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AERONET-OC: network status, quality control of data & recent advances

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The Fiducial Reference Measurement Network for Satellite Ocean Colour
4-5 October 2018 in NPL, Teddington, London, UK

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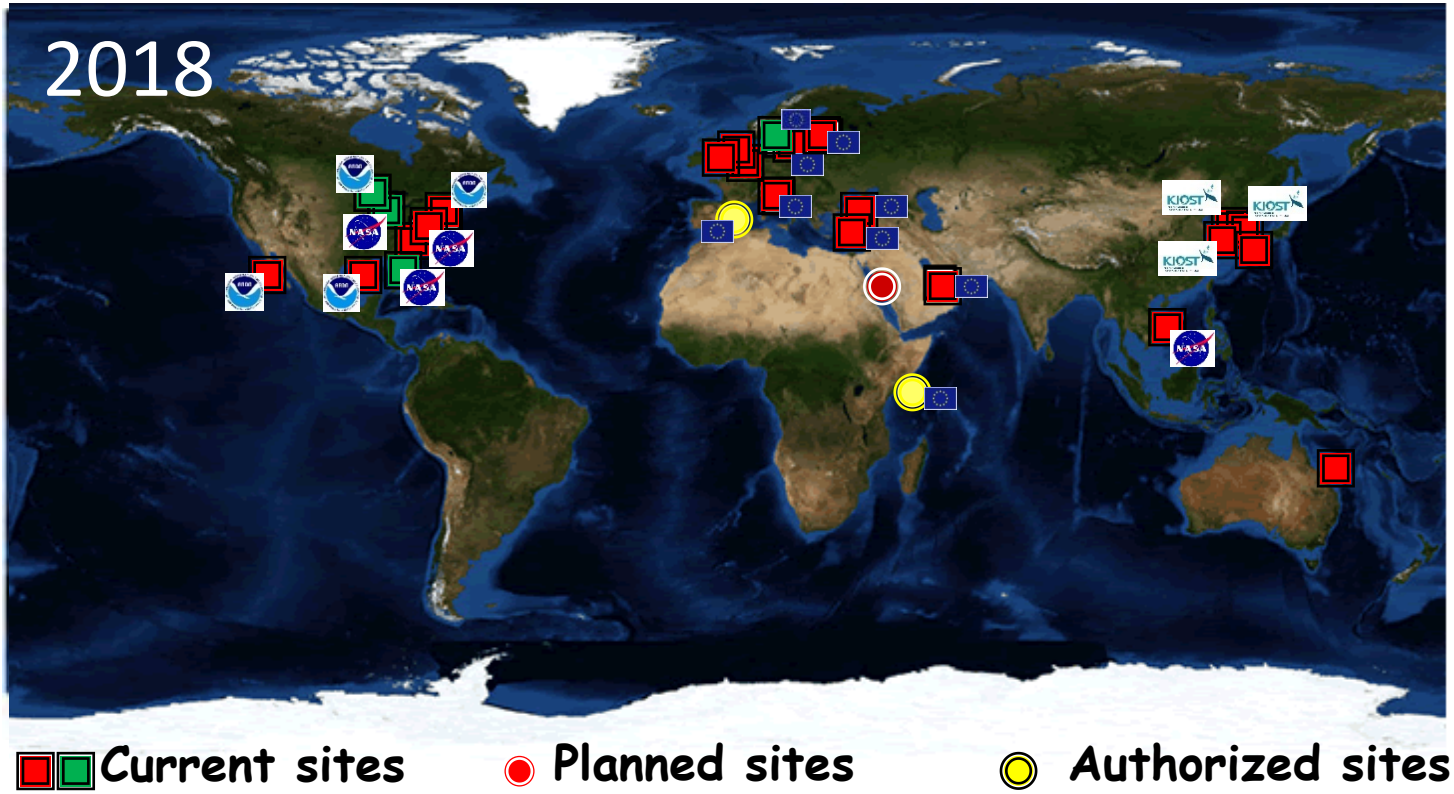
… adequately sampled, carefully calibrated, quality controlled, and archived data for key elements of the climate system will be useful indefinitely.

C. Wunsch, R. W. Schmitt, and D. J. Baker (2013). ***Climate change as an intergenerational problem. Proceedings of the National Academy of Sciences of the United States of America****, 110, 4435-4436.*

AERONET-OC

AERONET-OC generates globally distributed highly consistent time-series of standardized $L_{WN}(\lambda)$ and τ_a measurements.



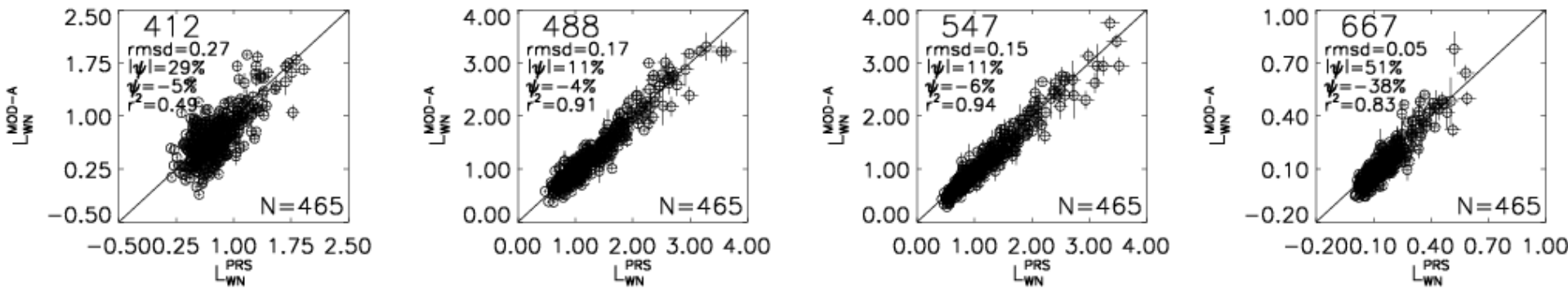
- NASA manages the network infrastructure (i.e., handles the instruments calibration and, data collection, processing and distribution within AERONET).
- JRC has the scientific responsibility of the processing algorithms and performs the final quality control of data products (in addition to the management of 7 out of approximately 27 sites).
- PIs establish and maintain individual AERONET-OC sites (which is essential for the network).

G.Zibordi, B.Holben et al. A Network for Standardized Ocean Color Validation Measurements. Eos Transactions, 87: 293, 297, 2006.

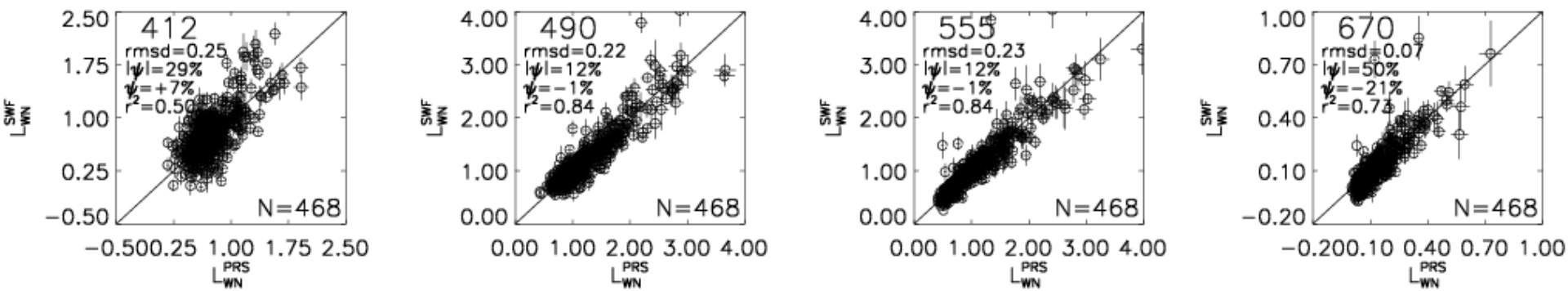
Application of AERONET-OC data

Matchups produced at the AAOT site with +/-1 hr Δt for the period April 2002 - November 2012

MOD-A vs AERONET-OC

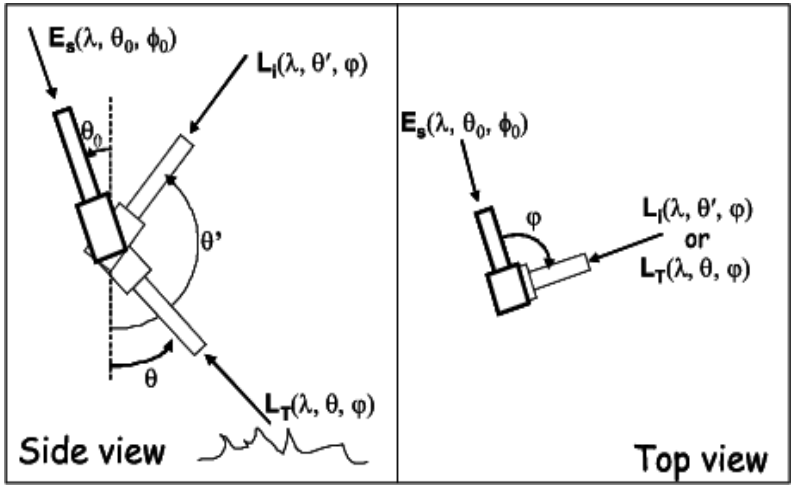


SeaWiFS vs AERONET-OC



G.Zibordi et al. An Assessment of MERIS Ocean Color Products for European Seas. Ocean Science, 9, 521–533, 2013.

AERONET-OC (Above Water Radiometry)



$$(\varphi = \varphi_0 + 90^0; \theta = 40^0; \theta' = 140^0)$$

Sea-radiance: L_T

Sky-radiance: L_i

Removal of sky glint contribution

$$L_W(\varphi,\theta,\lambda) = L_T(\varphi,\theta,\lambda) - \rho(\varphi,\theta,\theta_0,W)L_i(\varphi,\theta',\lambda)$$

with L_T determined from the mean of relative minima and, L_T and L_i passing strict QA/QC tests

Correction for off-nadir view

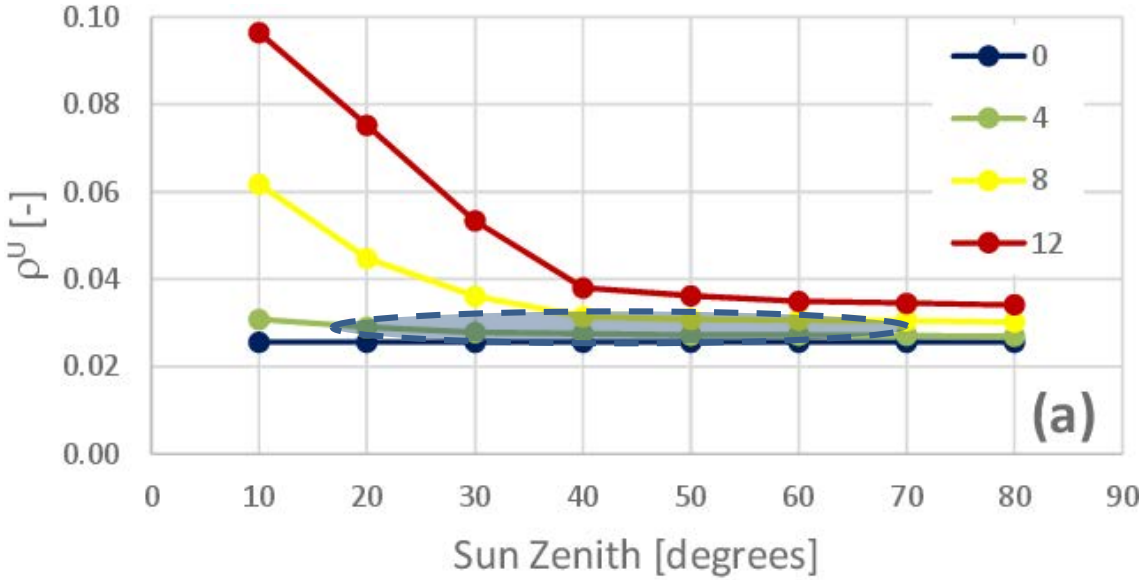
$$L_W(\lambda) = L_W(\varphi,\theta,\lambda)C_{\Im Q}(\lambda,\theta,\varphi,\theta_0,\tau_a,IOP,W)$$

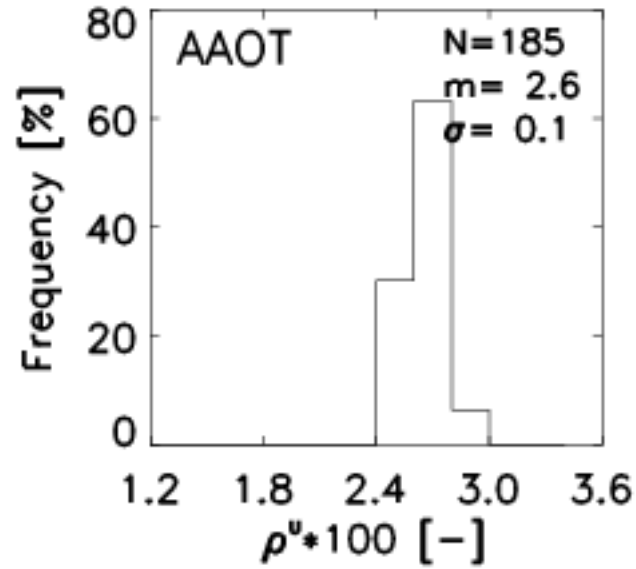
Transformation to exact normalized water-leaving radiance

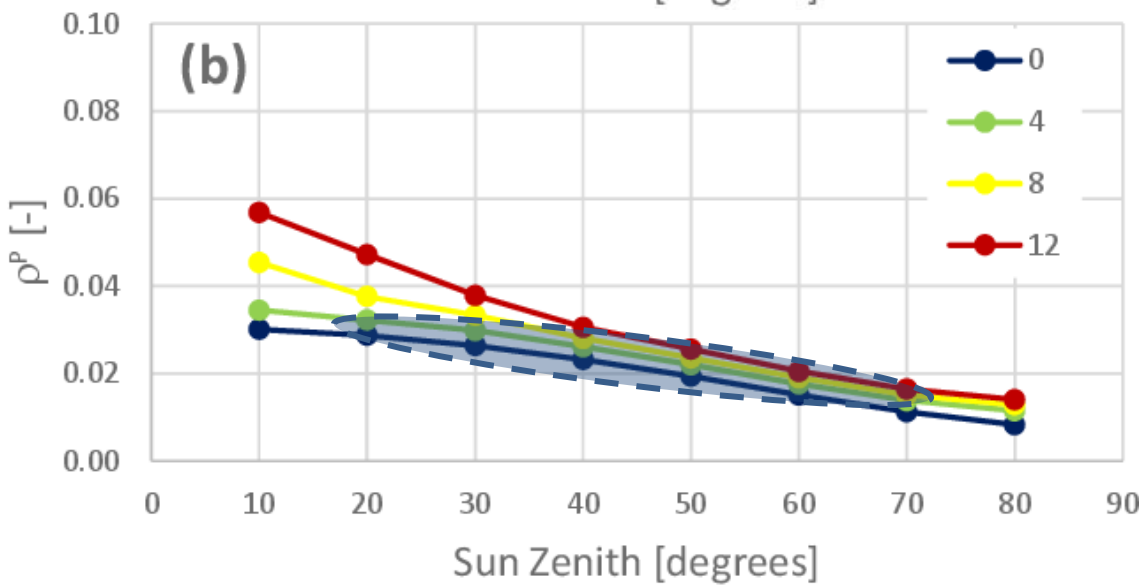
$$L_{WN}(\lambda) = L_W(\lambda)\left(D^2 t_d(\lambda)\cos\theta_0\right)^{-1} C_{f/Q}(\lambda,\theta_0,\tau_a,IOP)$$

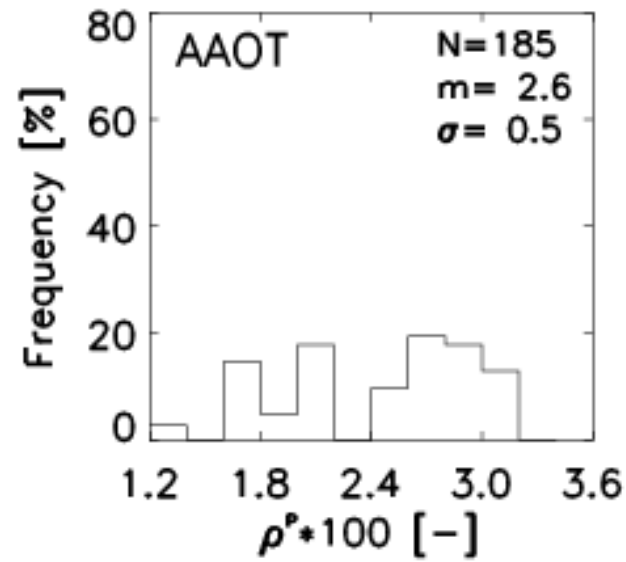
Zibordi, G. et al. (2009). AERONET-OC: a network for the validation of ocean color primary products. *Journal of Atmospheric and Oceanic Technology*, *26*(8), 1634-1651.

ρ^U and ρ^P factors (Mobley 1999 and 2015)



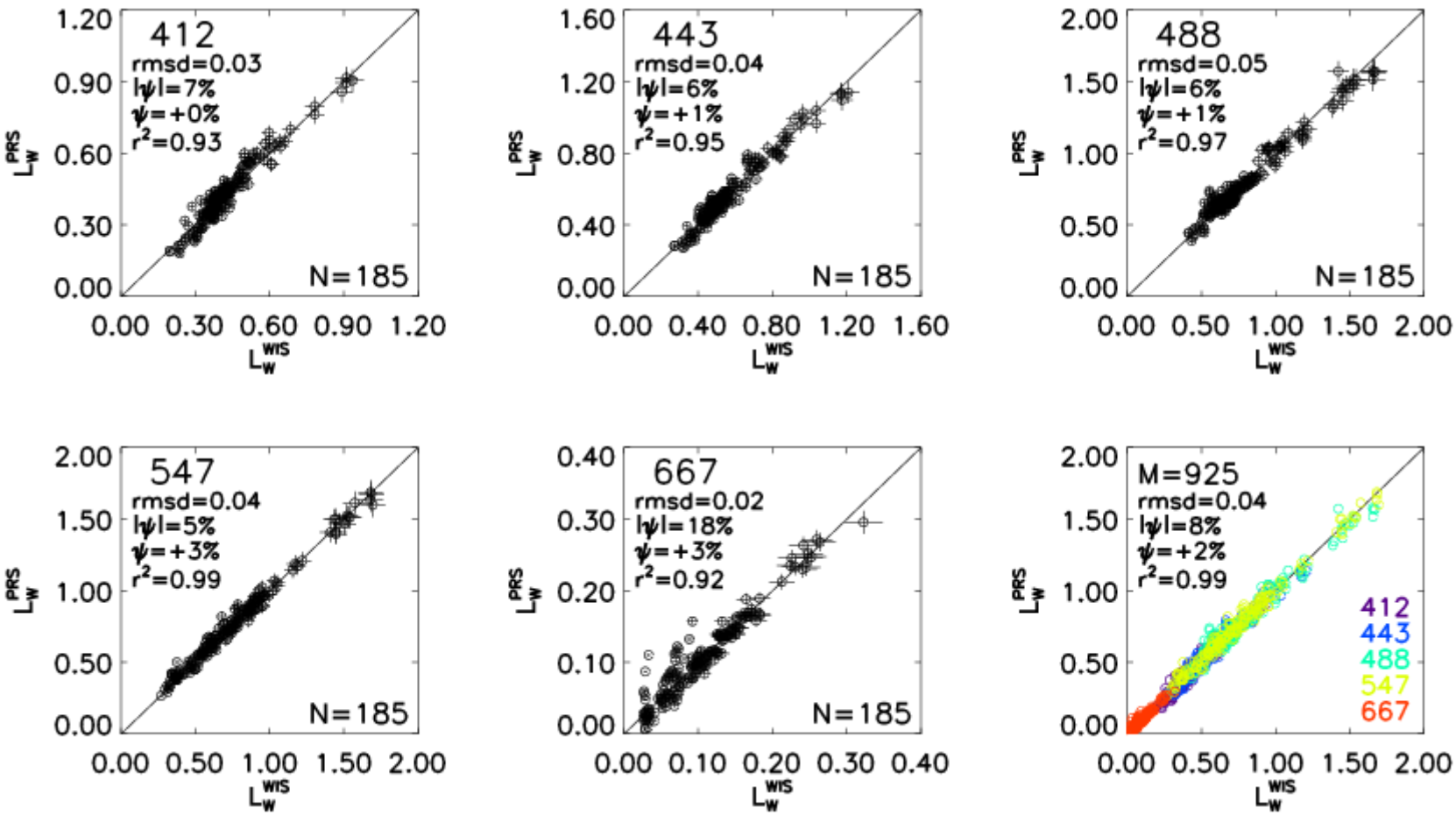






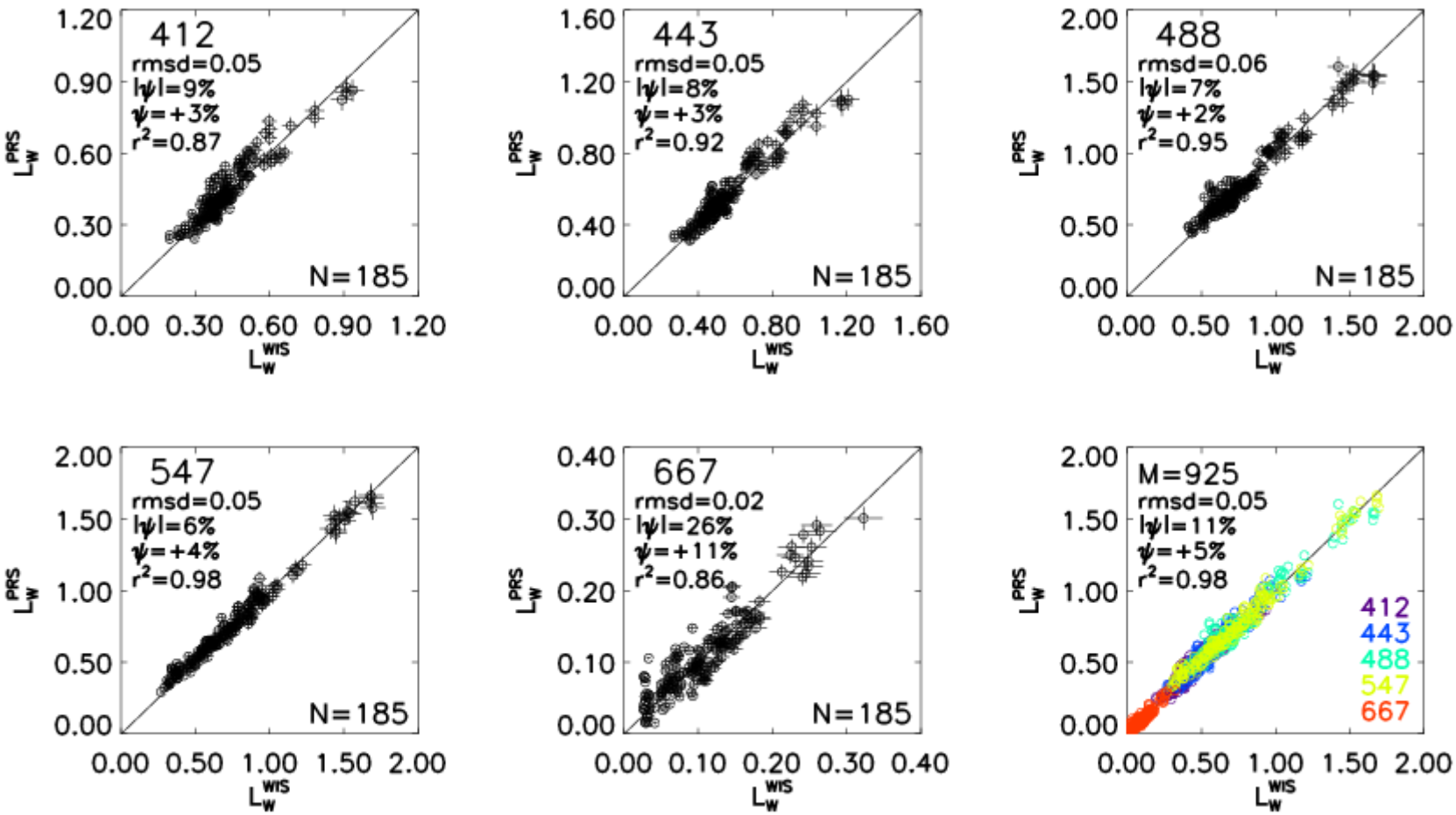
Zibordi, G., 2016. Experimental evaluation of theoretical sea surface reflectance factors relevant to above-water radiometry. *Optics Express*, *24*(6), pp.A446-A459.

Assessment: ρ^U



Zibordi, G., 2016. Experimental evaluation of theoretical sea surface reflectance factors relevant to above-water radiometry. Optics Express, 24(6), pp.A446-A459.

Assessment: ρ^P

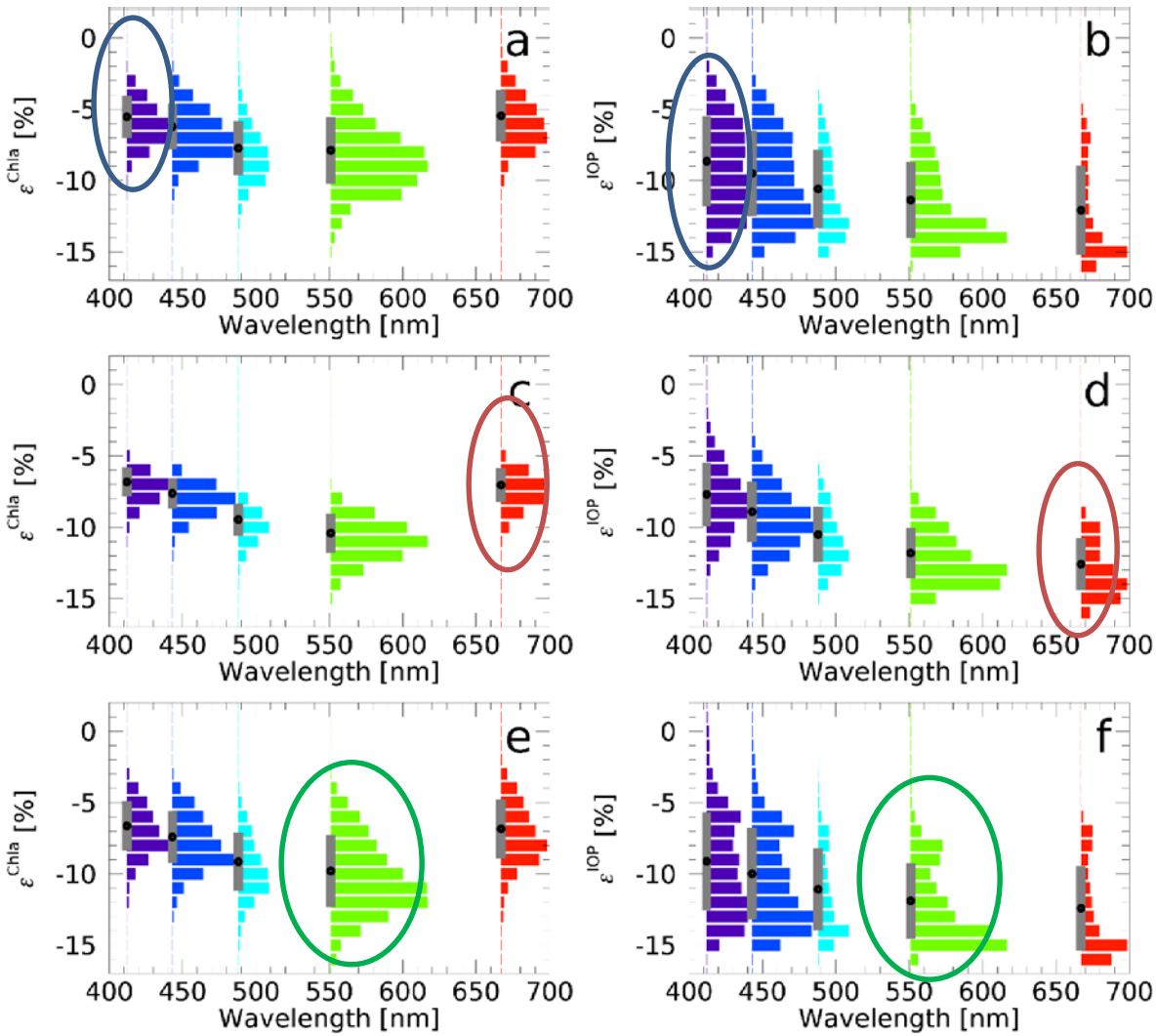


Zibordi, G., 2016. Experimental evaluation of theoretical sea surface reflectance factors relevant to above-water radiometry. Optics Express, 24(6), pp.A446-A459.

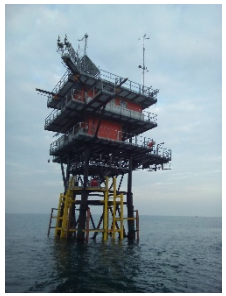
Off-nadir corrections

Chla-Based Approach (Morel et al. 2002)

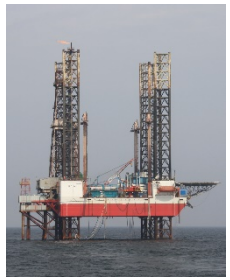
IOP-Based Approach (Lee et al. 2011)



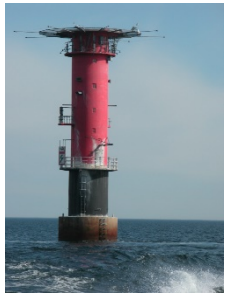
AAOT
(Adriatic Sea)



Gloria
(Black Sea)



Gustaf Dalen
(Baltic Sea)



Talone, M., Zibordi, G. and Lee, Z., 2018. Correction for the non-nadir viewing geometry of AERONET-OC above water radiometry data: an estimate of uncertainties. Optics express, 26(10), pp.A541-A561.

Uncertainties in off-nadir corrections

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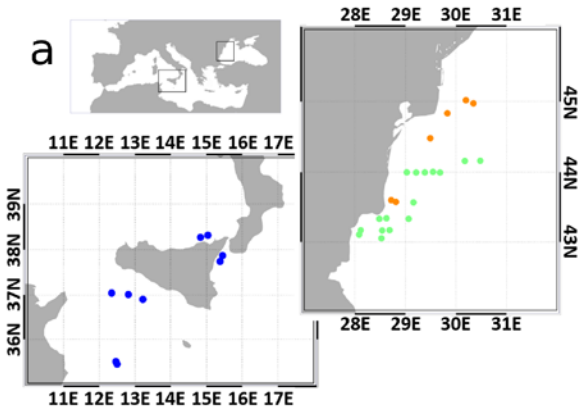
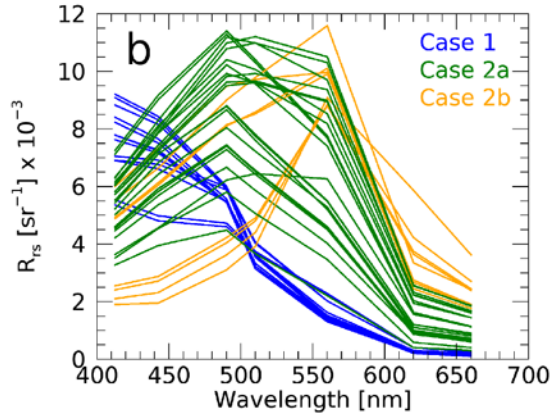
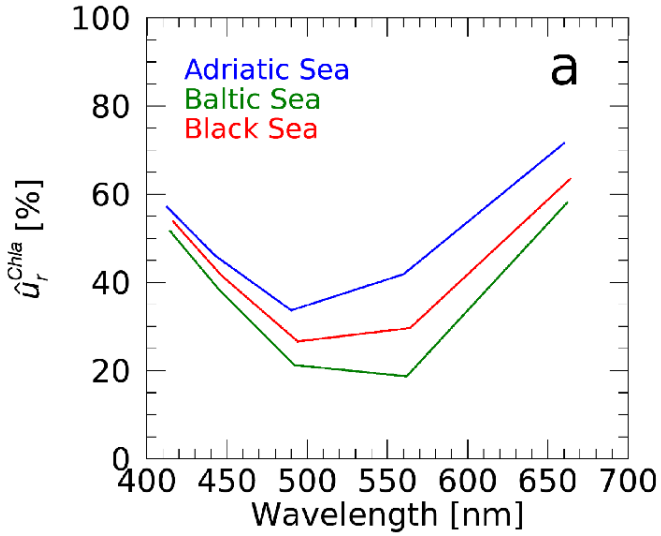
Optical Floating System

Sampled Regions

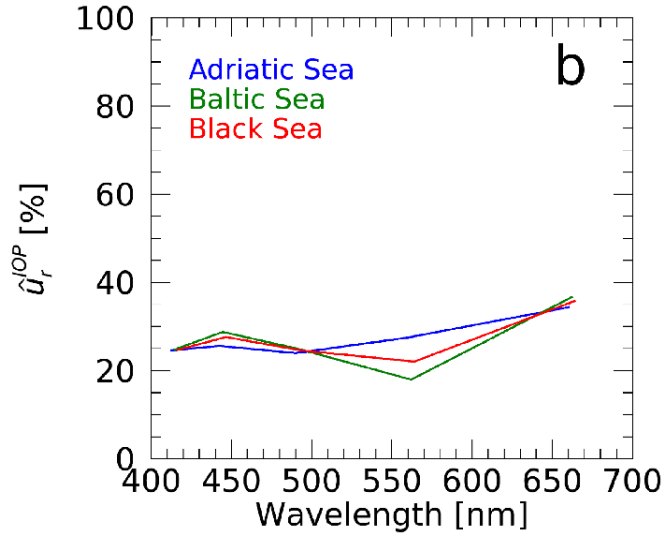


Sampled Spectra





Chla-Based Approach



IOP-Based Approach

Talone, M., Zibordi, G. and Lee, Z., 2018. Correction for the non-nadir viewing geometry of AERONET-OC above water radiometry data: an estimate of uncertainties. *Optics express*, *26*(10), pp.A541-A561.

Quality Control

AERONET-OC products are classified at different levels:

- Level 1.0-> ▪ $L_{WN}(\lambda)$ determined from complete measurement sequences.

- Level 1.5-> ▪ Cloud screened aerosol optical thickness data exist;
  - ▪ Replicate sky and sea radiance measurements exhibit low variance;
  - ▪ Empirical thresholds are satisfied (e.g., exceedingly negative values or high reflectance in the near infrared);

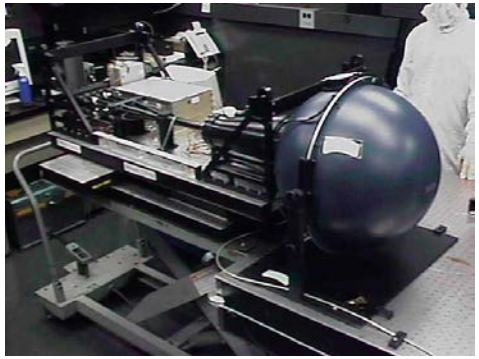
- Level 2.0-> ▪ Pre- and post-deployment calibration coefficients exhibit justifiable differences within 5%;
  - ▪ A final spectrum-by-spectrum screening is passed to determine the consistency of $L_{WN}(\lambda)$ spectral shapes (i.e., their statistical representativity within the data set itself (*self-consistency*) or non-anomalous features with respect to a reference set of quality-assured data (*relative- consistency*), and finally the short-term temporal evolution does not show glitches or systematic daily trends.

G.Zibordi, B.Holben, I.Slutsker, D.Giles, D.D'Alimonte, F.Mélin, J.-F. Berthon, D. Vandemark, H.Feng, G.Schuster, B.Fabbri, S.Kaitala, J.Seppälä. AERONET-OC: a network for the validation of Ocean Color primary radiometric products. Journal of Atmospheric and Oceanic Technology, 26, 1634-1651, 2009.

Radiometric traceability

Each individual radiometer is calibrated at NASA-GSFC using an integrating sphere. Sample radiometers are re-calibrated at the JRC for quality assessment using an FEL-1000 Watts quartz-halogen lamp, and Spectralon 99% reflectance plaques. All calibrations are traceable to the National Institute for Standards and Technology (NIST).

NASA-JRC differences in absolute radiance calibrations are generally better ±2% in the 400-700 nm spectral interval (typically within ±1% as confirmed by NIST, but may have reached ±3% beyond 700 nm before 2016).



NASA calibration rely on GSFC integrating sphere.

JRC calibration rely on a NIST traceable FEL-C 1000W lamp and a 99% Spectralon Reflectance panel.

G.Zibordi, B.Holben, I.Slutsker, D.Giles, D.D'Alimonte, F.Mélin, J.-F. Berthon, D. Vandemark, H.Feng, G.Schuster, B.Fabbri, S.Kaitala, J.Seppälä. AERONET-OC: a network for the validation of Ocean Color primary radiometric products. Journal of Atmospheric and Oceanic Technology, 26, 1634-1651, 2009.

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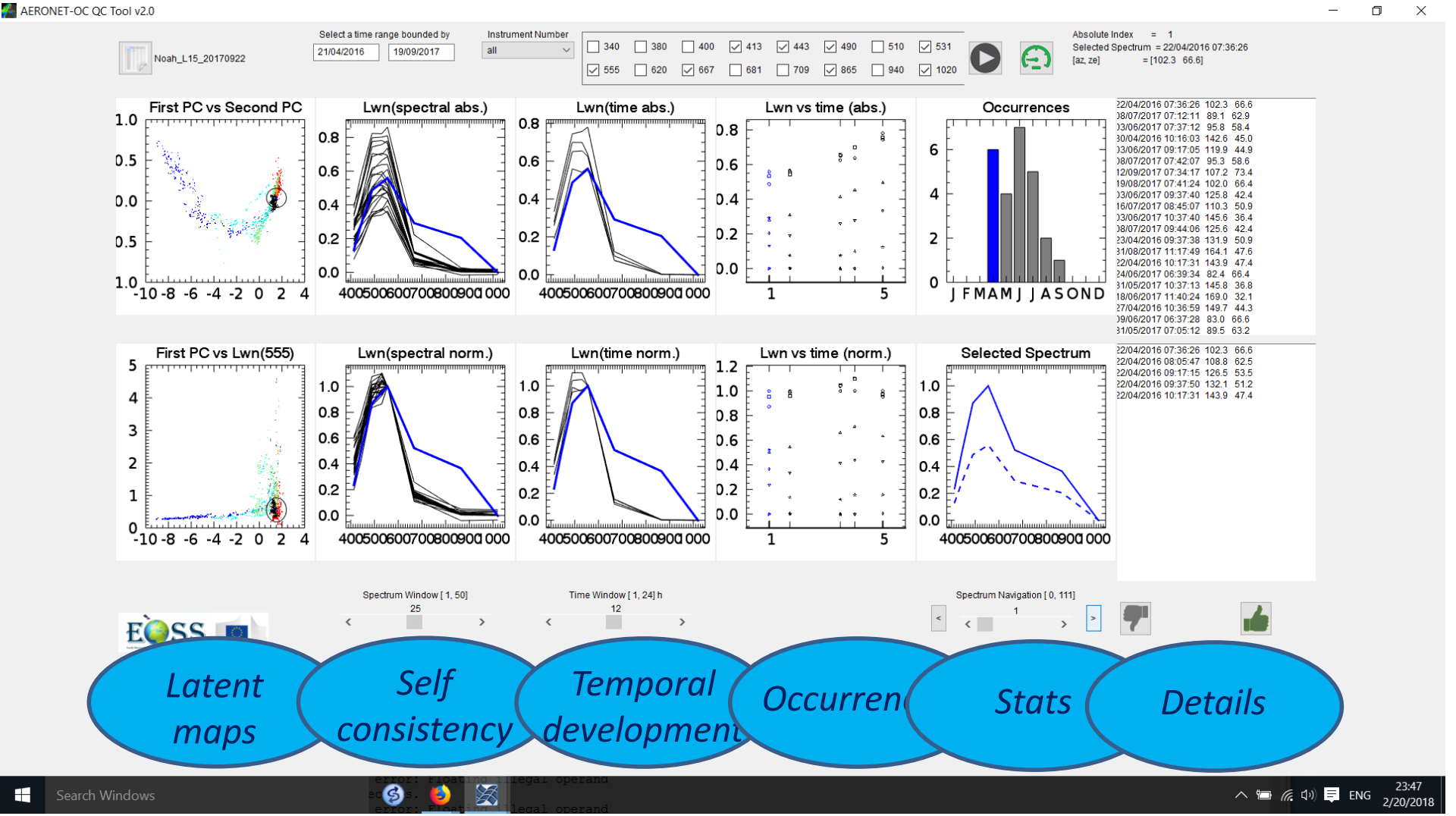
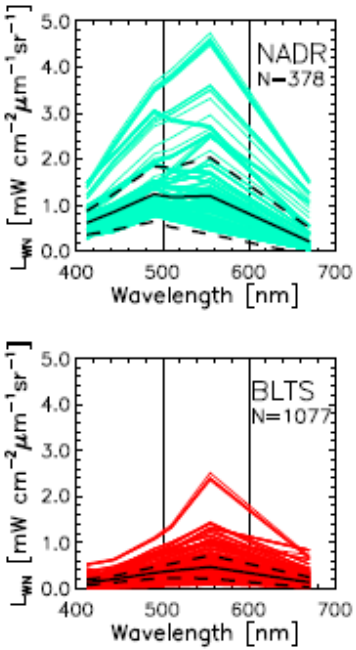
Level-2 data quality control



L_{WN} uncertainties

Relative combined uncertainties ***$u(L_{WN})/L_{WN}$*** *(%) and in square brackets the related combined standard uncertainties* ***$u(L_{WN})$*** *and* ***median L_{WN}*** *(mW cm^{-2} sr^{-1} µm^{-1}), respectively, at different λ (nm) for various AERONET-OC sites.*



λ	412	551	667
AAOT	5.3 [0.038; 0.71]	4.9 [0.049; 1.00]	7.3 [0.010; 0.13]
GLR	8.6 [0.027; 0.31]	5.6 [0.038; 0.67]	9.6 [0.011; 0.11]
AABP	11.1 [0.050; 0.44]	6.8 [0.033; 0.47]	9.5 [0.009; 0.08]
GDLT	16.3 [0.018; 0.11]	5.7 [0.027; 0.47]	6.4 [0.007; 0.10]
HLT	27.4 [0.016; 0.06]	6.7 [0.026; 0.39]	6.9 [0.008; 0.12]

$u(L_{WN})/L_{WN}$ ***$u(L_{WN})$*** ***L_{WN}***

M. Gergely and G. Zibordi, "Assessment of AERONET L_{WN} uncertainties," Metrologia ***51****, 40–47 (2014).*

AERONET-OC: recent developments

Features

- *12 Channels (instead of 9) with two standard configurations for **marine and lake** applications.*
- *Data transmission through Satellite (DCP), Mobile and Radio.*
- *Internal data storage.*
- *Additional programmable functions :*
  - *Daily programmable "sign" of the azimuth offset;*
  - *Programmable number of sea-viewing (i.e., PRS) scenarios;*
  - *Programmable number of PRS data transmitted through DCP.*

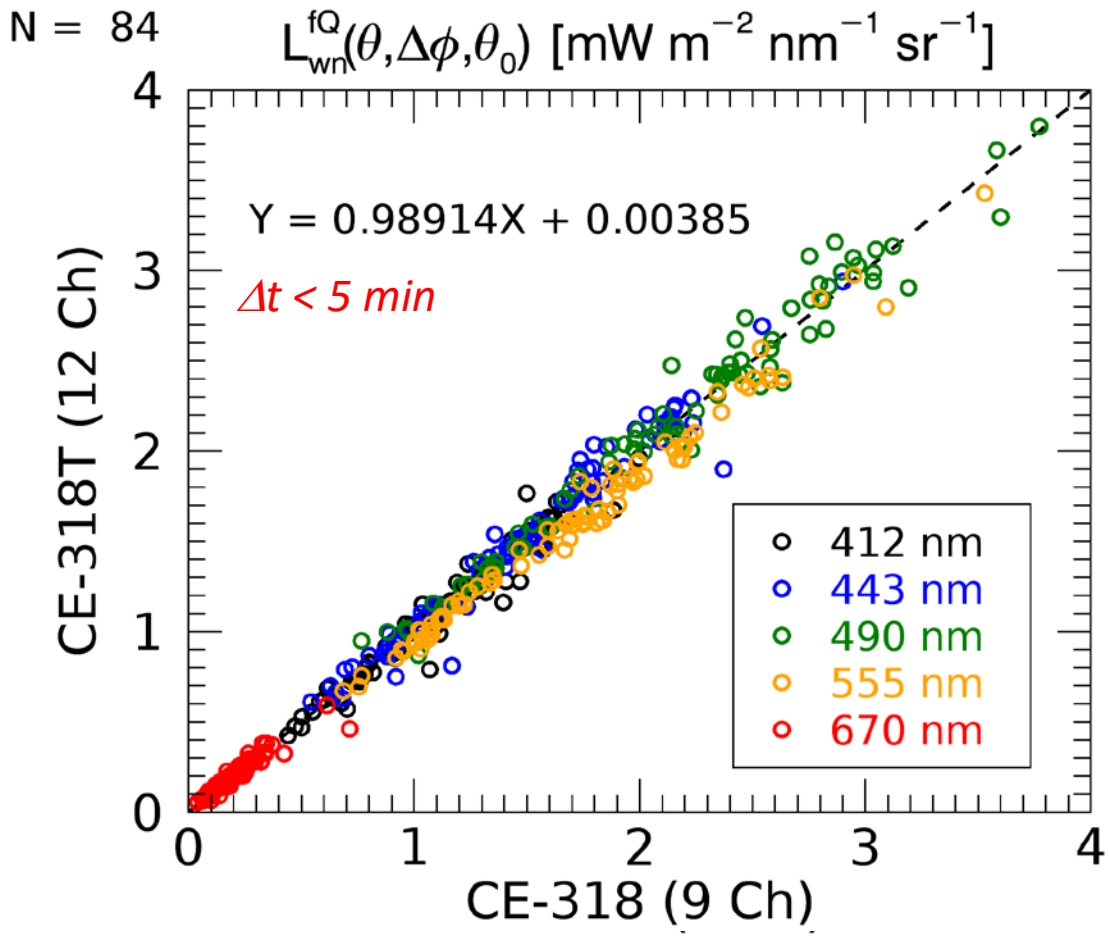
Band setting

Satellite Sensors	Wavelengths [nm]																			
MODIS		412.5	443	488		531	551		667	678		748				870		905	940	
VIIRS (20 nm)		412	445	488			555		672			746			865					
OLCI (10 nm)	400	412.5	442.5	490	510		560	620	665	681	709	754	...	779	865		885	900	940	1020

AERONET-OC										Wavelengths [nm]										
PRS-09		412	443	488		531	551		667							870			940	1020
PRS-12 (sea)	400	412.5	442.5	490	510		560	620	665					779	865				940	1020
PRS-12 (lake)		412.5	442.5	490	510		560	620	667	681	709				865				940	1020

Assessment of performances

How the new 12-channel and the previous 9-channel AERONET-OC data compare?



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Summary

AERONET-OC is an operational network delivering globally distributed and cross-site consistent measurements of τ_a and L_{WN} at coastal and occasionally at open sea sites.

Qualifying element is the capability of delivering in almost real time both, τ_a and L_{WN} based on standardization of its network components and metrology principles.

Major application is the validation of satellite ocean color primary data products. However, it also offers the capability of supporting climatological studies on atmospheric and marine processes.

Thanks

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An assessment of superstructure perturbations (AAOT, September 2018)