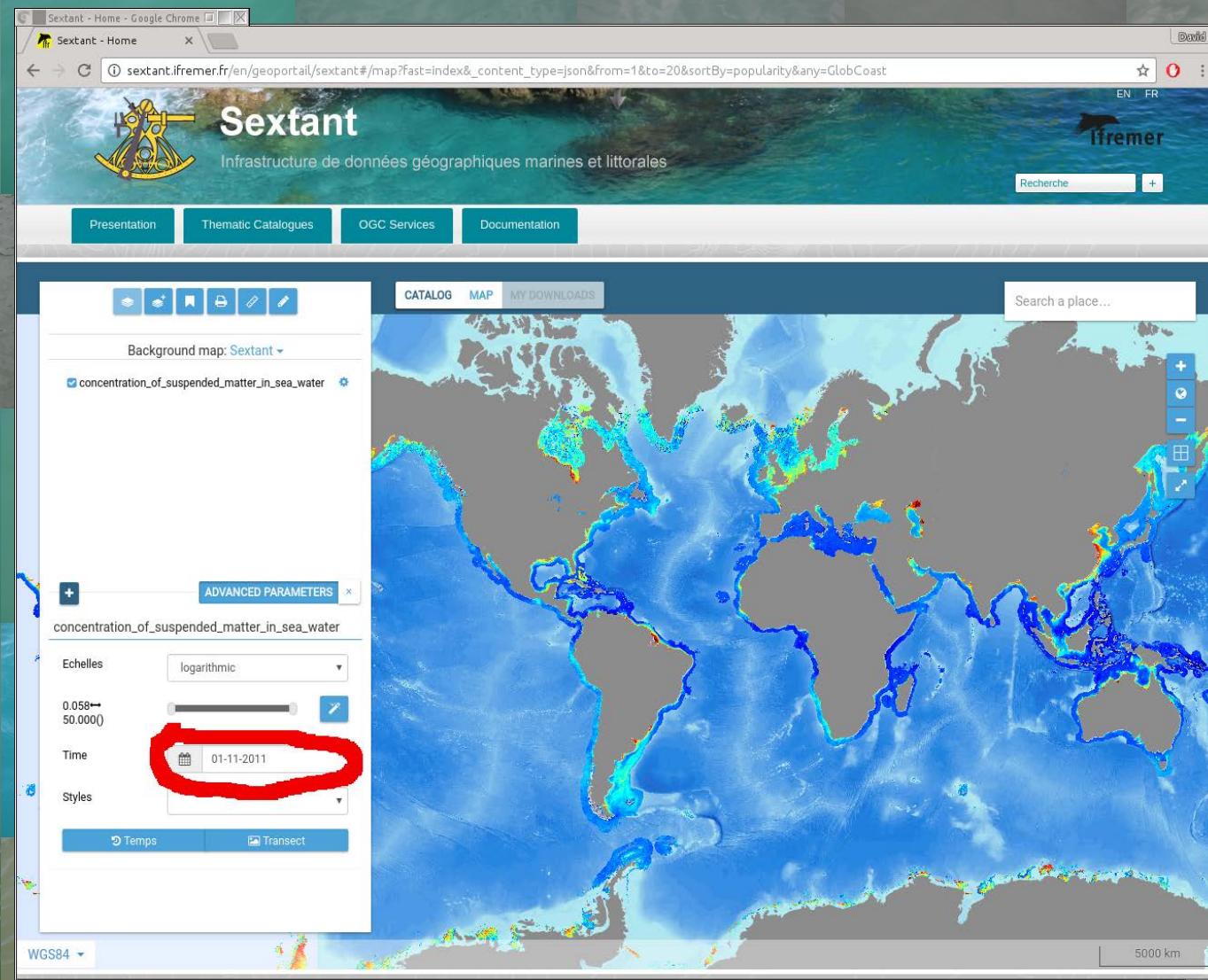
Activities on MERIS

- Validation of atmospheric correction and bio-optical algorithms (Loisel et al., 2017)
- Improvement of atmospheric correction over coastal waters → Coastal version of POLYMER
- Development of new products:
 - IOPs (Loisel et al., in prep)
 - Total Suspended Matter (Han et al., 2015)
 - Spectral diffuse attenuation coefficient (Jamet et al., 2012)
 - Dissolved Organic Carbon (Vantrepotte et al., 2015)
 - Colored Dissolved Organic Matter (Loisel et al., 2014)

A global climatology has then been developed using the 10 years of the MERIS data.

March





Data available at:
<http://sextant.ifremer.fr>

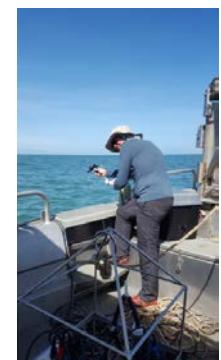
Validation and improvement of OLCI/S3 L2 Rrs products

- In-situ measurements:

- French Guiana: Rrs, IOPs, biogeochemical parameters. Bi-annual 5-day cruise
- Eastern English Channel: same parameters. Bi-monthly one-day cruise

- Use of new spectroradiometer:

- ASD FieldSpec 4
- Hyperspectral measurements in [350; 2500]



DATE	LATITUDE	LONGITUDE
01/04/2016	50°44N	1°31.6E
19/04/2016	50°44N	1°29.6E
03/05/2016	50°44N	1°29.6E
26/05/2016	50°44N	1°29.6E
20/06/2016	5°N	52°W
21/06/2016	5°N	52°W
22/06/2016	5°03N	52°06W
22/06/2016	4°56N	52°11W
23/06/2016	5°01N	52°06W
24/06/2016	4°53N	52°12W
14/09/2016	50°44N	1°26.5E
21/09/2016	50°44N	1°28E
11/10/2016	50°44N	1°29E
27/11/2016	4°53N	52°13W
28/11/2016	4°56N	52°15W
29/11/2016	4°51N	52°14W
01/12/2016	4°53N	52°12W
02/12/2016	4°52N	52°12W
19/01/2017	50°37N	1°22E
03/03/2017	50°40N	1°30N
10/03/2017	50°40N	1°30N
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30/03/2017	50°40N	1°30N
12/05/2017	50°40N	1°30N

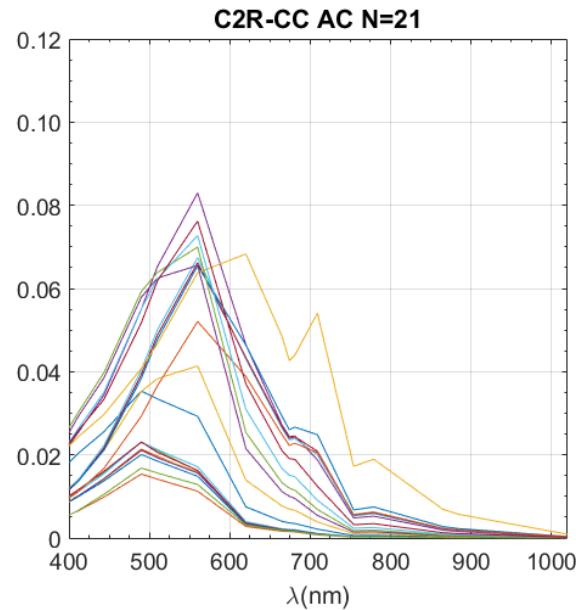
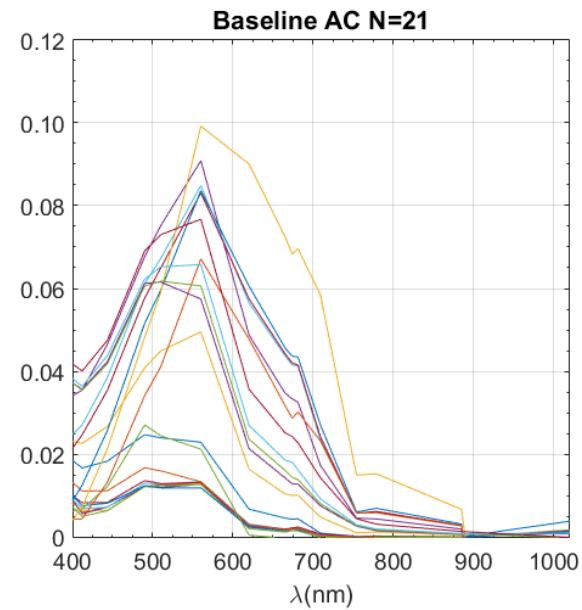
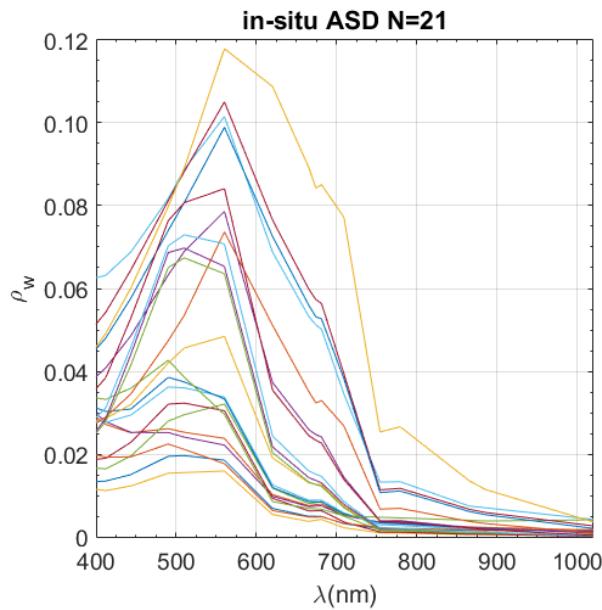


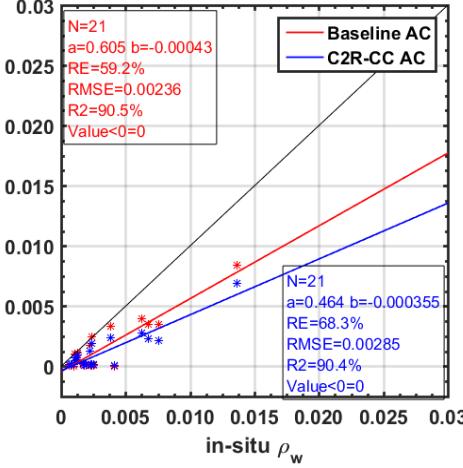
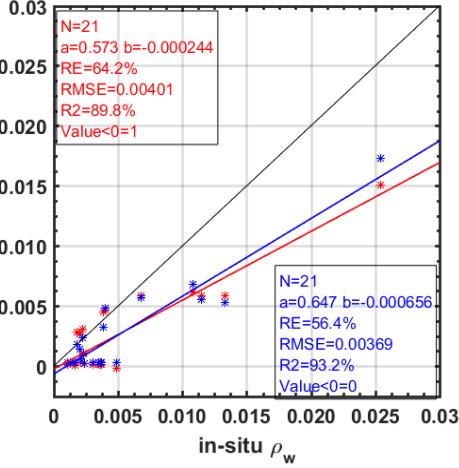
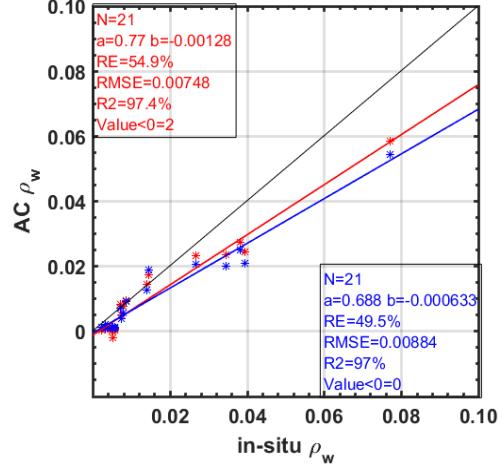
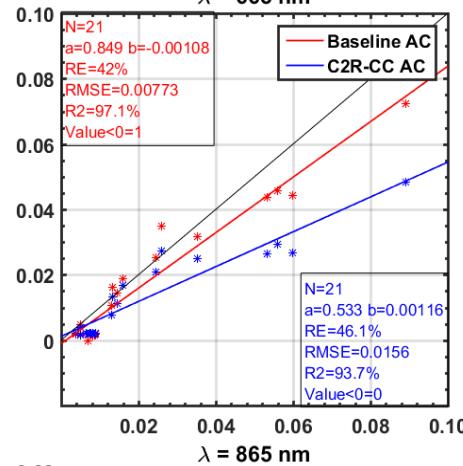
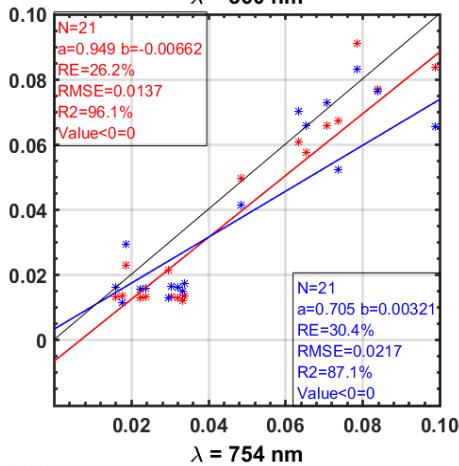
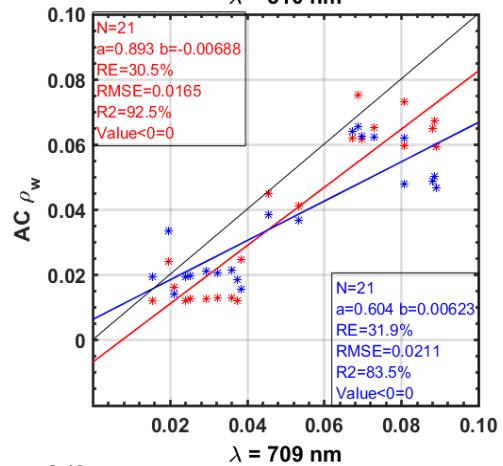
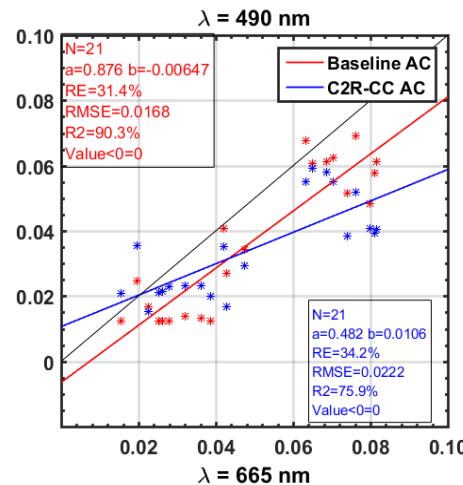
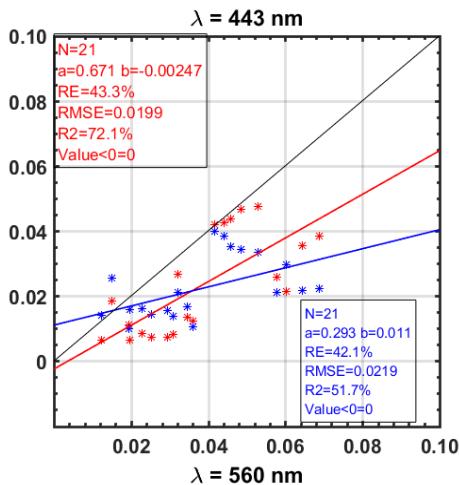
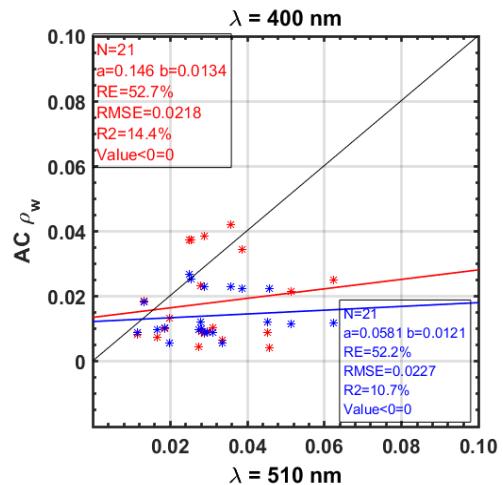
OLCI/S3 match-ups exercise

- Selection criterion (Bailey and Werdell, 2006; Jamet et al., 2011; Goyens et al., 2013)
 - Time difference \Rightarrow +/- 2 h
 - Space window \Rightarrow median of 3x3 pixel window
 - 9 pixels out 9 valid
 - CV at 560 nm <20% and BPAC flag
- Satellite data \Rightarrow OLCI L2 ρ_w at full spatial resolution 300m
 - Baseline AC \Rightarrow Combination of BPAC (*Lavender et al., 2005*) and CWAC (*Antoine and Morel, 1999*)
 - C2R-CC AC (*Doerffer and Schiller, 2007*) \Rightarrow Processed in SNAP from OLCI L1B full spatial resolution data
- Sea field campaigns \Rightarrow 55 stations \Rightarrow **21 match-ups**

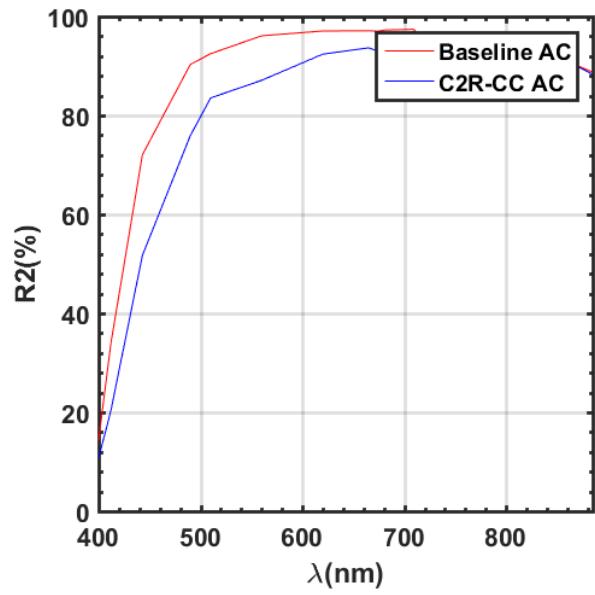
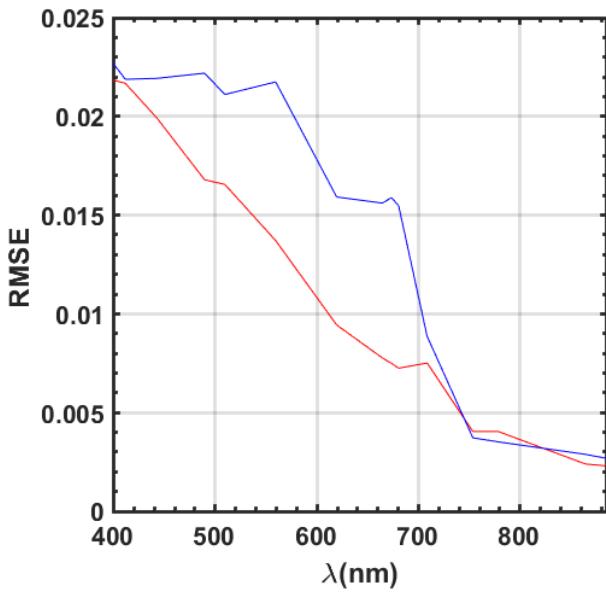
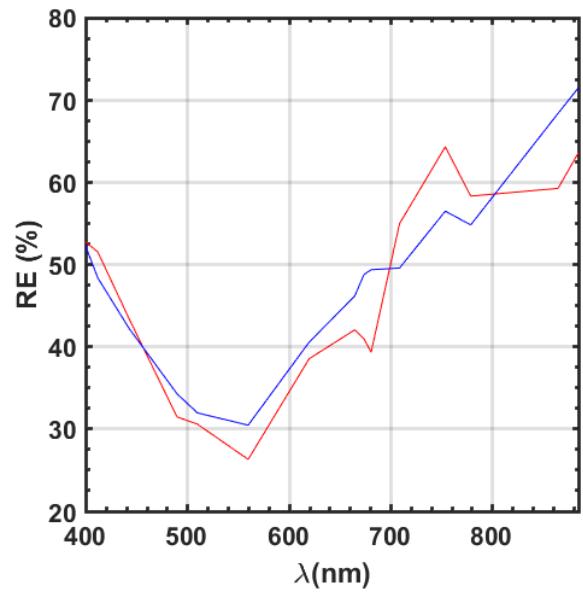
Match-ups results

- Baseline AC + C2R-CC AC spectra vs. ASD spectra
⇒ similar shape + less intensity





Match-ups results



Conclusions

- Radiometric, optical and biogeochemical measurements in different contrasted coastal waters
- **Global coastal MERIS archive with improved parameters** (R_{rs} , chl-a, TSM, Kd, a_{cdom} , ...)
- **OLCI validation:**
 - 21 match-ups in English Channel and French Guiana
 - Baseline AC slightly more accurate than C2R-CCAC in [400-865]
 - Baseline AC: negative values at 400, 665, 709, 754 nm

Perspectives

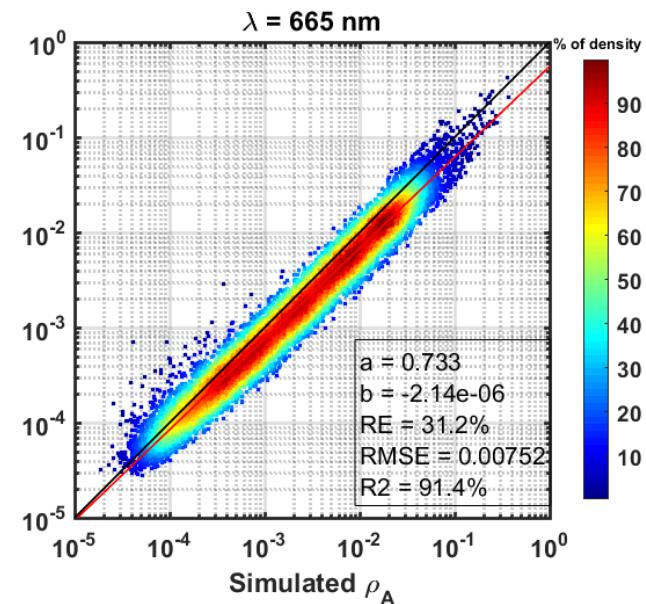
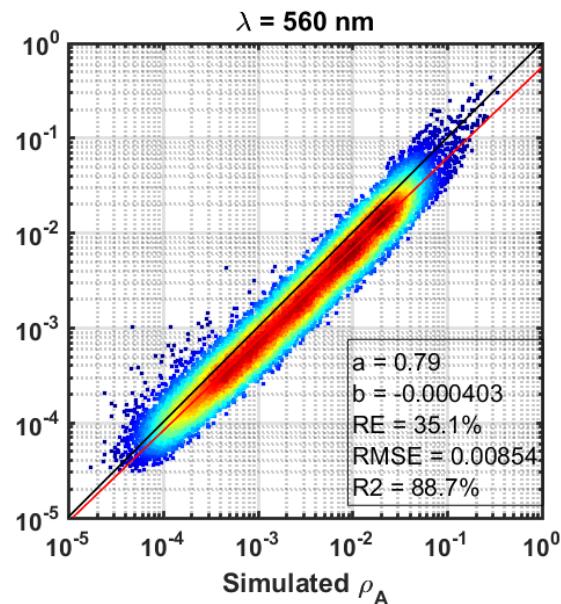
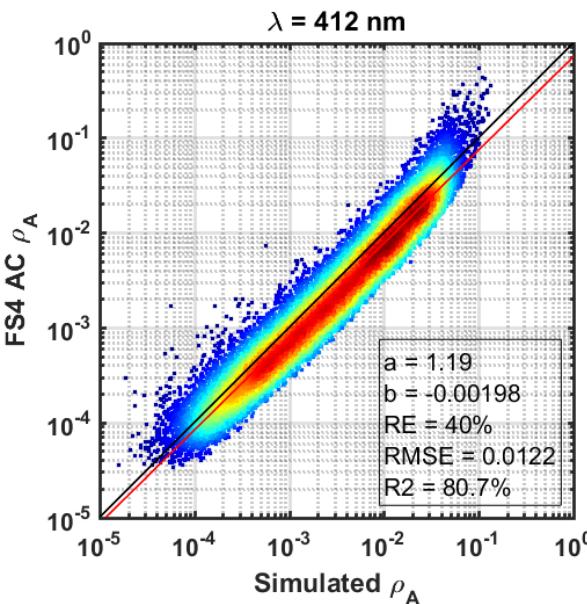
- Sea campaigns:
 - Bi-monthly one-day cruise in French Guiana
 - 5-day cruise in French Guiana early July and November
- Uncertainties budget for ASD measurements
- Use of spectral relationship for improvement of AC in coastal waters → OLCI/SLSTR synergy

Spectral relationship of aerosol reflectance

- FS4 AC:

- Black pixel in SWIR (Wang et Shi, 2005)
- Use of SLSTR SWIR bands
- ρ_{rc} at 1020, 1610 et 2250 nm → Extrapolation of $\rho_A(\lambda)$ to visible
- Use of synthetic dataset developed for IOCCG WG on AC over turbid waters

$$\rho_A(\lambda_i) = \rho_{rc}(2250nm) \left(\frac{\rho_{rc}(1610nm)}{\rho_{rc}(2250nm)} \right)^{\frac{2250nm - 1020nm}{2250nm - 1610nm}} \left(\frac{\rho_{rc}(2250nm)}{\rho_{rc}(1020nm)} \right)^{\frac{1020nm - 400nm}{1020nm - 2250nm}} \left(\frac{\rho_{rc}(1020nm)}{\rho_{rc}(2250nm)} \right)^{\frac{400nm - \lambda_i}{2250nm - 1020nm}}$$



Perspectives

- Sea campaigns:
 - Bi-monthly one-day cruise in French Guiana
 - 5-day cruise in French Guiana early July and November
- Uncertainties budget for ASD measurements
- Use of spectral relationship for improvement of AC in coastal waters → OLCI/SLSTR synergy
- Application of LOG algorithms to OLCI Rrs
- Same exercise for S2

Bot-of-atmosphere images corrected from gas absorptions



French Guiana
28/11/2016



Eastern English Channel
21/09/2016



Eastern English Channel
19/01/2017

Thank you for your attention

Acknowledgments

- EUMETSAT for providing the OLCI products through S3VT
- Brockmann Consult for BEAM and implementation of C2RCC
- French Ministry of Education and the Nord de France region for PhD fellowship of M.A. Mograne
- CNES for funding these activities through the TOSCA program
- Université du Littoral-Côte d'Opale for funding

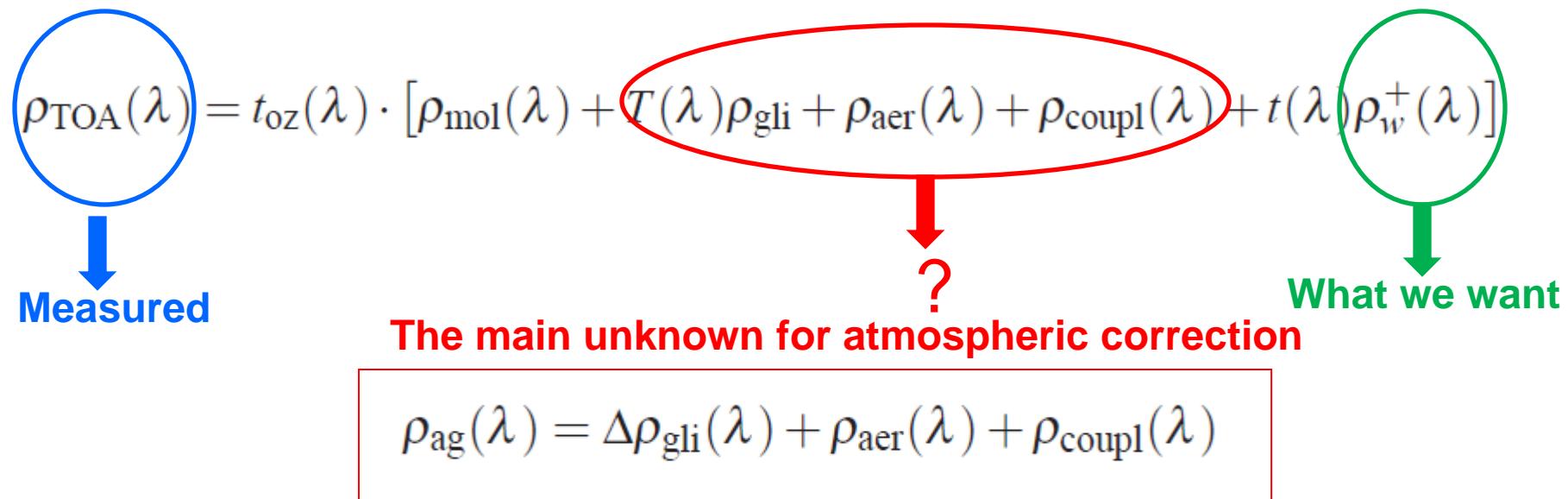
Additional slides

Activities on MERIS

- Validation of atmospheric correction and bio-optical algorithms
- Improvement of atmospheric correction over coastal waters → Coastal version of POLYMER algorithm



The POLYMER approach has been adapted for coastal waters.



POLYMER is based on a polynomial decomposition of the signal, and a iterative optimization of the different parameters over the whole spectrum.

$$\rho_{\text{ag}}(\lambda) \approx T_0(\lambda)c_0 + c_1\lambda^{-1} + c_2\lambda^{-4}$$

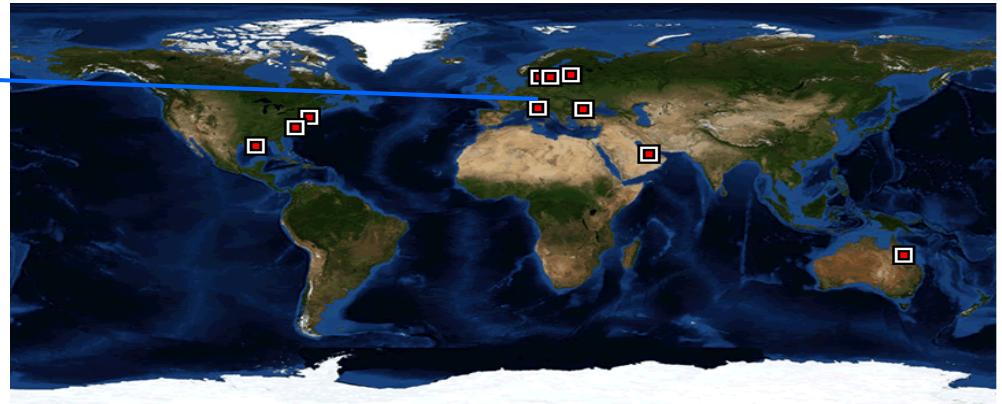
Standard Polymer
(Open ocean)

$$\rho_w(\lambda) = f(\text{Chl})$$

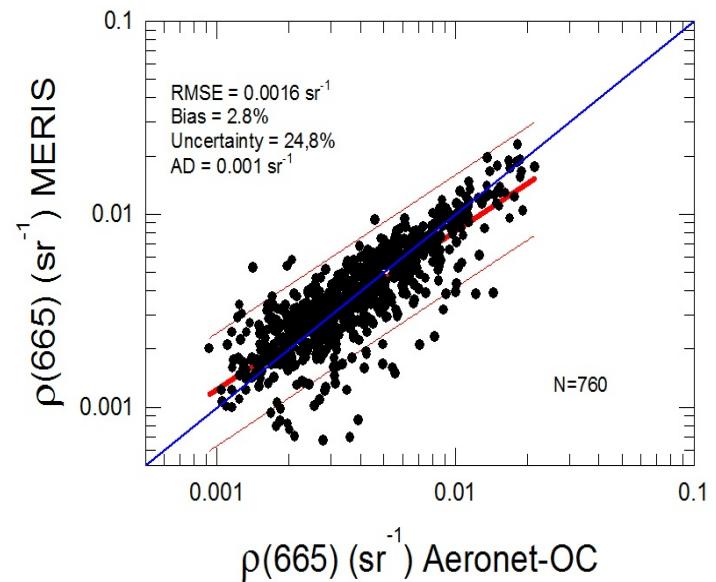
Polymer
GlobCoast

$$\rho_w(\lambda) = f(\text{IOPs})$$

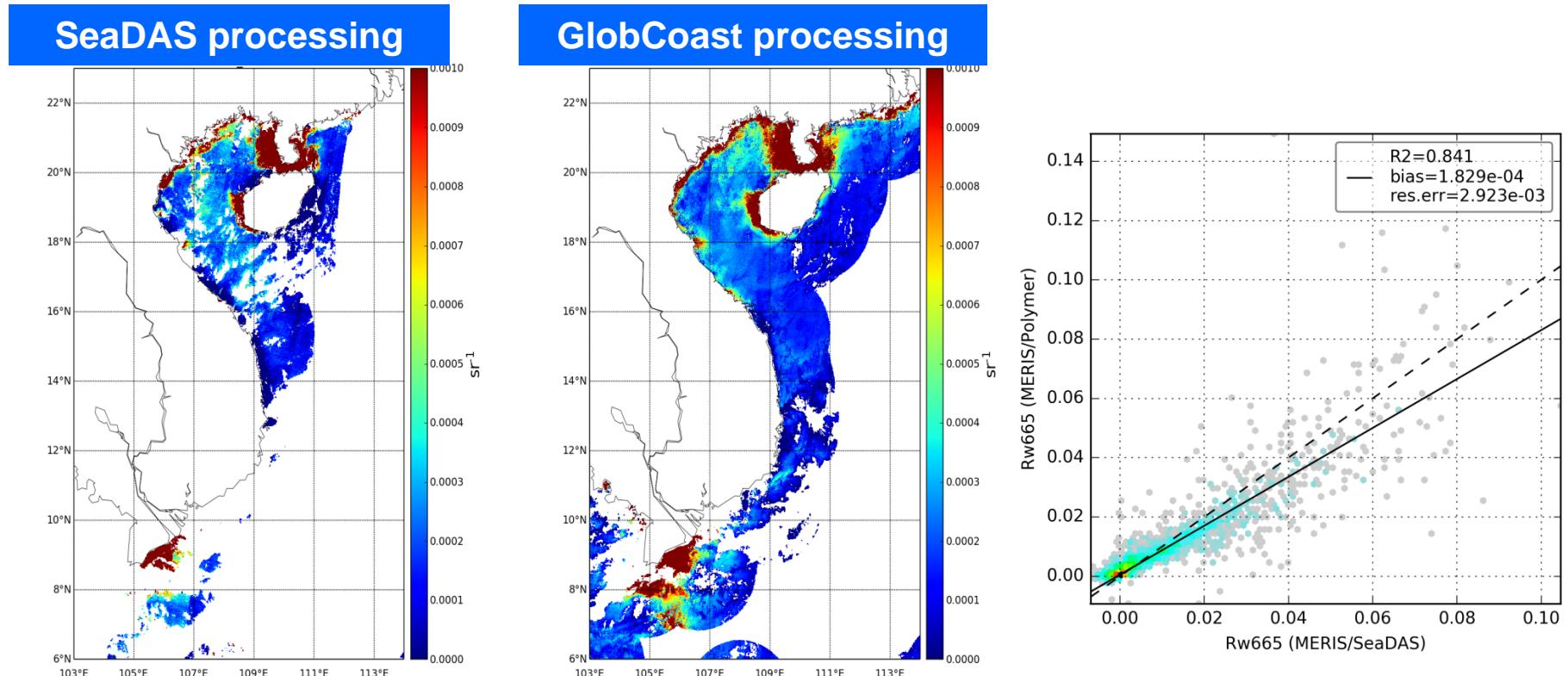
Validation of the atmospheric correction algorithm has been performed using the Aerosol Robotic Network for ocean color (AERONET-OC)



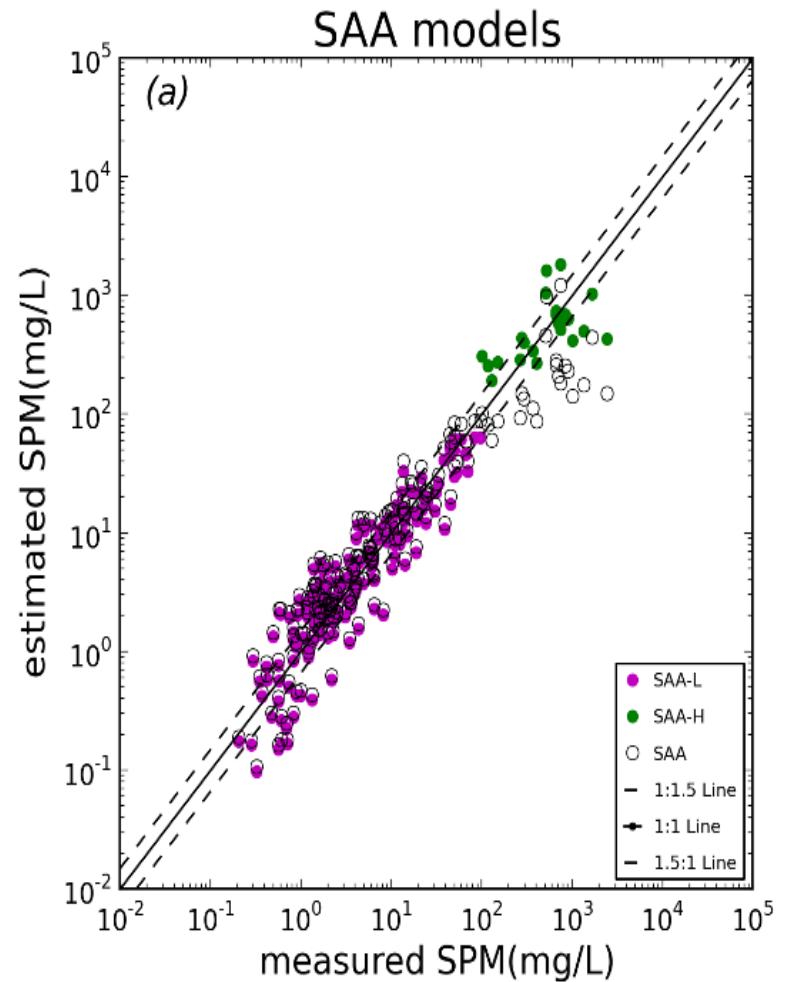
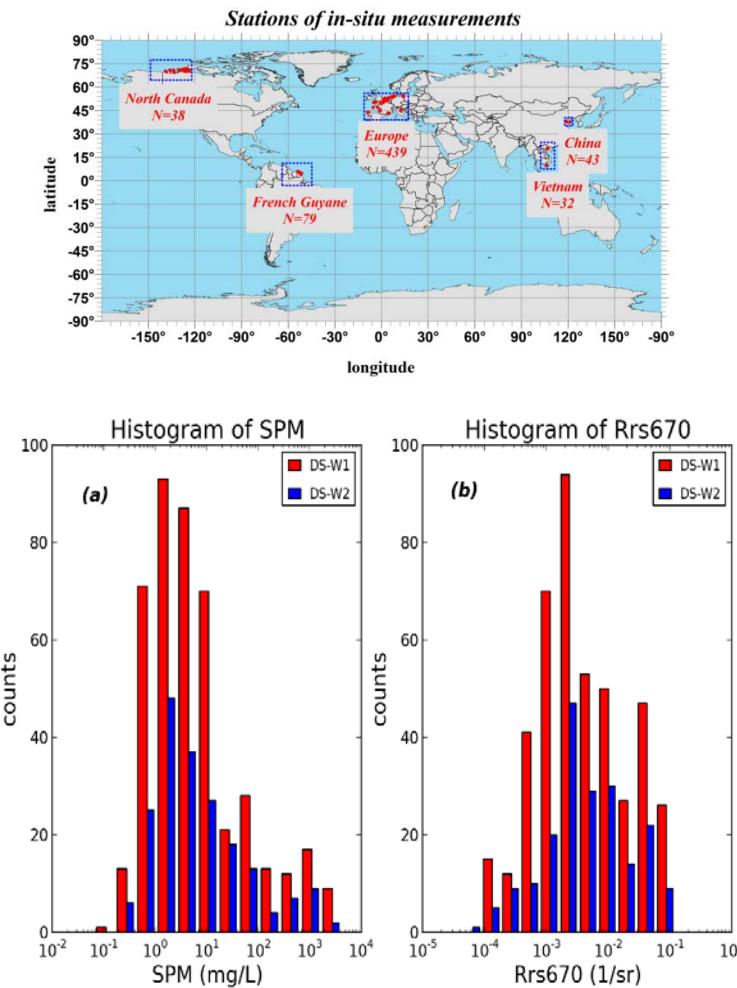
- Polymer allows to increase the number of match-ups
- RMSE (red) = 0.0016 sr^{-1}



Compared to SeaDAS processing, the POLYMER-coast allows the spatial (and then temporal) coverage to be increased with a similar performance in term of radiometry.



SPM is retrieved by a new semi-analytical algorithm which allows SPM to be assessed over 4 orders of magnitude (thanks to a switching approach) from $R_{rs}(665)$.



Match-ups results

- Baseline AC + C2R-CC AC spectra vs. ASD spectra
⇒ similar shape + less intensity
- Baseline AC:
 - RE between 26.2% at 560nm and 59.2% at 865nm
 - RMSE between 0.00236 at 865nm and 0.0218 at 400nm
 - Negative Rrs at 400, 665, 709 and 754nm
- C2R-CCAC
 - RE between 30.4% at 560nm and 68.3% at 865nm
 - RMSE between 0.00285 at 865 nm and 0.0227 at 400nm

Processing of ASD radiometric measurements

Ocean color radiometry measurement Protocol

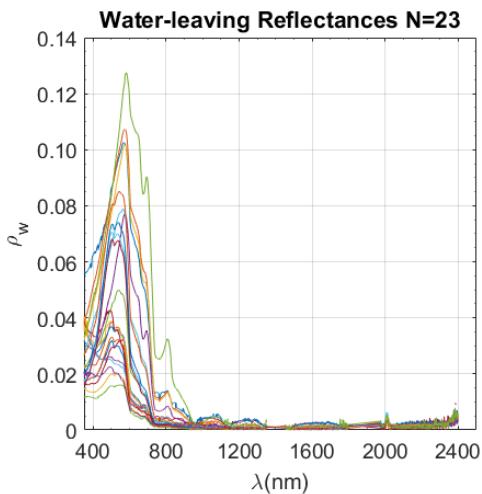
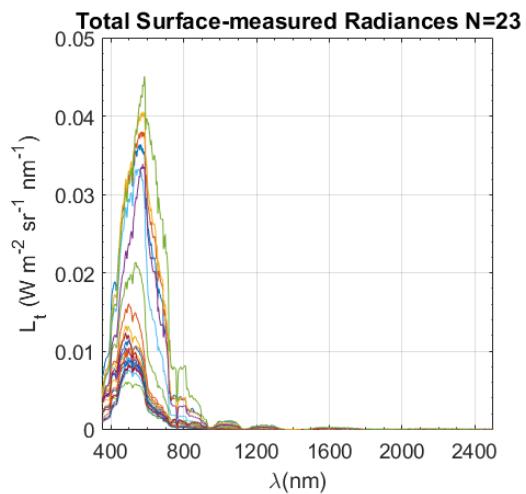
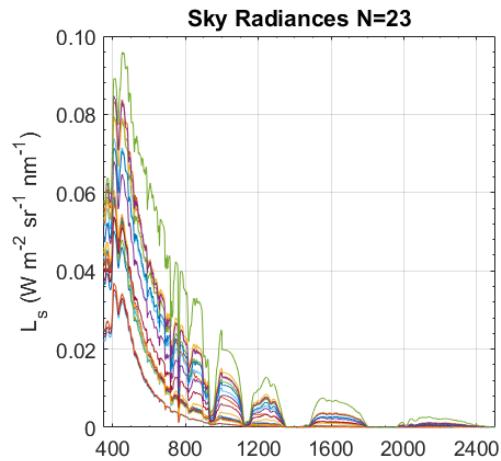
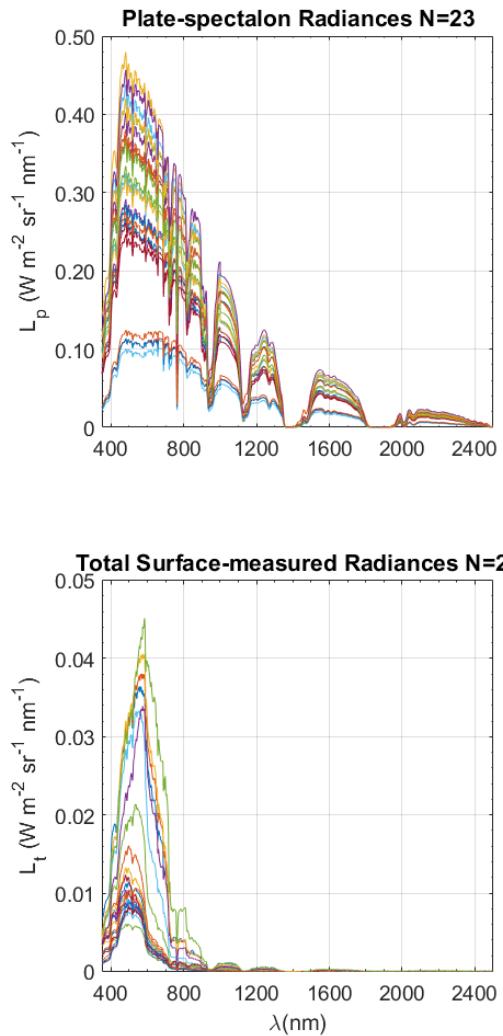
- ⇒ 3 types of radiances ⇒ Plate spectralon L_p , Sky L_s and Sea L_t
- ⇒ Viewing geometries ⇒ Similar to TRIOS above water protocol (*Mobley, 1999*)
- ⇒ Sequential measurements of L_p , L_s and L_t
- ⇒ 10 scans for each measurement
- ⇒ Treplica

Post-processing protocol

- ⇒ Pre-checking ⇒ sequence and types of measurements depending of field conditions
- ⇒ Double quality control ⇒ L_p , L_s and L_t replica and scans variability ⇒ 10% threshold
 - ⇒ Replica inputs check ⇒ Standard deviation/Median ratio of L_p , L_s and L_t
 - ⇒ Scan inputs check ⇒ Relative absolute difference
- ⇒ Radiance final spectra ⇒ Median of median of selected L_p , L_s and L_t
- ⇒ Water-leaving reflectance ρ_w (*Mobley, 1999*)

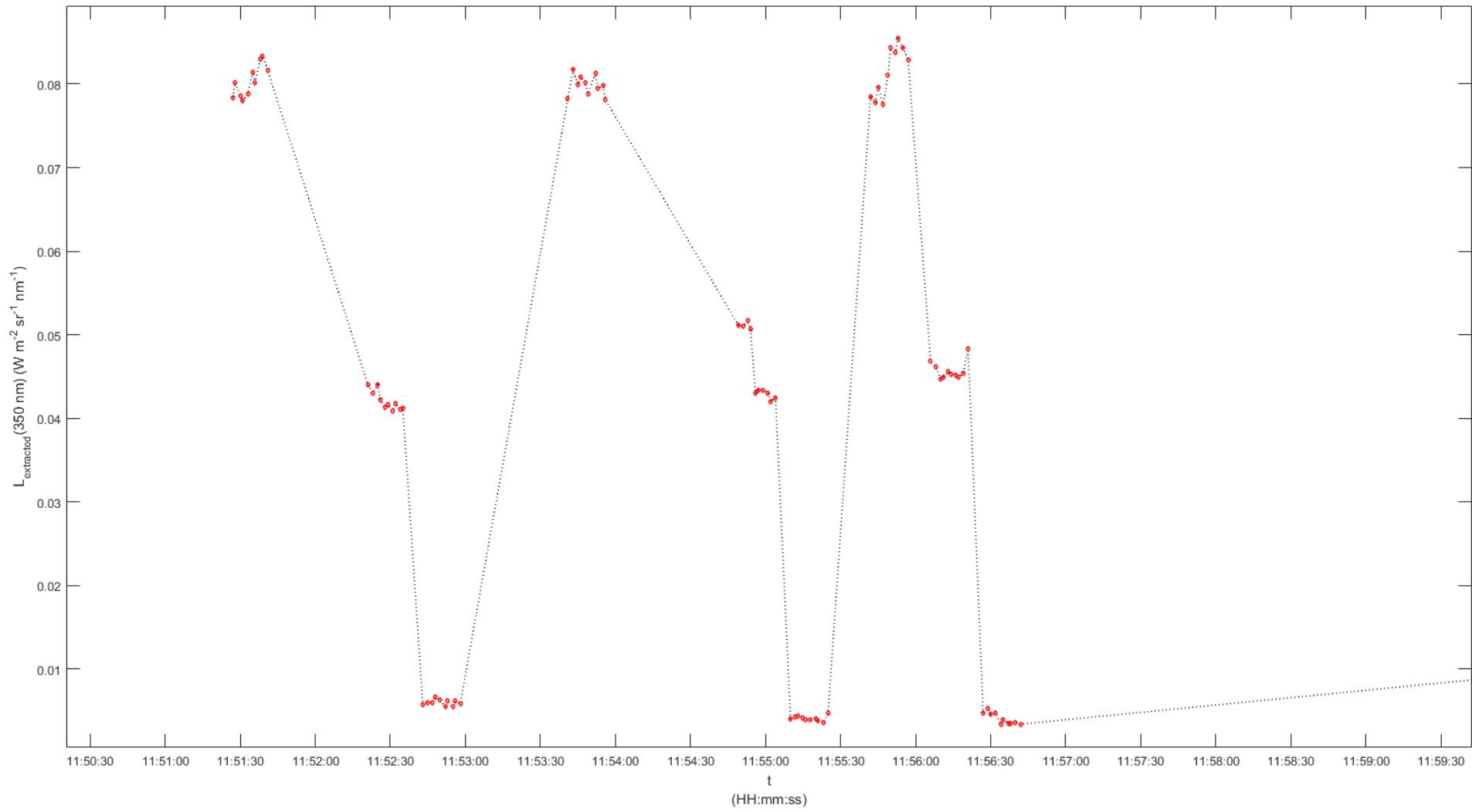
$$\rho_w(\lambda) = \frac{L_t(\lambda) - \frac{\rho_s(W)}{L_p(\lambda)} L_s(\lambda)}{\rho_p(\lambda)}$$

- ⇒ Wind speed data missing ⇒ hypothesis $W = 5$ m/s
- ⇒ Air-sea interface reflection coefficient ρ_s ⇒ according to W (*Ruddick et al., 2006*)



Post-processing protocol

- Control of the sequence of the measurements
- Manual selection of radiances following the sequence of measurements
- Filter of redundant measurements



Post-processing

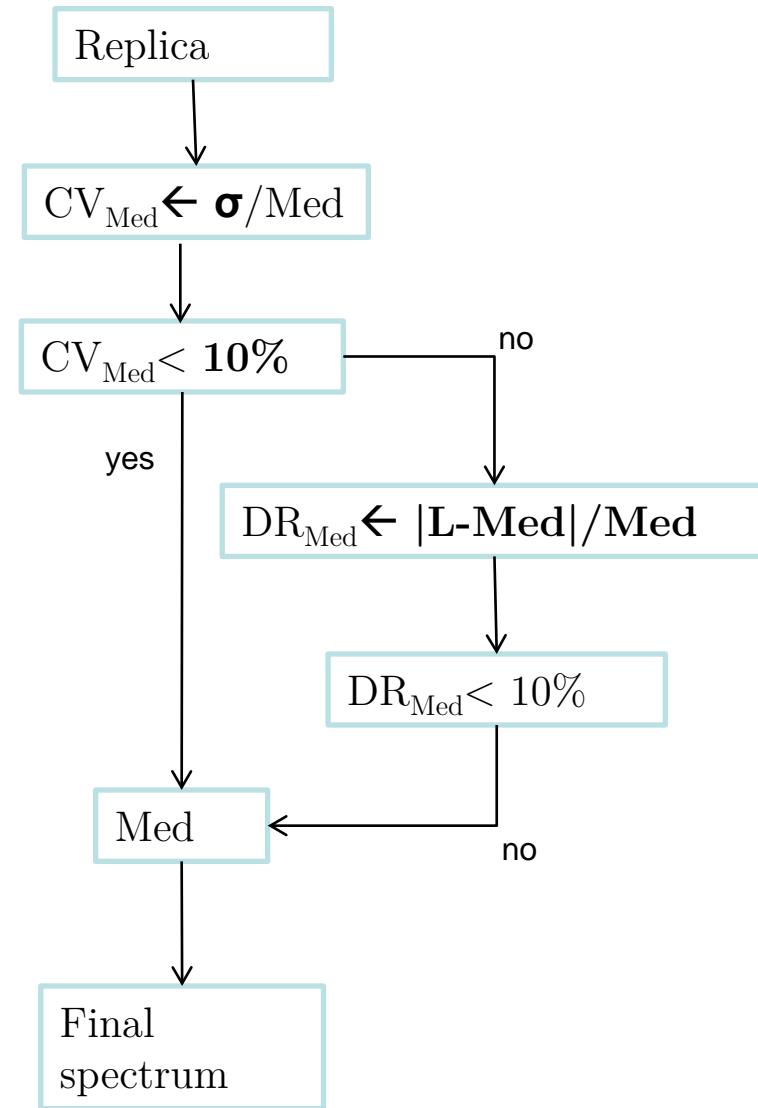
Quality control for each λ

- Quality control of the replica for each radiance

- Calculation of the median Med
 - Calculation of the standard deviation σ
 - Calculation of variability coefficient CV_{Med}
 - If $CV_{Med} < 10\% \rightarrow$ valid and save of median of the replica

- Quality control of the values

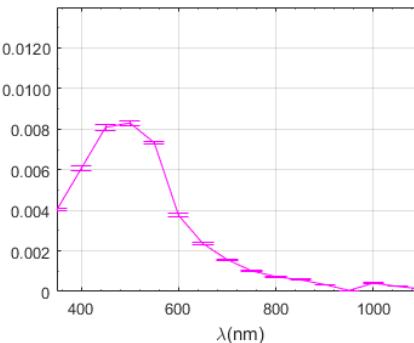
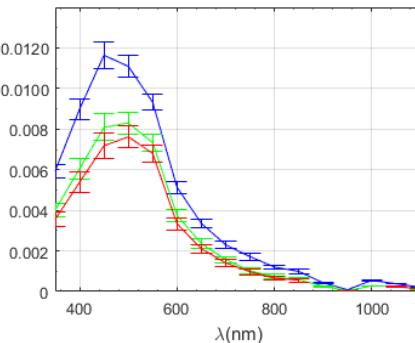
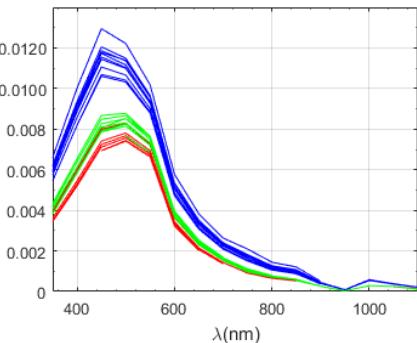
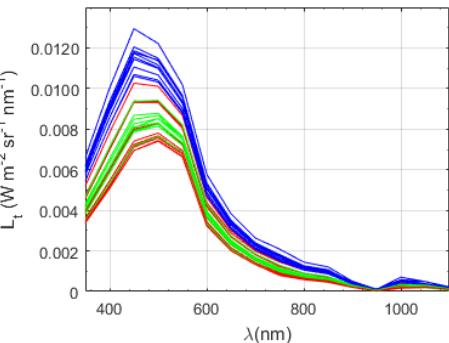
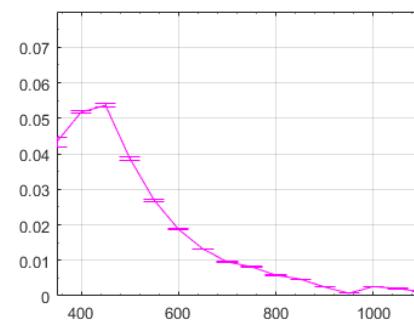
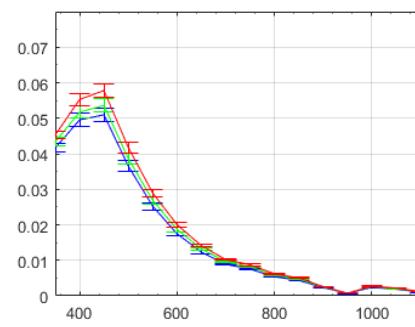
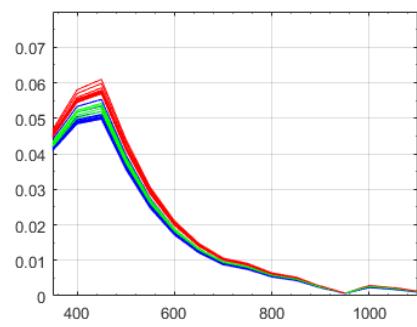
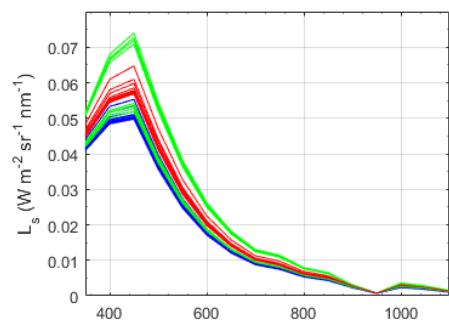
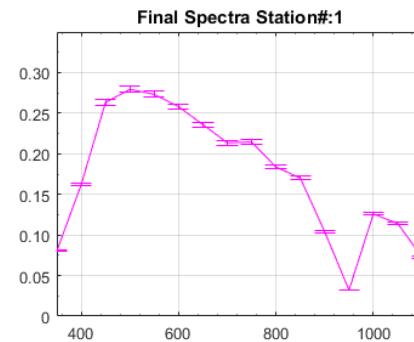
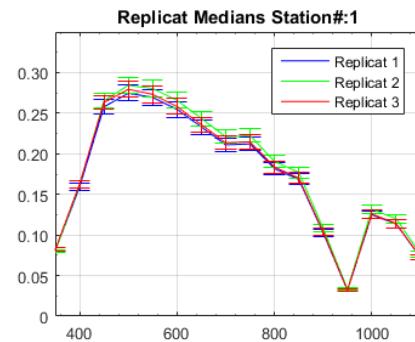
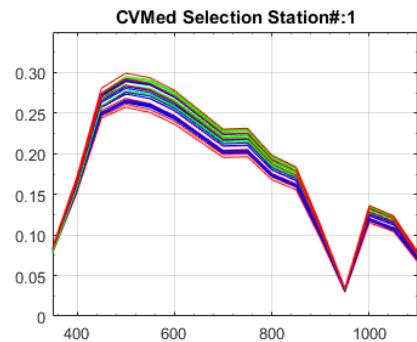
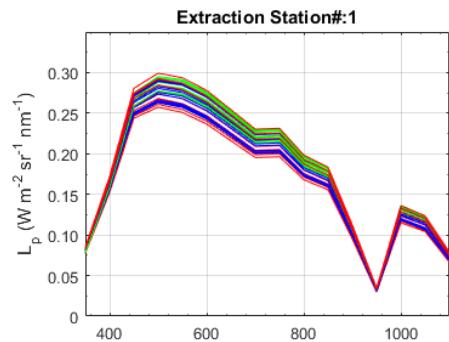
- If $CV_{Med} > 10\% \rightarrow$ Relative difference / median RD_{Med}
 - If $RD_{Med} < 10\% \rightarrow$ good L
 - Calculation of median Med



Median of replica for each type of measurements

Post-processing

- English Channel for 14/09/2016



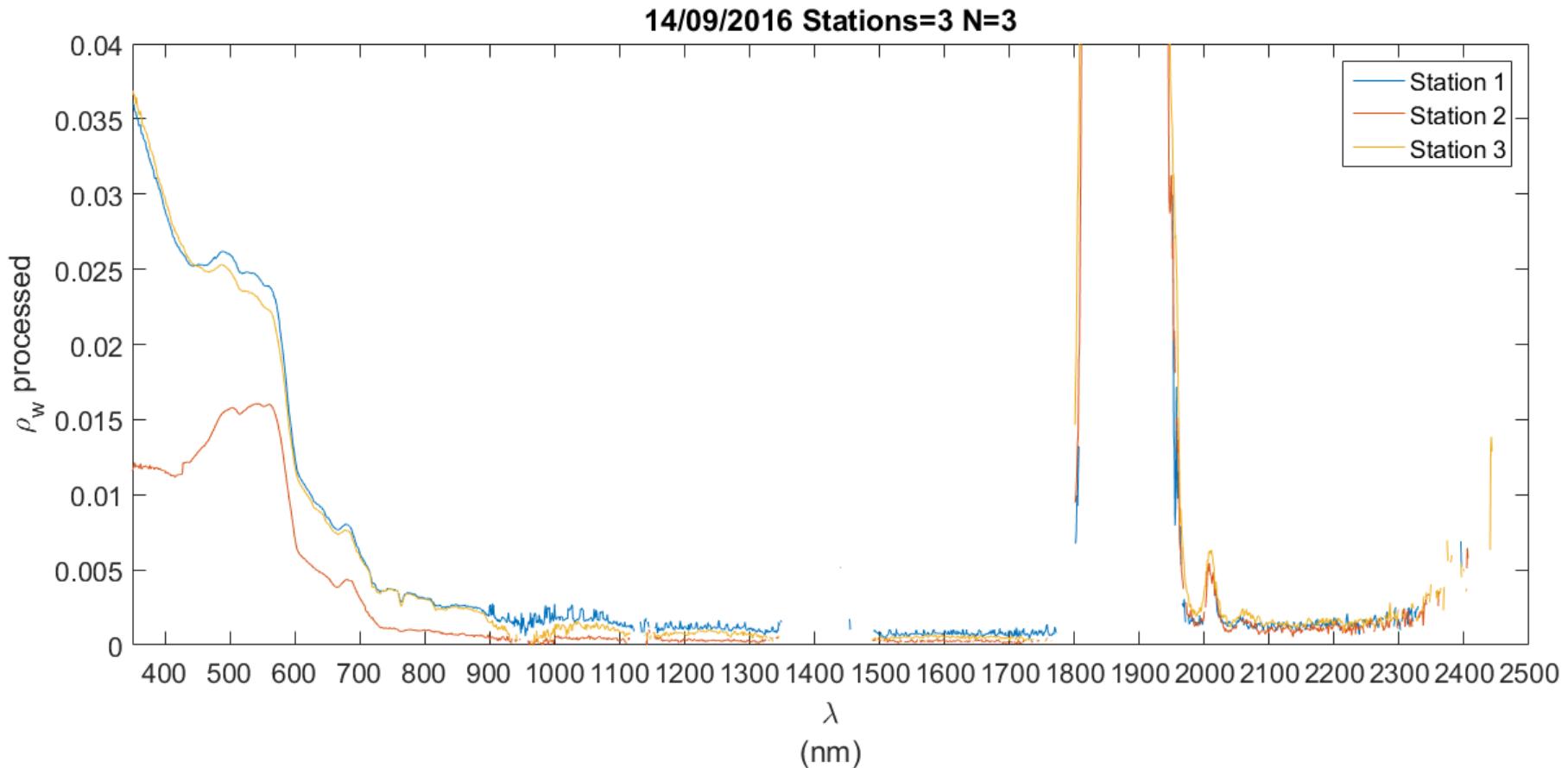
Post-processing

$$\rho_w(\lambda) = \pi \frac{L_t(\lambda) - \rho_s(w) L_s(\lambda)}{\pi \frac{L_p(\lambda)}{\rho_p(\lambda)}}$$

- Estimation of the marine reflectance (Mobley, 1999; Rudorff et al., 2014)
 - Sky reflectance ρ_s
 - If no wind data → Hypothesis: $W = 5 \text{ m/s}$ (Ruddick et al., 2006)
 - If $L_s/L_p(750 \text{ nm}) < 0.05$ clear sky
→ $\rho_s = 0.0256 + 0.000039 W + 0.000034 W^2$
 - If $L_s/L_p(750 \text{ nm}) > 0.05$ cloudy sky
→ $\rho_s = 0.0256$

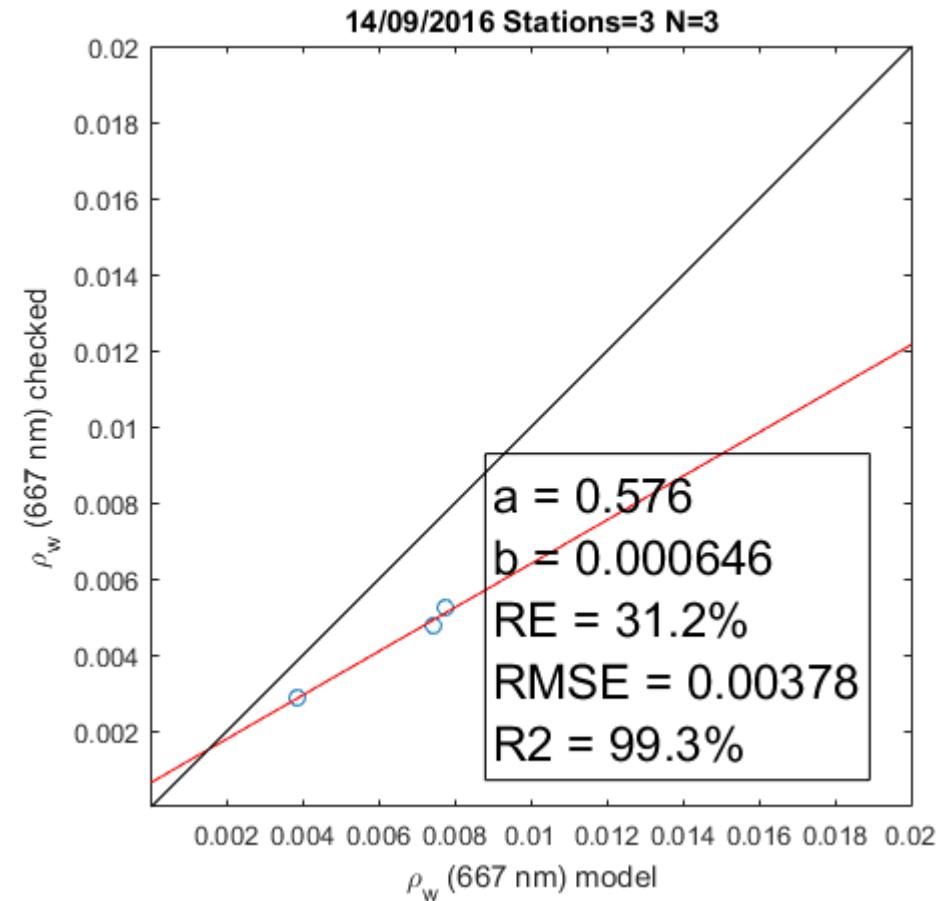
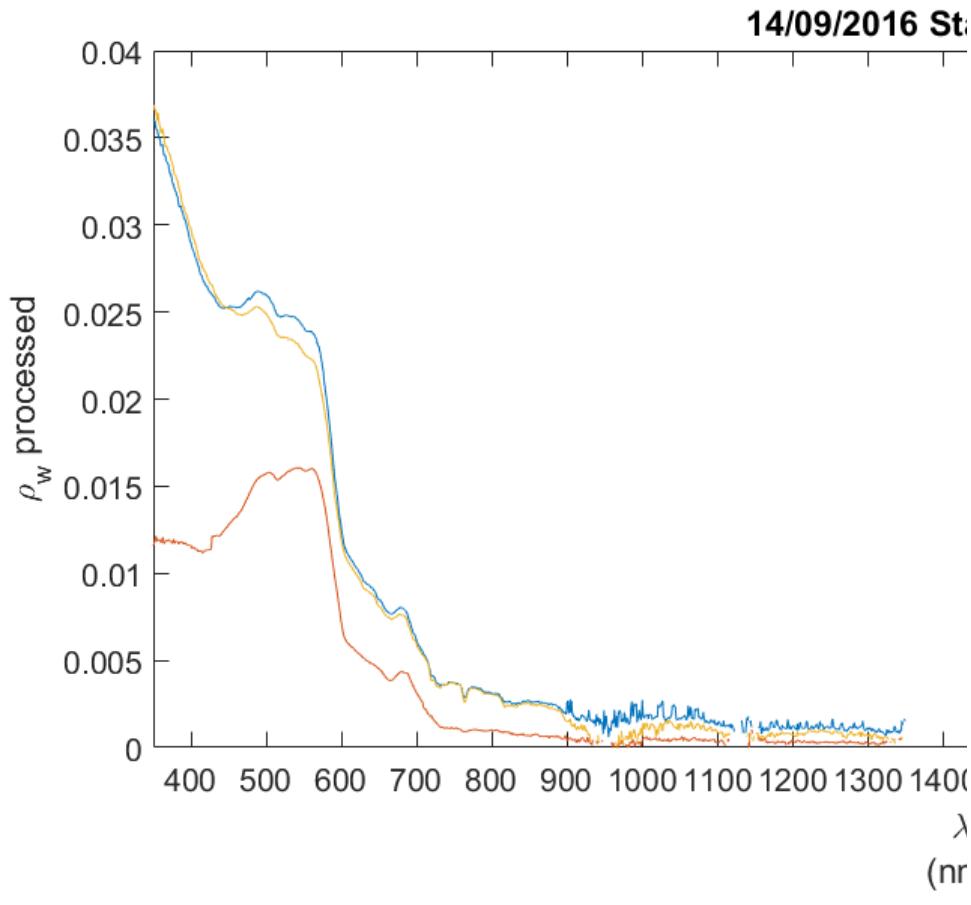
Post-processing

- English Channel for 14/09/2016



Post-processing

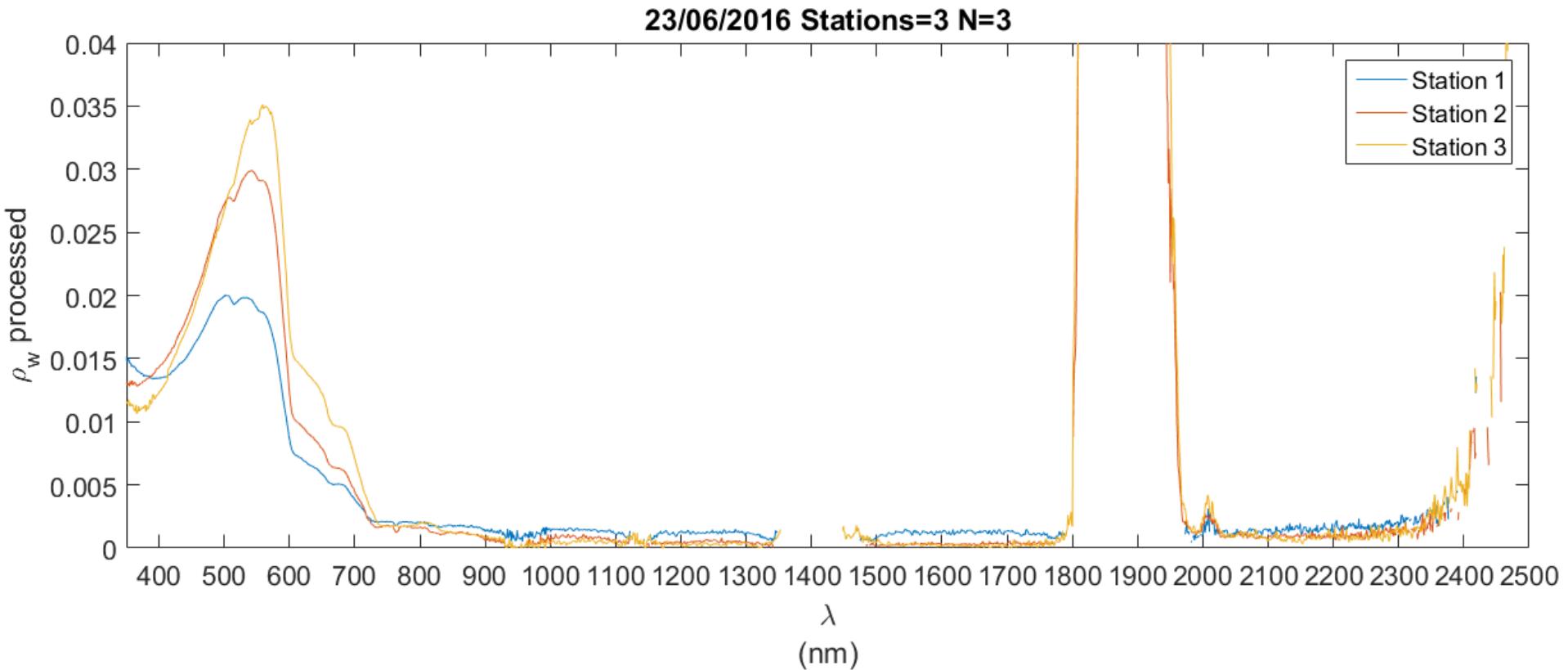
- English Channel for 14/09/2016



$$\rho_w^{\text{mod}}(667 \text{ nm}) = 1.27 \rho_w(555 \text{ nm})^{1.47} + \frac{0.00018}{\pi} \left[\frac{\rho_w(490 \text{ nm})}{\rho_w(555 \text{ nm})} \right]^{-3.19} \quad (\text{Lee et al., 2009})$$

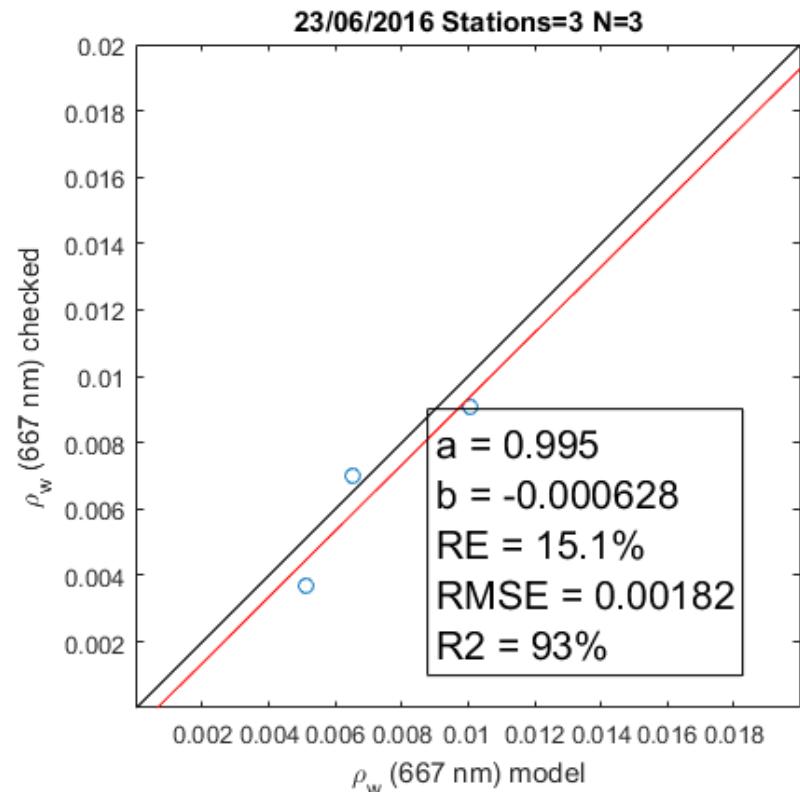
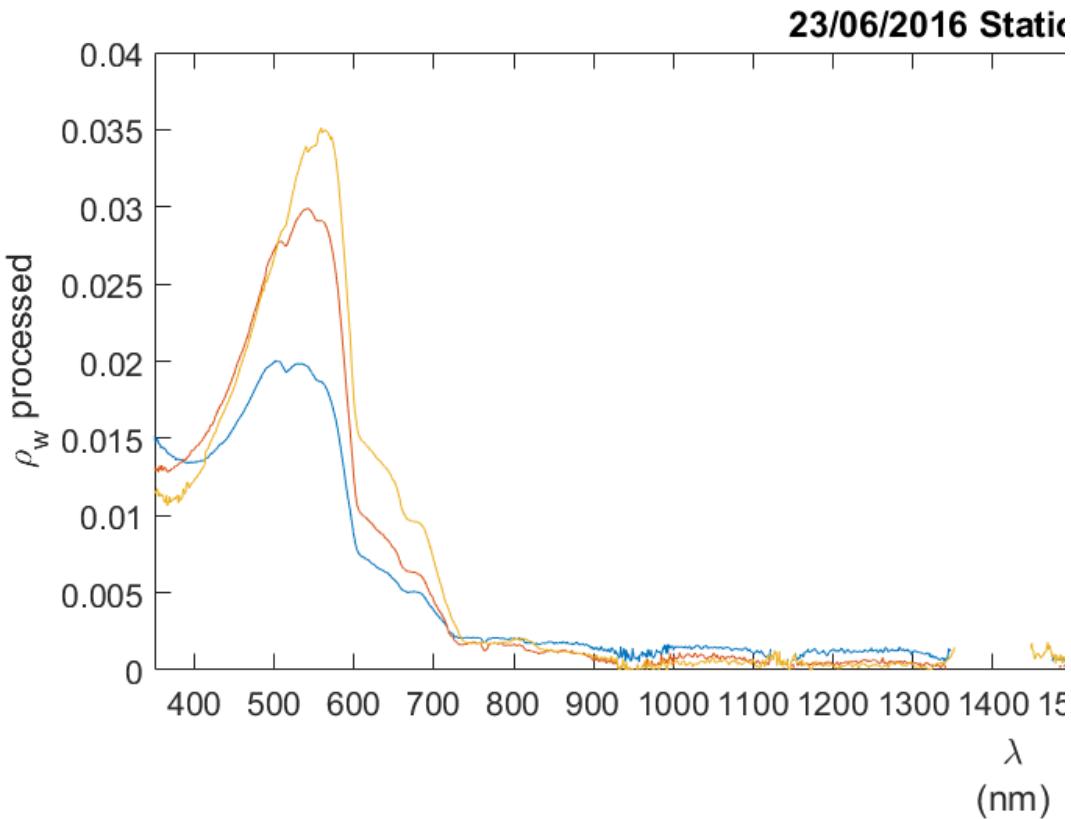
Post-processing

- English Channel for 23/06/2016



Post-processing

- English Channel for 23/06/2016



$$\rho_w^{\text{mod}}(667 \text{ nm}) = 1.27 \rho_w(555 \text{ nm})^{1.47} + \frac{0.00018}{\pi} \left[\frac{\rho_w(490 \text{ nm})}{\rho_w(555 \text{ nm})} \right]^{-3.19} \quad (\text{Lee et al., 2009})$$