

Evaluation of the EnMAP L2A water product by intercomparison to other atmospheric correction retrievals and validation with hyperspectral and multispectral *in situ* measurements

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Atmospheric Correction (AC) over Water

Determine the water leaving reflectance ($[pW]_N$ or $[pW]$) from top of atmosphere (TOA) radiances ($[L_{TOA}]$).

Intercomparison of AC methods as update to Soppa et al. 2024

(<https://doi.org/10.1364/OE.523813>)

MIP EnMAP L2A, 01.05.02 (4 updates since Soppa et al. 2024)

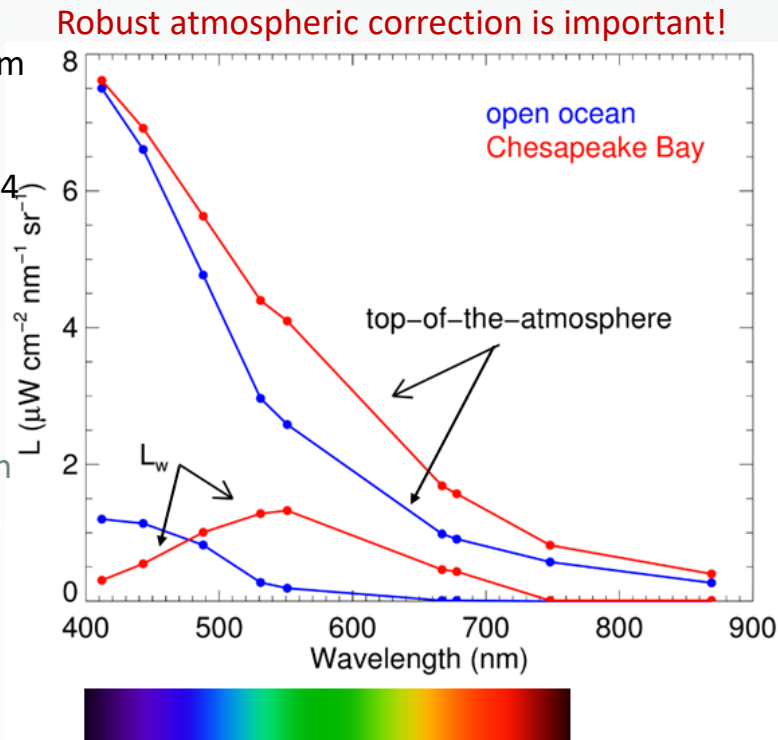
Acolite (update to Soppa et al. 2024)

Polymer processor MSI inland water, ACWater implementation v4.16.1 (=Soppa2024*,**) –

PACO-WASI: new sunglint & skyglint corr. (talk by P. Gege)

*Processing for 2024 matchups pending

** update to v5 planned for fall 2025

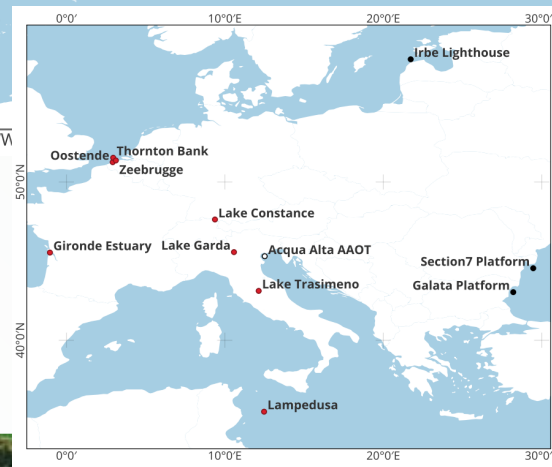
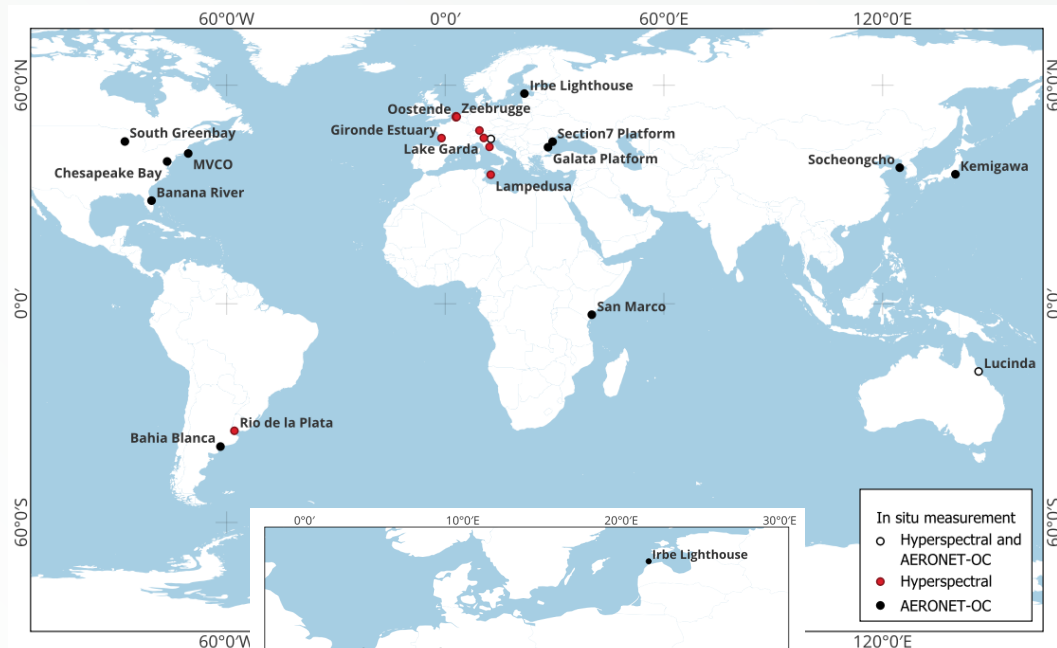


<https://coastwatch.gitbook.io/satellite-course/lectures/ocean-color>

L_w is only a small part of L_{TOA} (max. 10%)!

In-situ validation sites for EnMAP-AC

Sites	Location	In situ measurement
Acqua Alta AAOT	45.31°N, 12.51°E	Hyperspectral and AERONET-OC
Bahia Blanca	39.14°S, 61.72°W	AERONET-OC
Banana River	28.37°N, 80.63°W	AERONET-OC
Chesapeake Bay	39.12°N, 76.35°W	AERONET-OC
Galata Platform	43.04°N, 28.19°E	AERONET-OC
Gironde Estuary	45.54°N, -1.04°W	Hyperspectral
Irbe Lighthouse	57.75°N, 21.72°E	AERONET-OC
Kemigawa	35.61°N, 140.02°E	AERONET-OC
Lake Constance	47.63°N, 09.37°E	Hyperspectral
Lake Garda	45.57°N, 10.57°E	Hyperspectral
Lampedusa	35.49°N, 12.47°E	Hyperspectral
Lucinda	18.52°S, 146.39°E	Hyperspectral and AERONET-OC
Oostende	51.25°N, 02.92°E	Hyperspectral
MVCO	41.32°N, 70.57°W	AERONET-OC
Rio de la Plata	34.81°S, 57.89°W	Hyperspectral
San Marco	02.94°S, 40.21°E	AERONET-OC
Section7 Platform	44.55°N, 29.45°E	AERONET-OC
Socheongcho	37.42°N, 124.74°E	AERONET-OC
South Greenbay	44.60°N, 87.95°W	AERONET-OC
Thornton Bank	51.53°N, 2.95°E	Hyperspectral
Lake Trasimeno	43.12°N, 12.13°E	Hyperspectral
Zeebrugge	51.36°N, 3.12°E	Hyperspectral

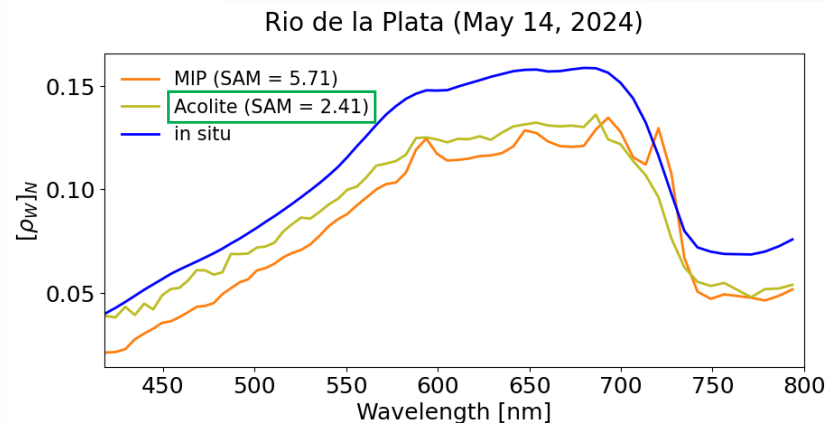


In situ measurement
 ○ Hyperspectral and AERONET-OC
 ● Hyperspectral
 ● AERONET-OC

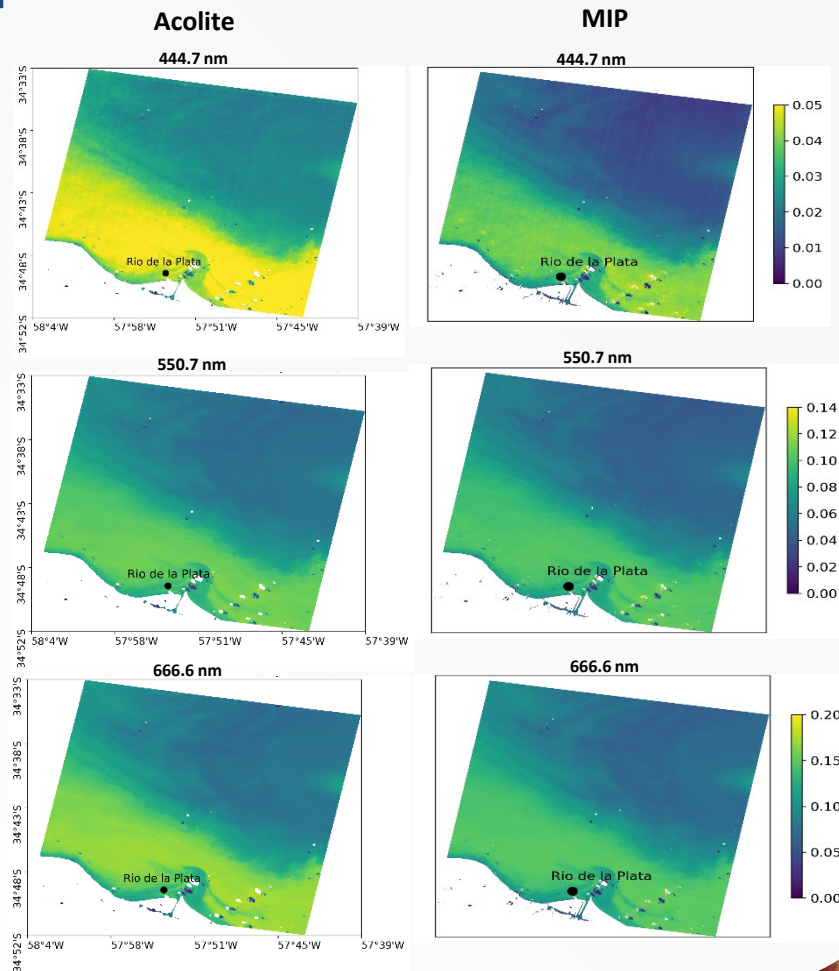
In situ hyperspectral measurements were provided by the PIs of each site.

Example comparison hyperspectral in-situ [ρ_w] vs. EnMAP-AC MIP [ρ_w]_N & Acolite [ρ_w]

Rio de le Plata (May 14, 2024)

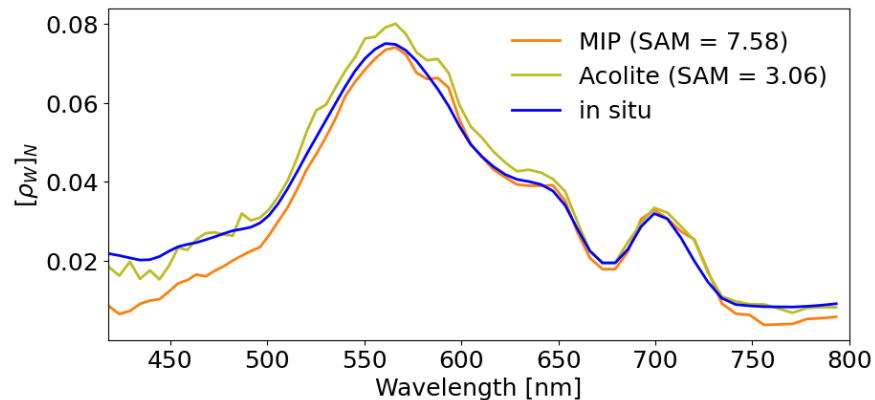


The median EnMAP spectra of the 3 x 3 pixel box around the validation site: MIP in orange and Acolite in light green

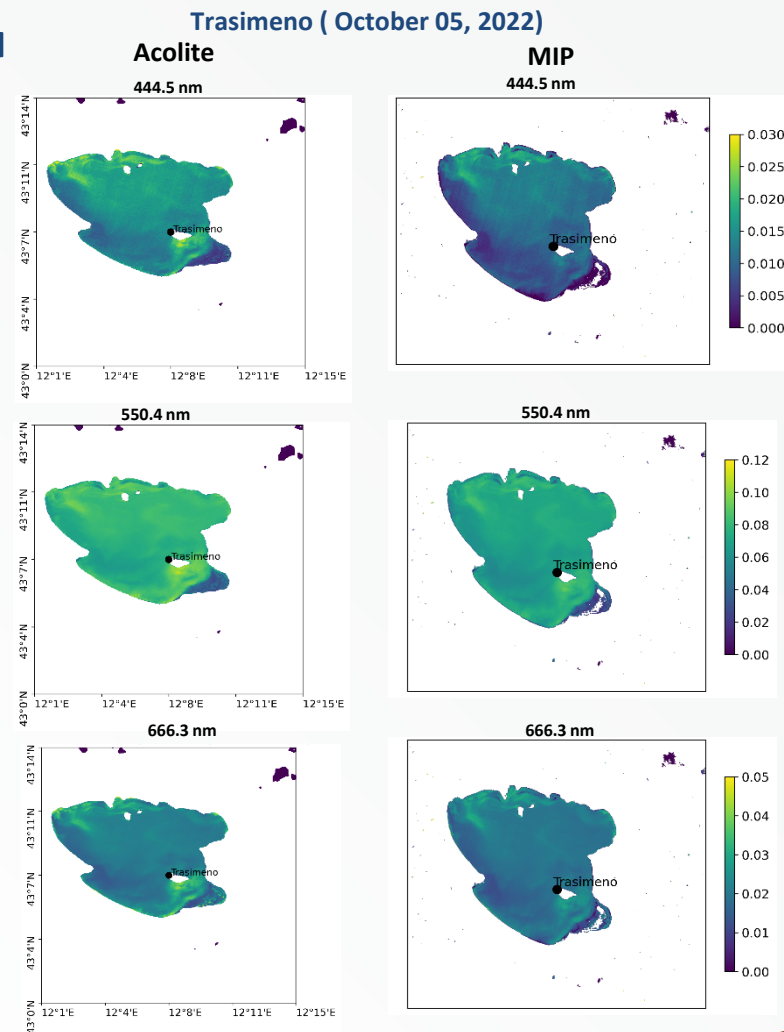


Example comparison hyperspectral in-situ [ρ_w] vs. EnMAP-AC MIP [ρ_w]_N & Acolite [ρ_w]

Lake Trasimeno (October 05, 2022)



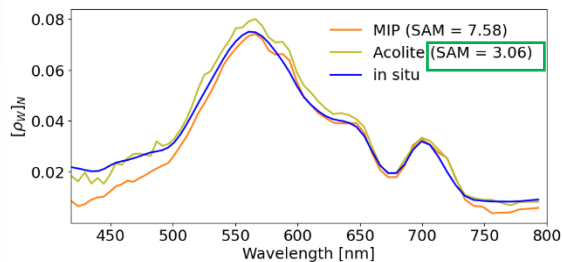
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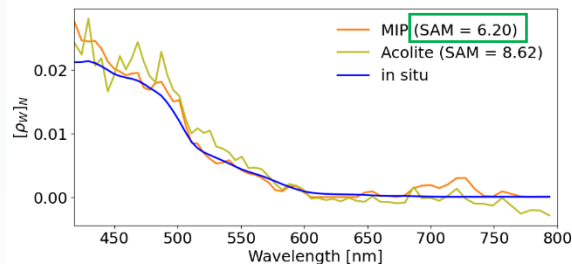
Example matchups *in-situ* [pW] vs. EnMAP-AC MIP [pW]_N & Acolite [pW]

The lower the SAM value, stronger the spectral similarity between *in situ* and EnMAP-AC.

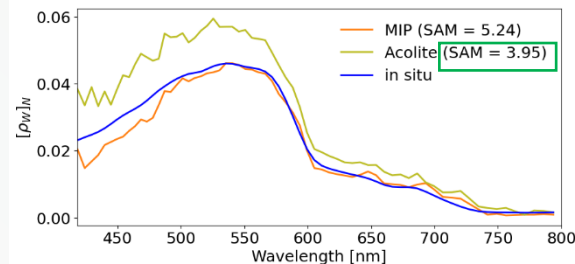
Lake Trasimeno (October 05, 2022)



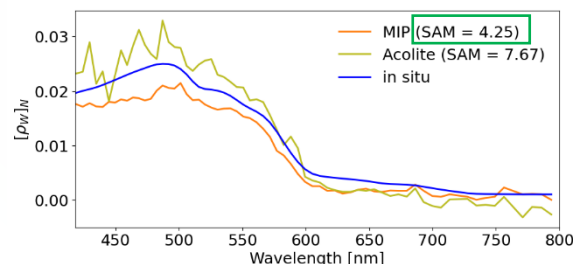
Lampedusa (March 27, 2023)



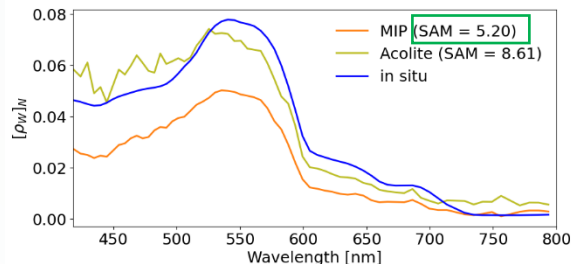
AAOT (November 07, 2023)



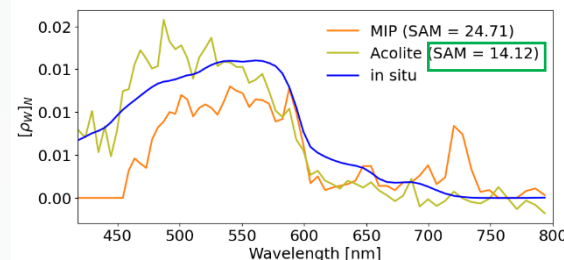
AAOT (July 29, 2023)



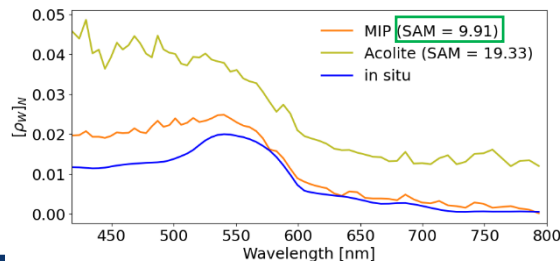
Lake Garda (August 10, 2024)



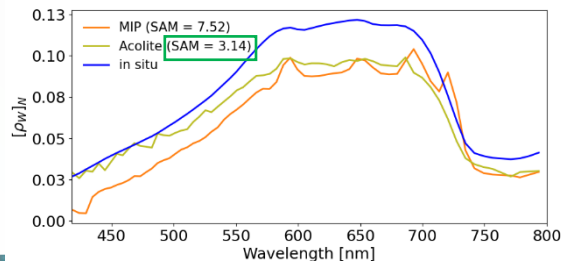
Lake Garda (December 24, 2024)



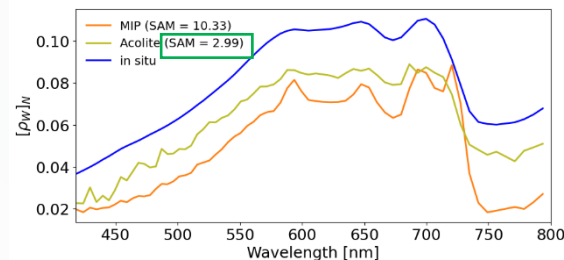
Lake Garda (July 11, 2024)



Rio de la Plata (July 07, 2024)

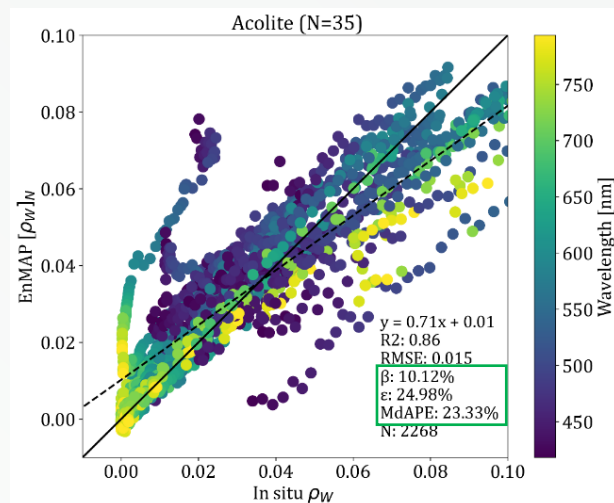
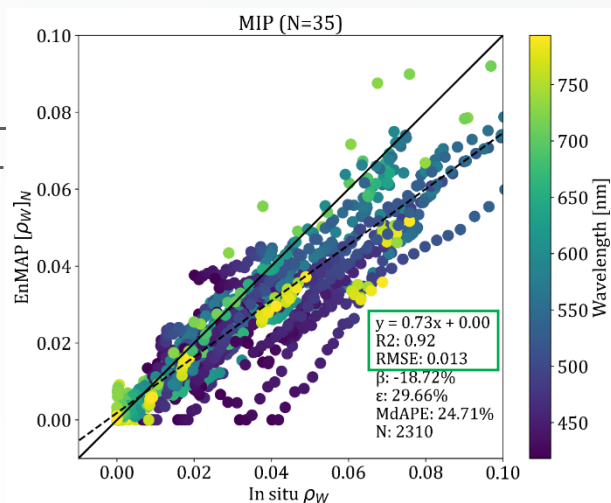


Rio de la Plata (December 04, 2024)

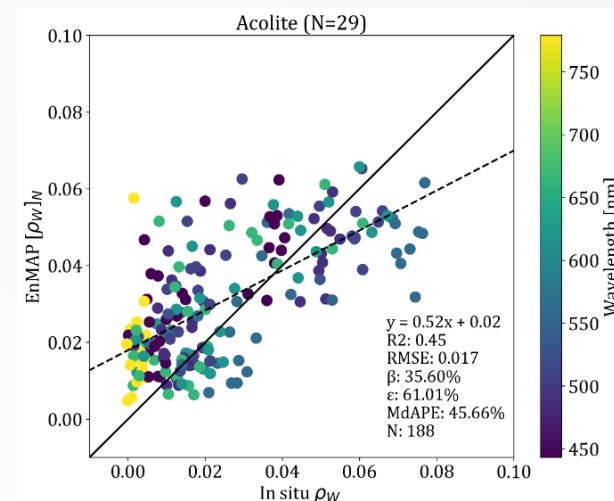
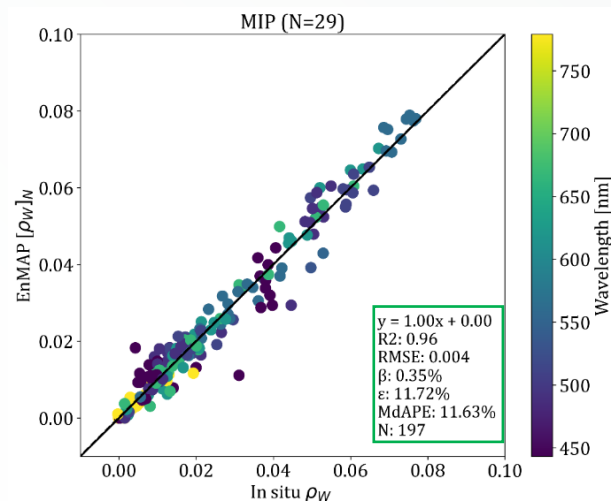


Matchups in-situ [ρ_W] vs. EnMAP-AC MIP [ρ_W]_N & Acolite [ρ_W]

vs. same hyper-
spectral match-
ups (N=29).

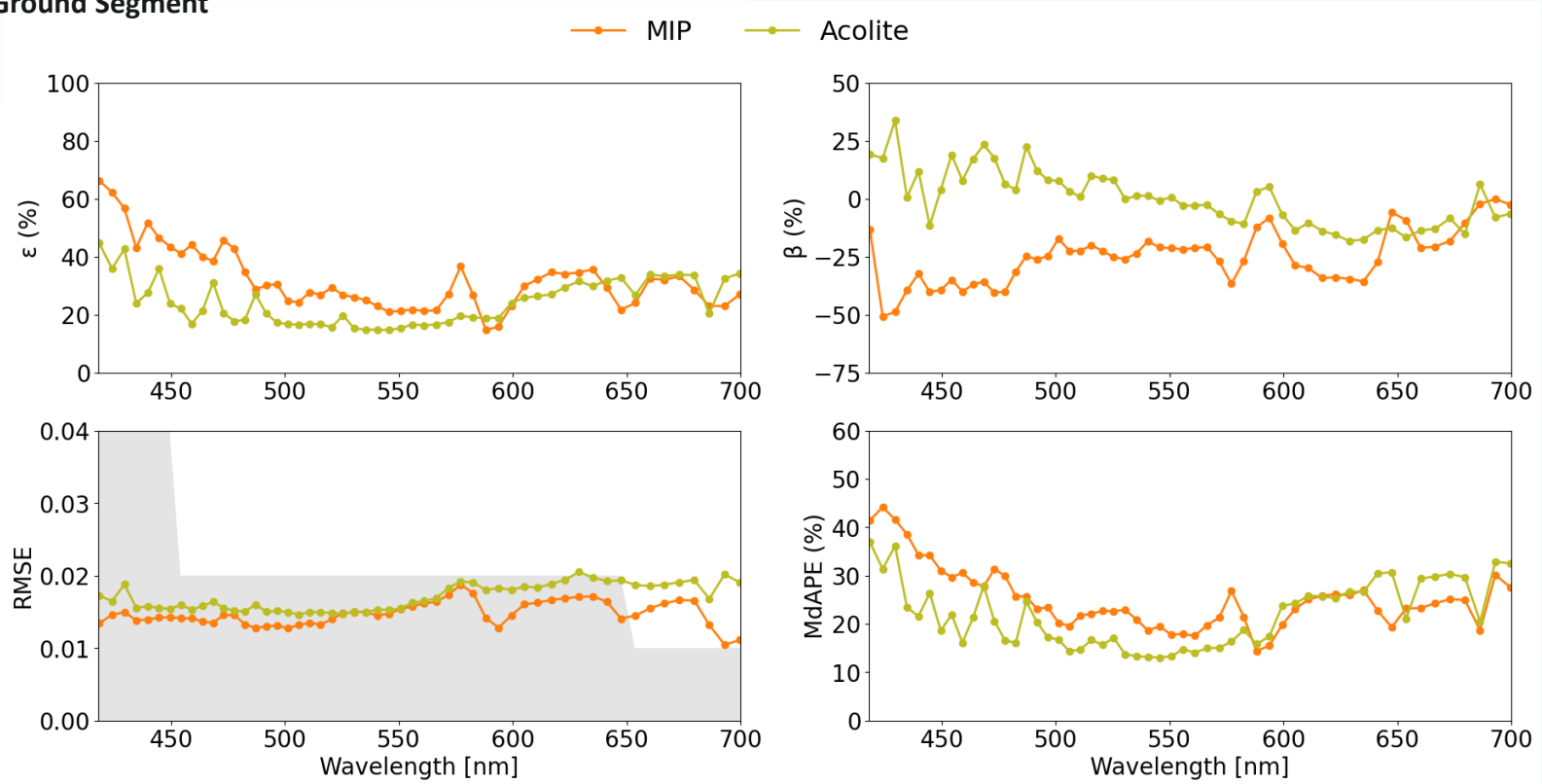


vs. same multi-
spectral match-
ups (N=29).



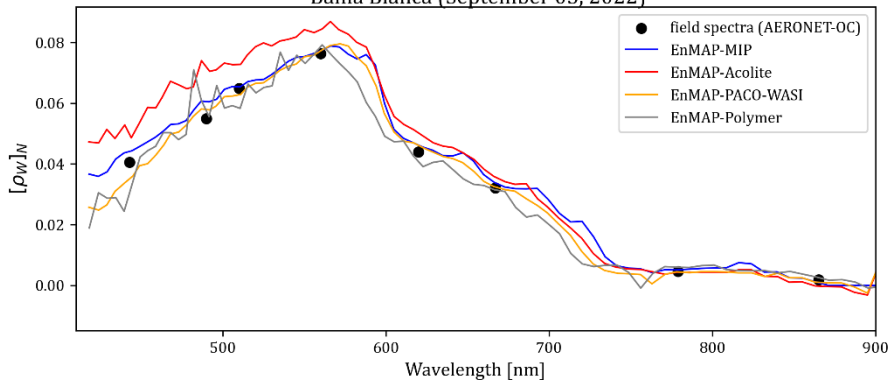
Spectra of ϵ , β , RMSE and MdAPE for MIP and Acolite for hyperspectral match-ups

Grey = required uncertainty (RMSE) outside of strong atmospheric absorption regions and for AOT at 550 nm lower than 0.4 as defined by EnMAP Ground Segment

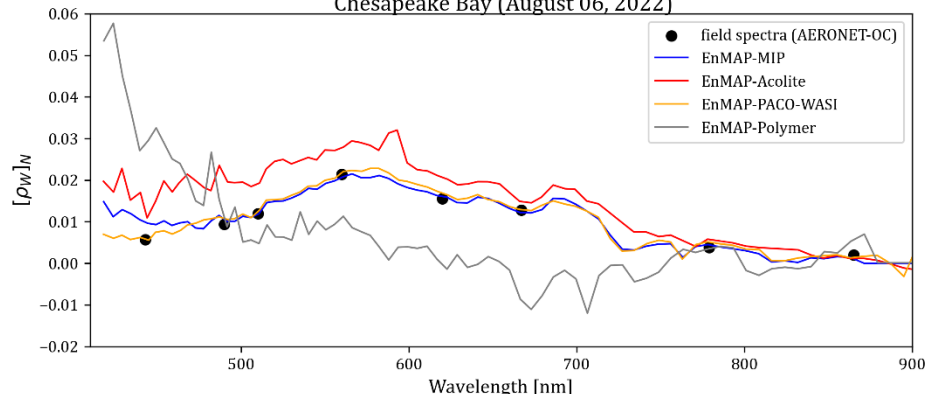


Comparison of EnMAP [pW]_N or [pW] from MIP, Acolite, PACO-WASI, and Polymer (ACWater) to multispectral in-situ match-ups

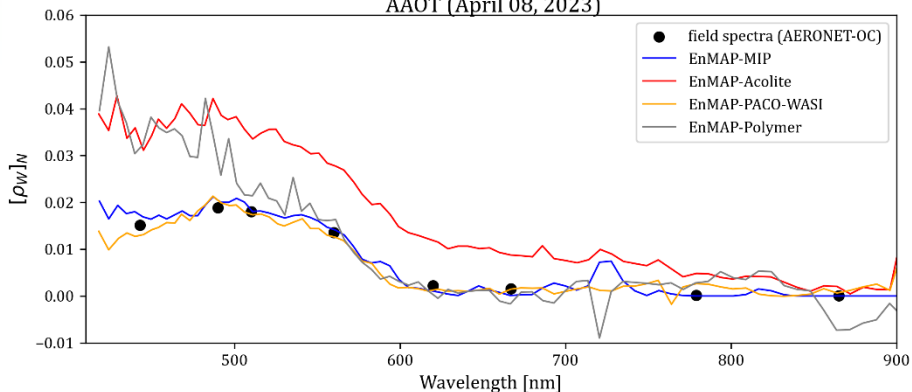
Bahia Blanca (September 05, 2022)



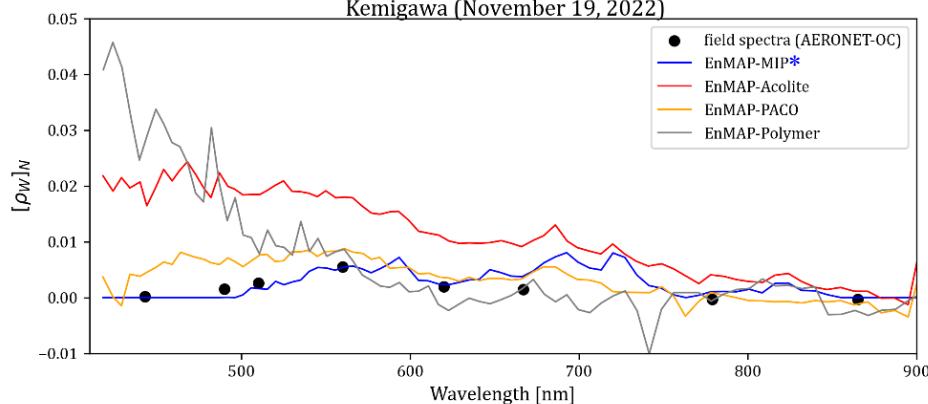
Chesapeake Bay (August 06, 2022)



AAOT (April 08, 2023)



Kemigawa (November 19, 2022)



*MIP: will be updated to turbid output!

Summary & Outlook

- In 2024 in-situ matchups for water reflectance validation doubled as compared to 2022-2023 (Soppa et al. 2024), benefitting from new installations of many automated hyperspectral in-situ stations (WATER-HYPERNET, ...).
- EnMAP L2A (MIP; v01.05.02) performs similar for all hyperspectral bands, and even better when just considering AERONET-OC bands, as compared to assessment by Soppa et al. (2024) and within mission requirements.
- Similar performance of EnMAP-MIP (better R2, slope, intercept) to Acolite (lower bias and errors) and better performance of MIP compared to Acolite regarding comparison to hyperspectral and multispectral in-situ matchups, respectively.
- First results from WASI-PACO to AERONET-OC matchups show promising results and similar to MIP.
- Complete comparison of four (MIP, ACOLITE, PACO-WASI, ACWATER) AC methods planned for mid 2025.
- Monitoring of level 2 EnMAP water product will continue in 2025 – 2026 and hopefully beyond.

THANK YOU



- **Funding.**

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