Hyperspectral EnMAP Data Processing for Aquatic Science and Applications

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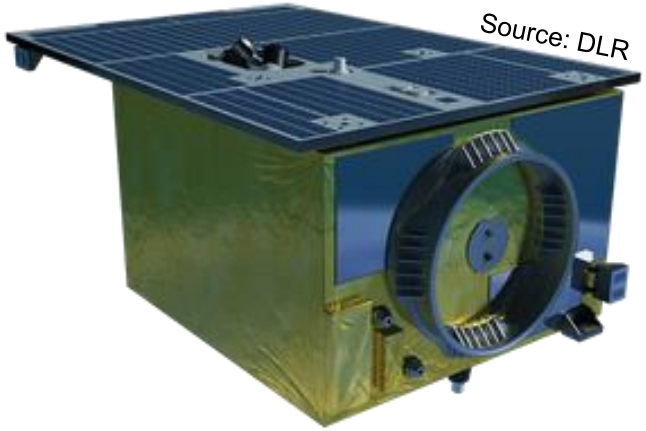
Federal Ministry for Economic Affairs and Climate Action

EnMAP Mission (www.enmap.org)



Project Management
DLR Space Agency

Scientific Principal Investigator
GFZ Potsdam

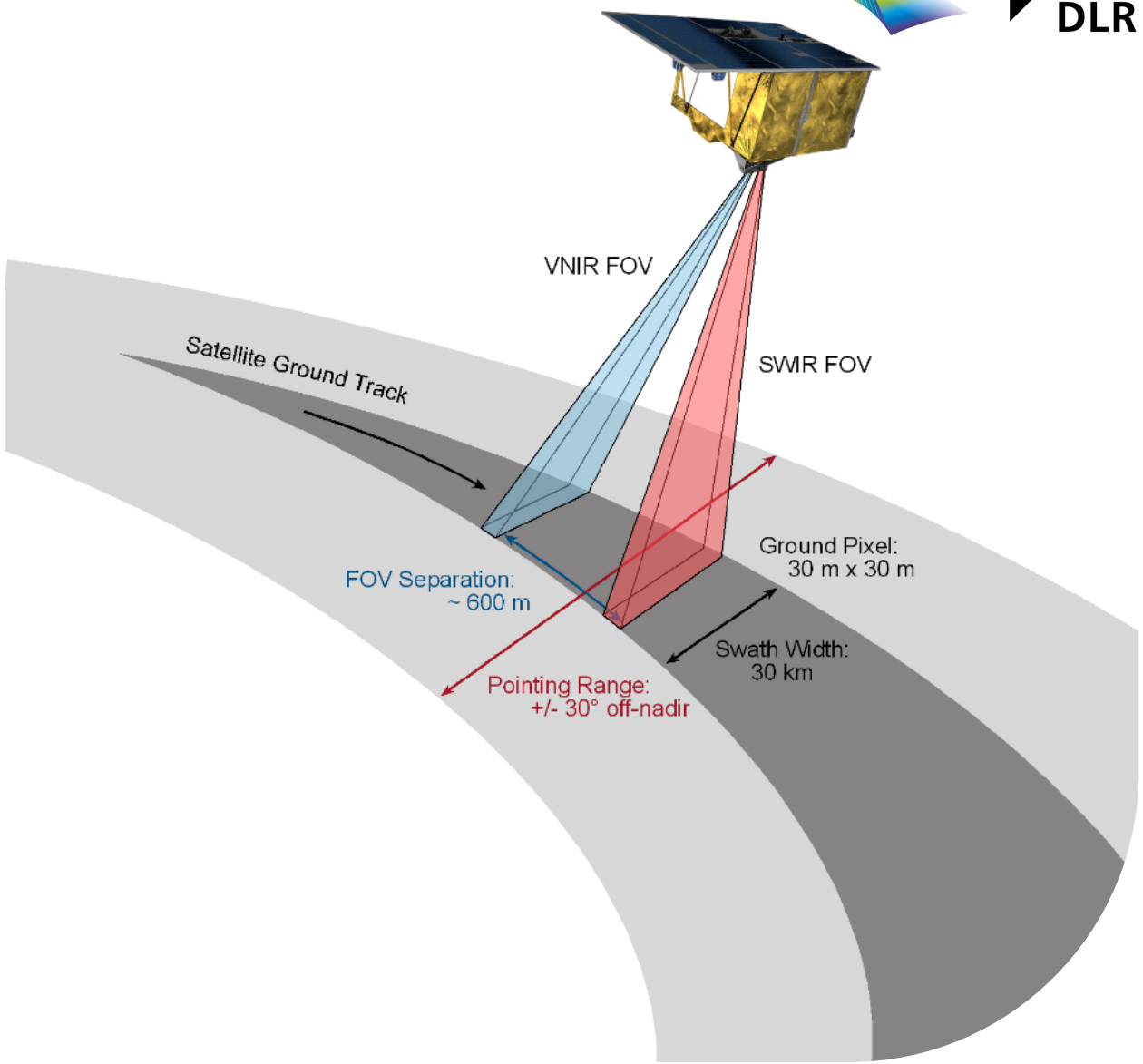
EnSAG

Space Segment

Sensor | Platform

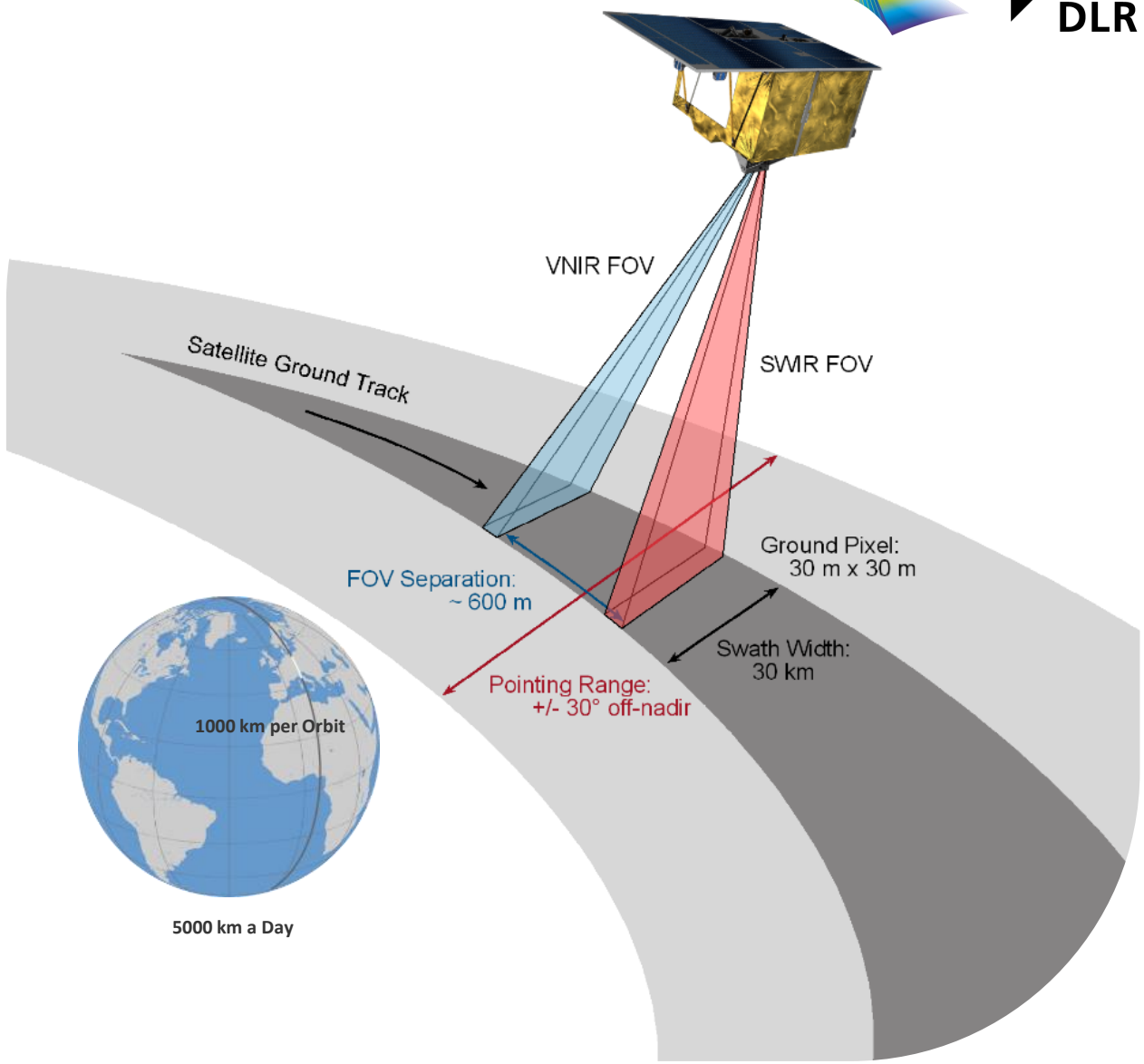
Ground Segment

Operations *DLR-GSOC* | Payload *DLR-DFD* | Processing *DLR-IMF*



EnMAP Mission

EnMAP specification	VNIR	SWIR
Spectral range	420 – 1000 nm	900 – 2445 nm
Number of spectral bands	91	133
Spectral sampling distance	6.5 nm	10 nm
Spectral full width at half maximum	6 – 11 nm	7 – 11 nm
Spectral accuracy	0.5 nm	1 nm
Signal-to-noise ratio	>500 (at 495 nm)	>150 (at 2200 nm)
Radiometric accuracy	<5%	
Radiometric stability	<2.5%	
Orbit type, altitude and inclination	Sun-synchronous, 653 km, 97.96°	
Orbit period and repeat cycle	1.6 h, 398 revolutions in 27 days	
Local time descending node	11:00 h ± 18 min	
Revisit time	4 days (±30° off-nadir tilt) 27 days (±5° off-nadir tilt)	
Ground sampling distance	30 m (at nadir; sea level)	
Swath width	30 km (2.63° across track)	
Swath length	1000 km / orbit; 5000 km / day	
Product size / type	30 km x 30 km / L1B, L1C, L2A	



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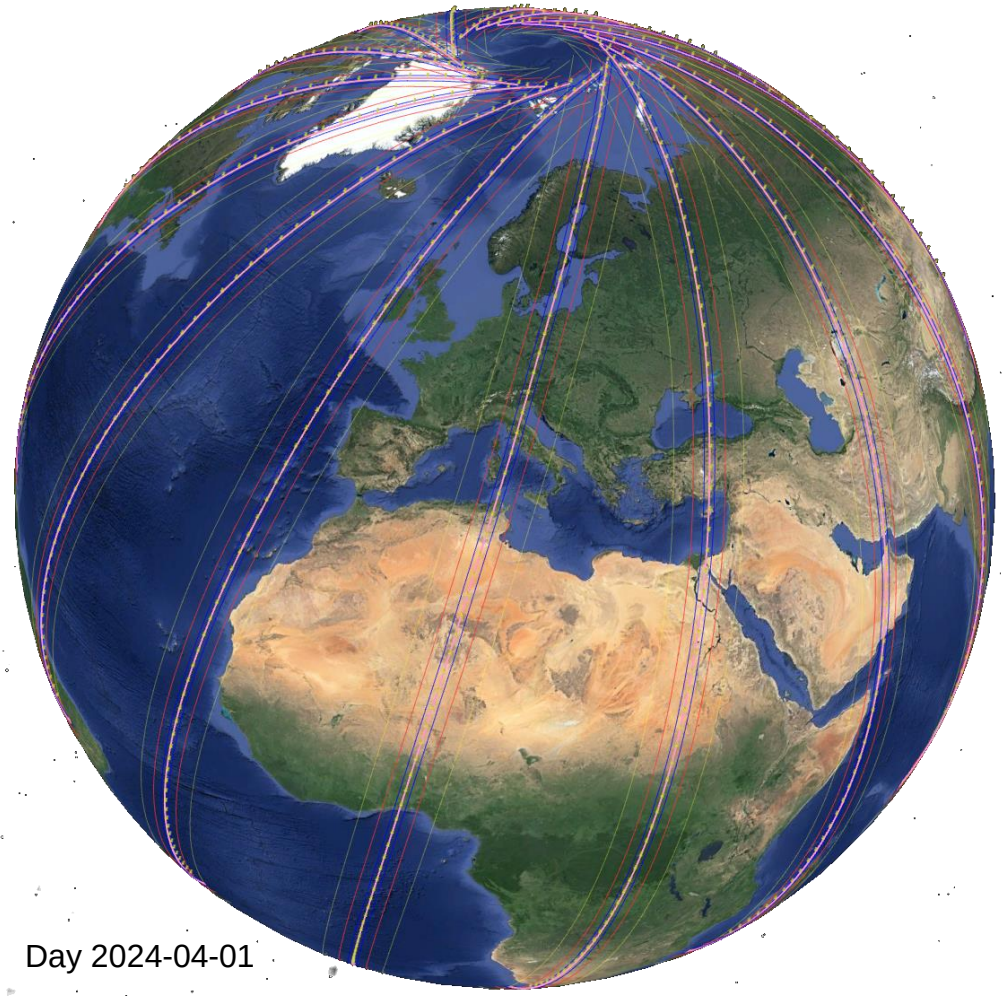
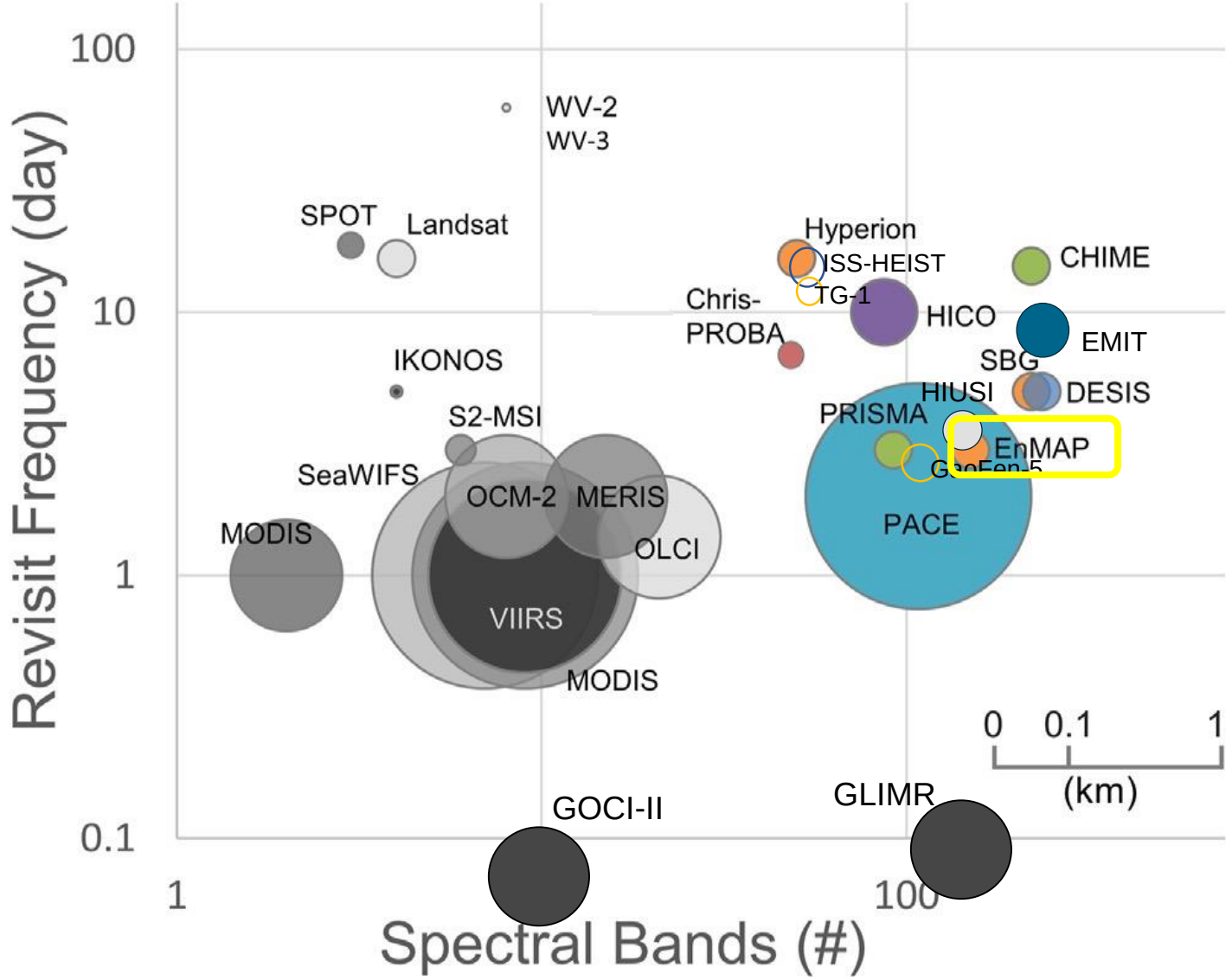
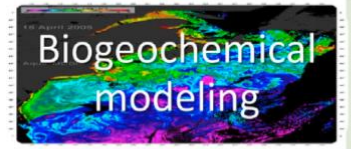


Day 2024-04-01

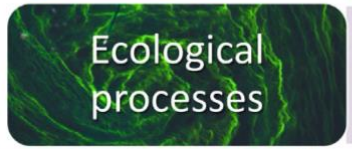
Hyperspectral Aquatic Remote Sensing



- latitudinal distributional shifts
- phenology shifts
- bloom dynamics



- phytoplankton community composition
- nutrient cycling
- export of particles



- rates of primary production
- nitrogen fixers, DMS producers, silicifiers, calcifiers
- trophic dynamics & food web efficiency

- hypoxia
- eutrophication
- informed monitoring and assessment

- meeting thresholds
- species composition
- detecting anomalies

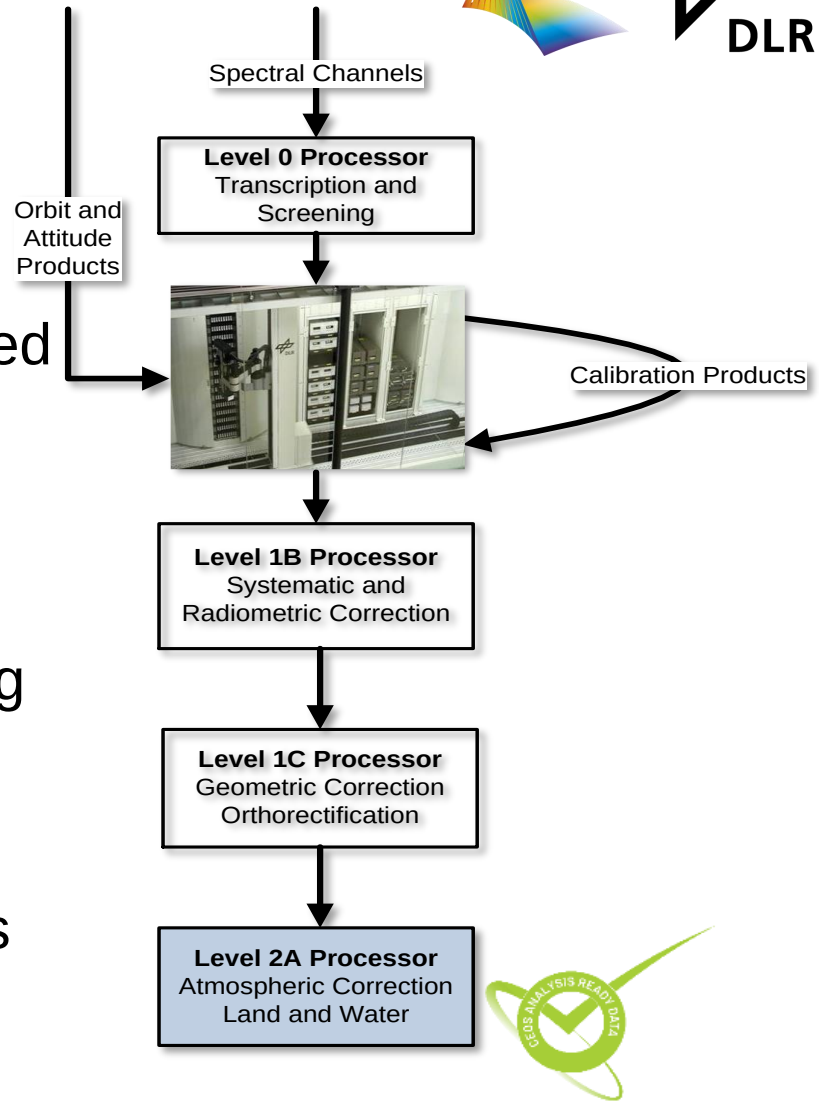
- detection and tracking of harmful algal blooms
- assessing storm impacts
- monitoring oil spill extent and cleanup

- finding pelagic and benthic habitats for fisheries
- locations/monitoring for aquaculture
- food safety & toxin production

Modified from Dierssen et al., 2020 and 2021

EnMAP Data Products

- **Level 1 B**
  - top-of-atmosphere radiance
- **Level 1C**
  - geometrically corrected (orthorectified) and re-sampled to a specified grid
- **Level 2 A**
  - Converts Level 1C products to surface reflectances separately for land and water applications.
  - This split procedure is quite unique in data processing
- Calibration of the instrument during operations
- Quality control of the products.
- Official EnMAP products fullfil strict mission requirements that are validated extensively



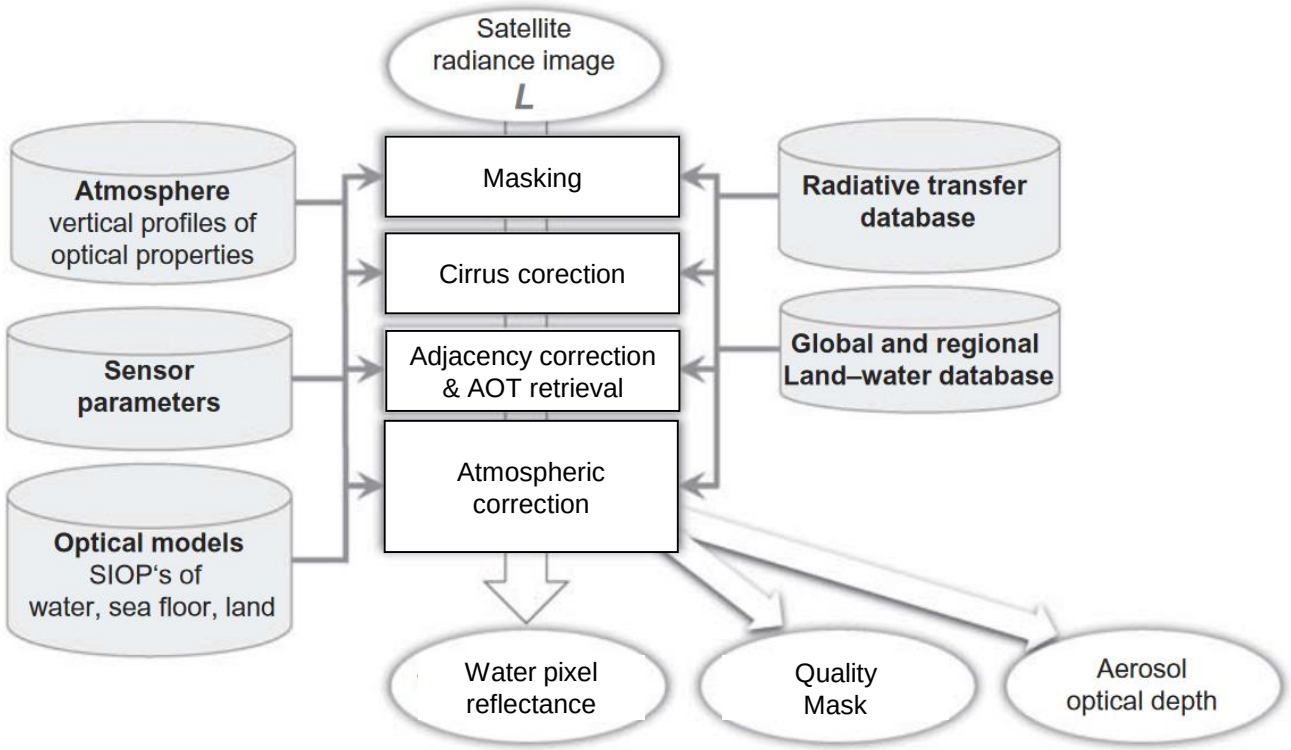
L2A Products

L2A Land
(PACO)

L2A combined
PACO and MIP

L2A Water
(MIP)

EnMAP L2A Water-related Ground Segment Processor



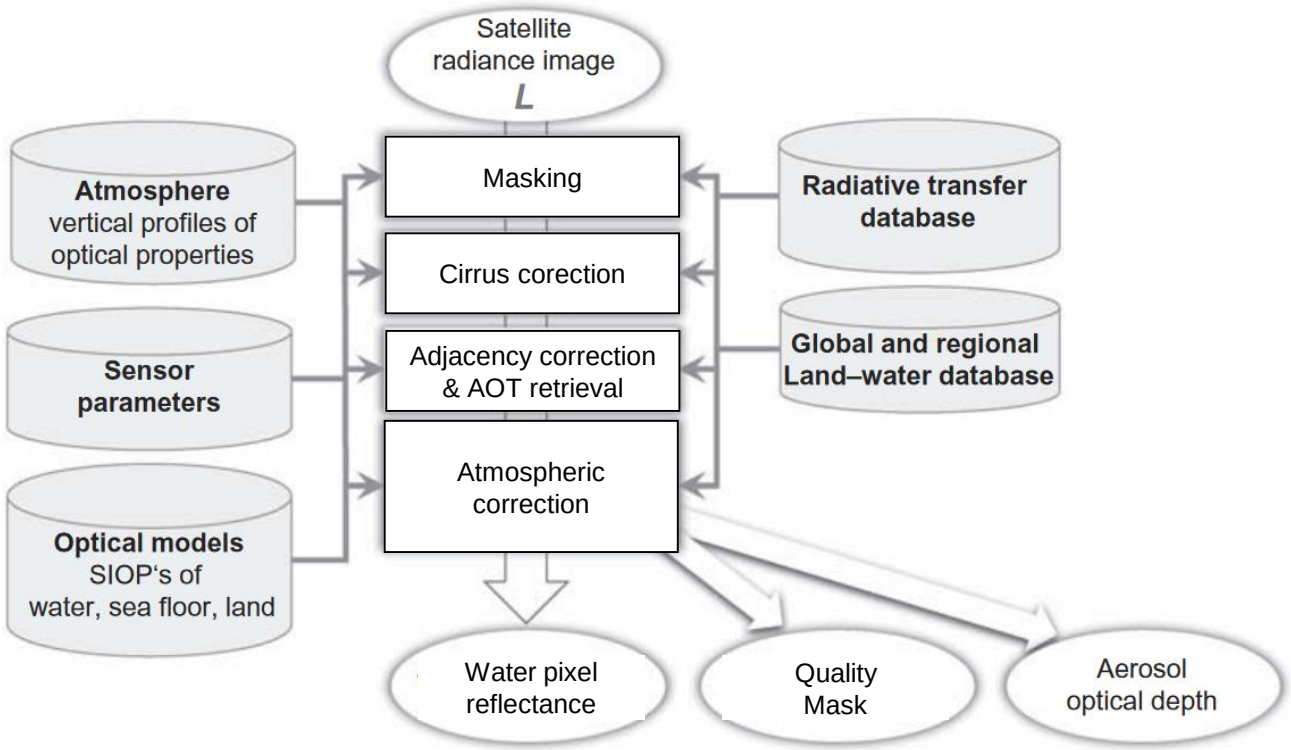
Modular Inversion Processor (MIP)

Fully physics-based processor for EnMAP AC correction over water, includes coupled AC-water retrieval

L2A User Parameters:

- **Correction_Type**
  (Combined, Land, Water)
- **Terrain_Correction**
  (Automatic, Yes, No)
- **Band_Interpolation**
  (Yes, No)
- **Cirrus_Haze_Removal**
  (No, Cirrus, Cirrus/Haze)
- **Ozone_Column**
  (Automatic, Custom Value)
- **Season**
  (Automatic, Summer, Winter)
- **Water_Type**
  (Clear, Turbid, Highly Turbid)
- **Water_Reflectance_Product**
- (Normalized_Rrs, Subsurface_RE)

EnMAP L2A Water-related Ground Segment Processor



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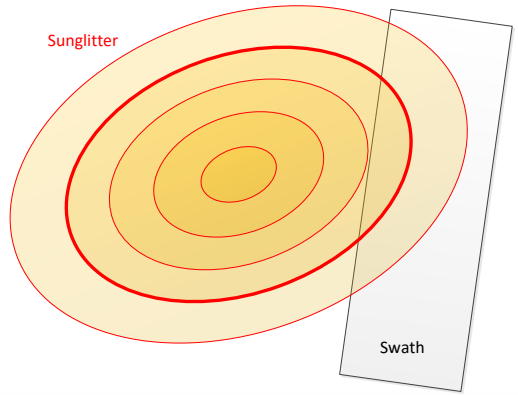
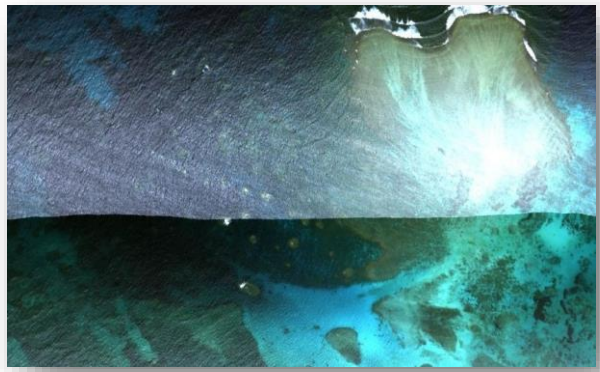


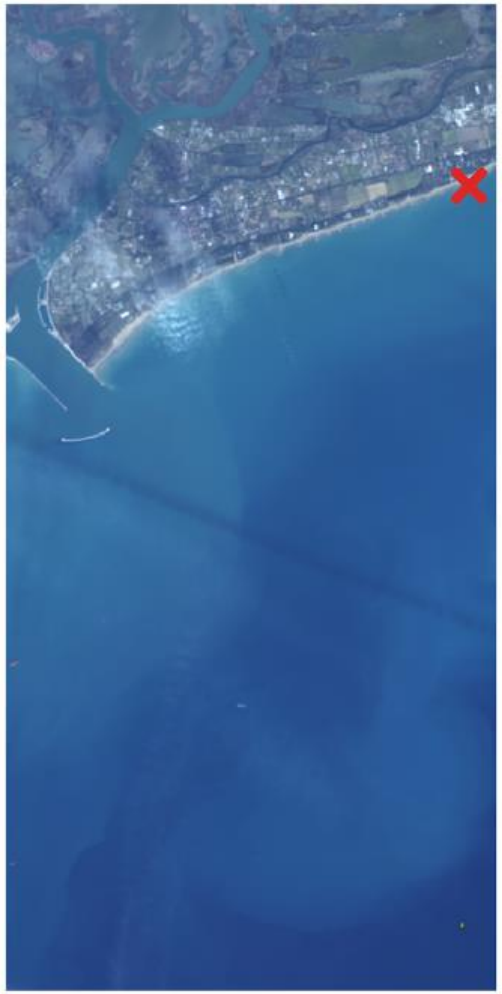


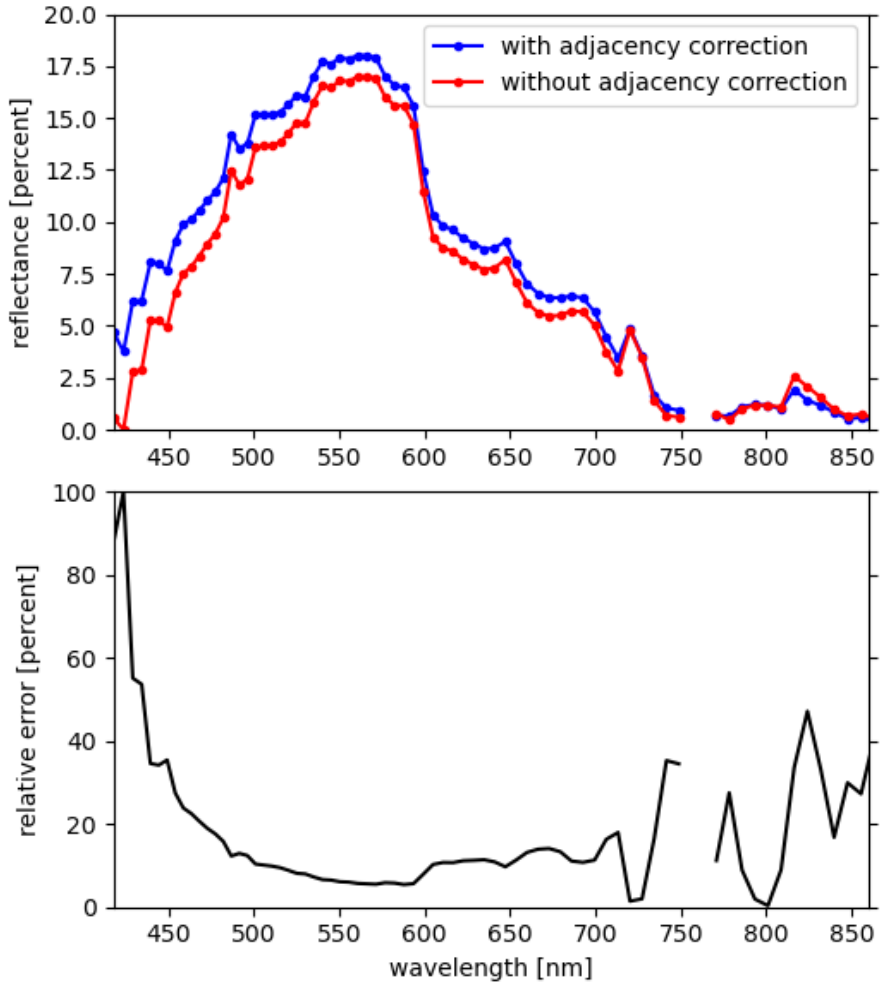
Sunglint avoidance algorithm

Maximum coverage of areas affected by sunglint will be considered during acquisition planning

L2A Water Spectra

Adjacency correction was re-activated in processor version V01.04.00 (Sep 2023)



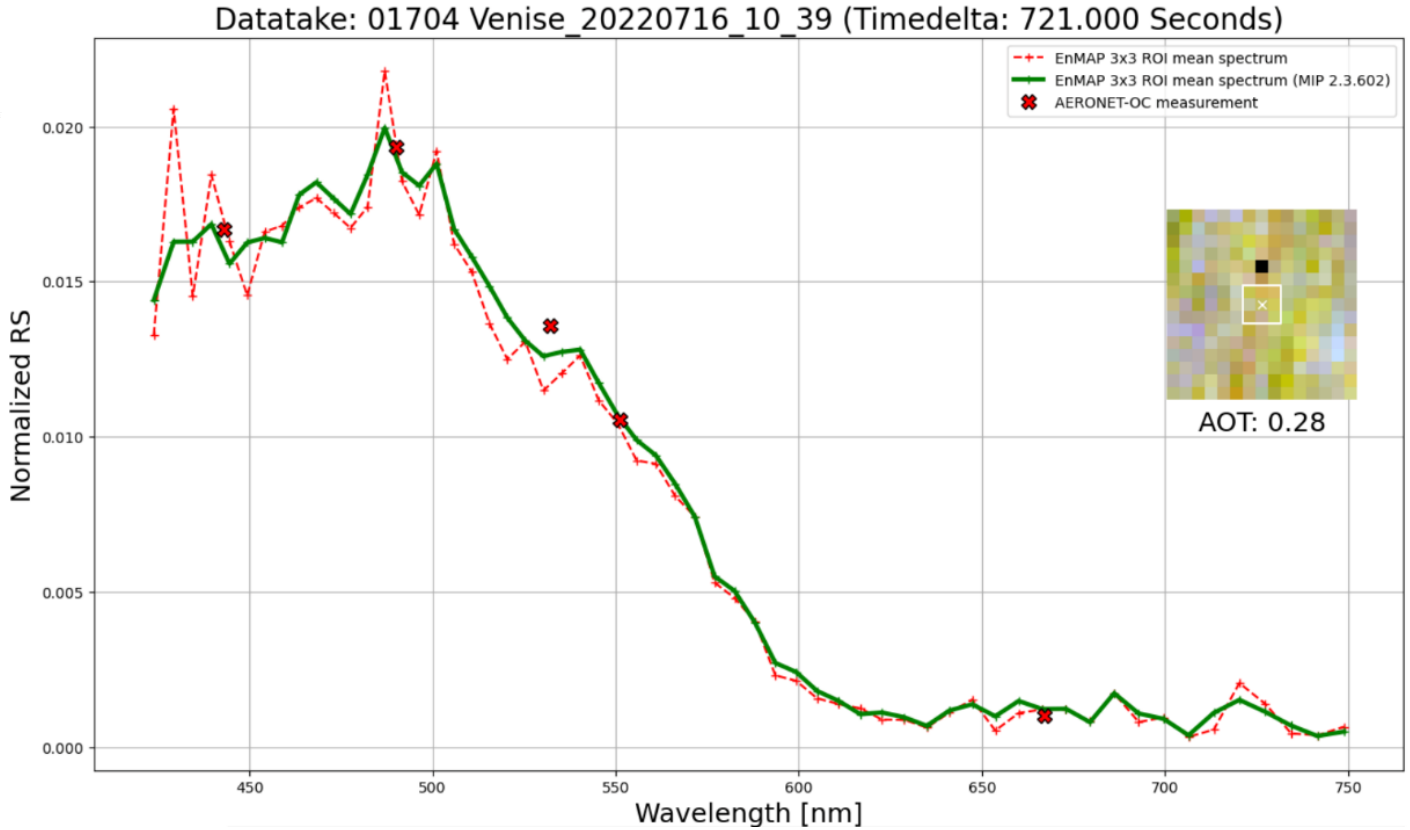


Bay of Venice, 2023-03-16 , adjacency radiance for band 10 at 463nm

L2A Water Spectra

Spectral noise below 500 nm fixed in processor version V01.04.02 (Mar 2024)

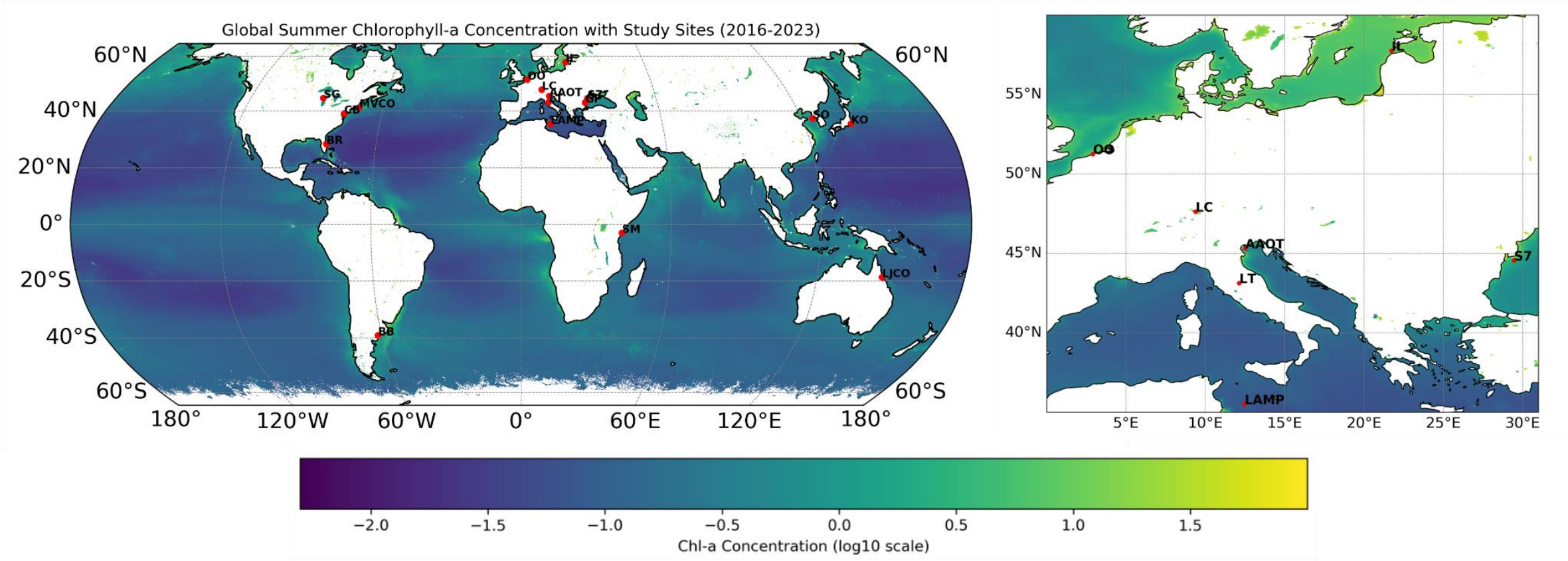
Bay of Venice, 2022-07-16



Users may simply re-order their products to benefit from improvements

Validation of EnMAP L2A Water Product

in-situ hyper- and multispectral radiometry



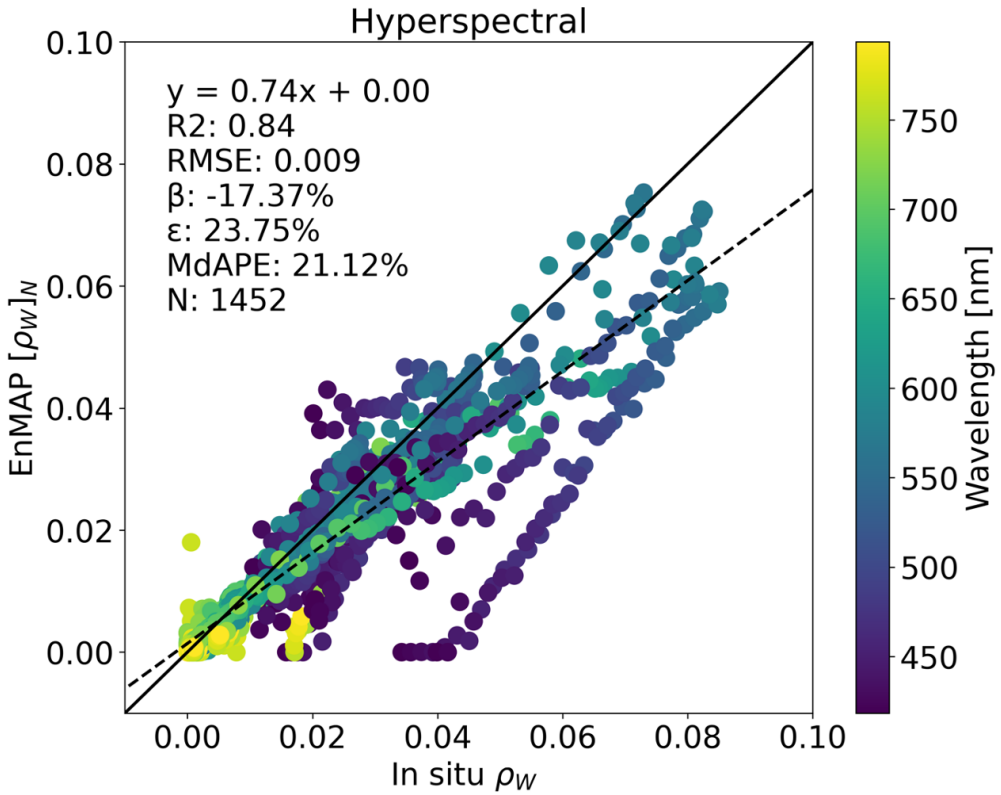
Soppa et al. in review (Optics Express)

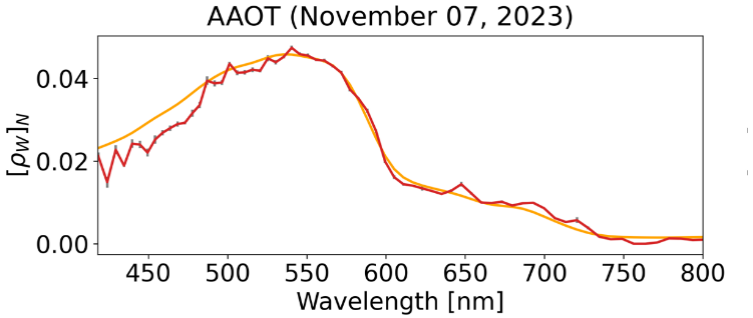
Also Talk on Thursday on 11:45 (Session 3.4)

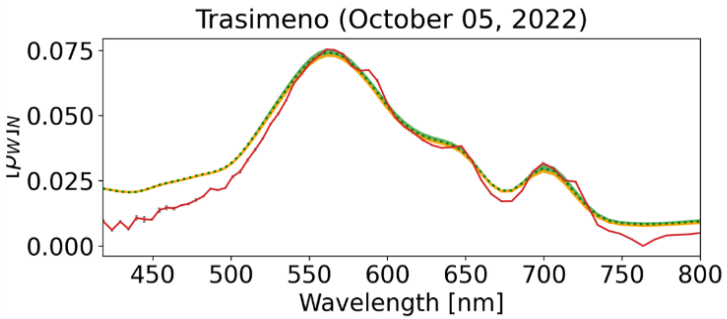
Funding: 50 EE 2401C and 50 EE 1923

Validation of EnMAP L2A Water Product

in-situ hyper- and multispectral radiometry







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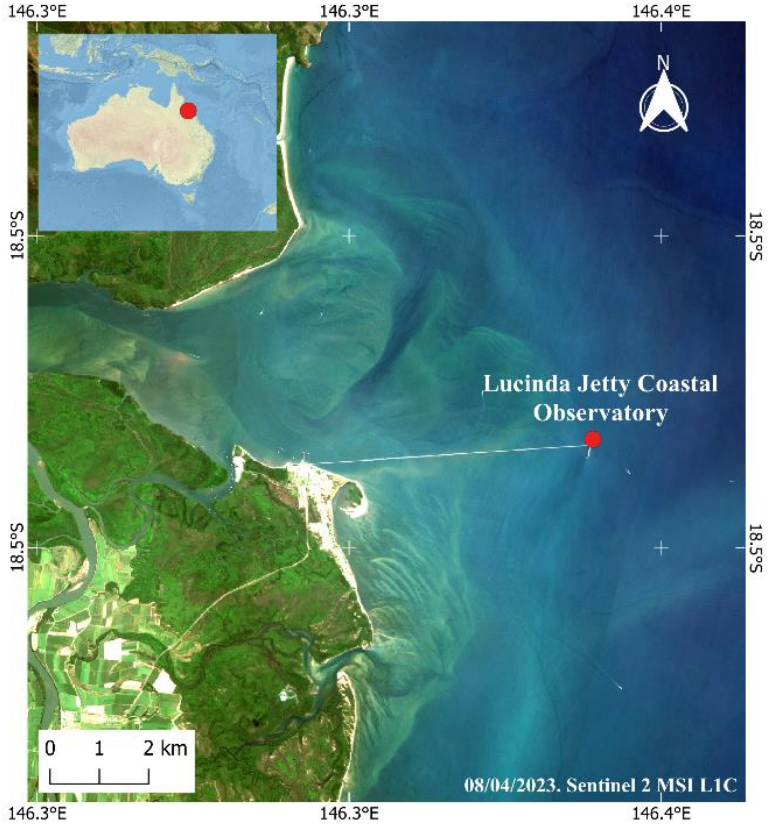
Intercomparison of EnMAP and S2

Water Quality Retrievals from EnMAP and Sentinel 2 at Lucinda Jetty Coastal Observatory (LJCO)

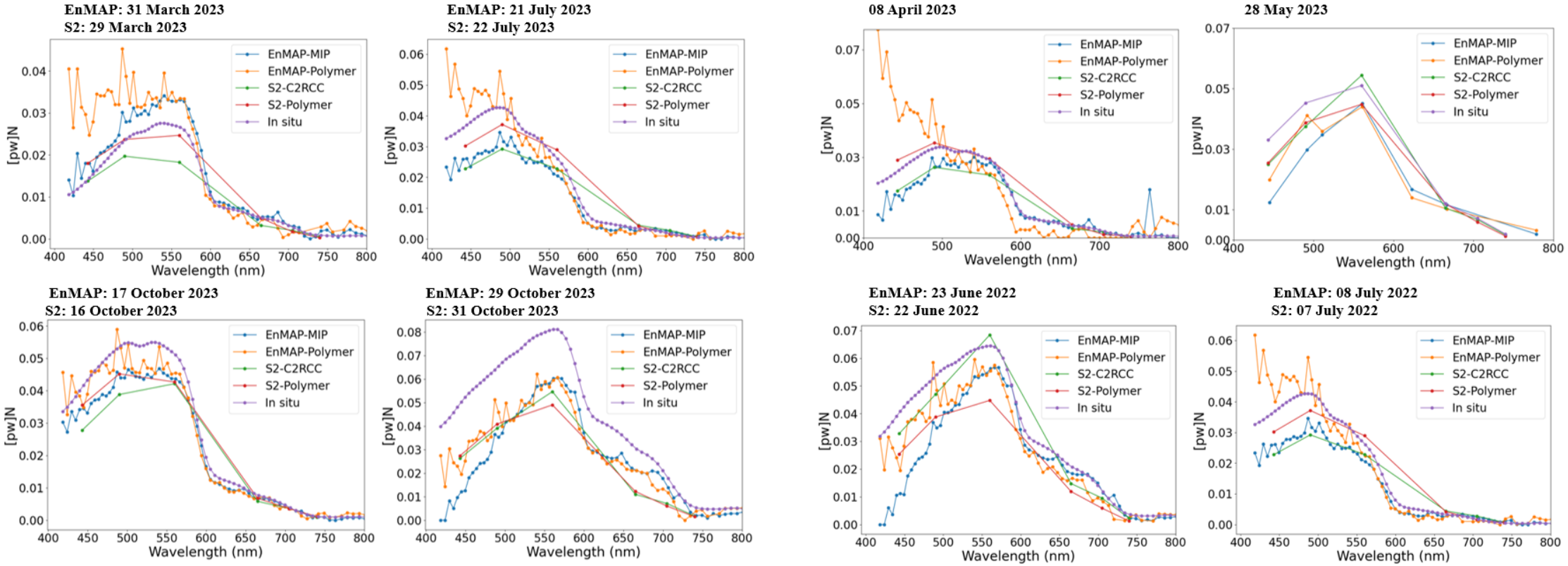
- Validation of $[\rho_w]_N$: EnMAP-MIP, EnMAP-Polymer, S2-C2RCC and S2-Polymer;
- Intercomparison of $[\rho_w]_N$ and water quality retrievals (Chl-a, CDOM, TSM) between EnMAP-MIP and S2-C2RCC using WASI.



Source: Randrianalisoa et al (2024), (in prep.)

Intercomparison of EnMAP and S2

	N	Slope	R^2	MdAPE	MdPE	RMSE
S2-C2RCC	8	0.83	0.897	19.39%	-11.01%	0.0066
S2-Polymer	8	0.761	0.89	32.14%	-11.52%	0.0099
EnMAP-MIP	8	0.68	0.82	**15.71%**	**-1.57%**	0.0055
EnMAP-Polymer	8	0.69	0.71	44.73%	-13.41%	**0.0052**



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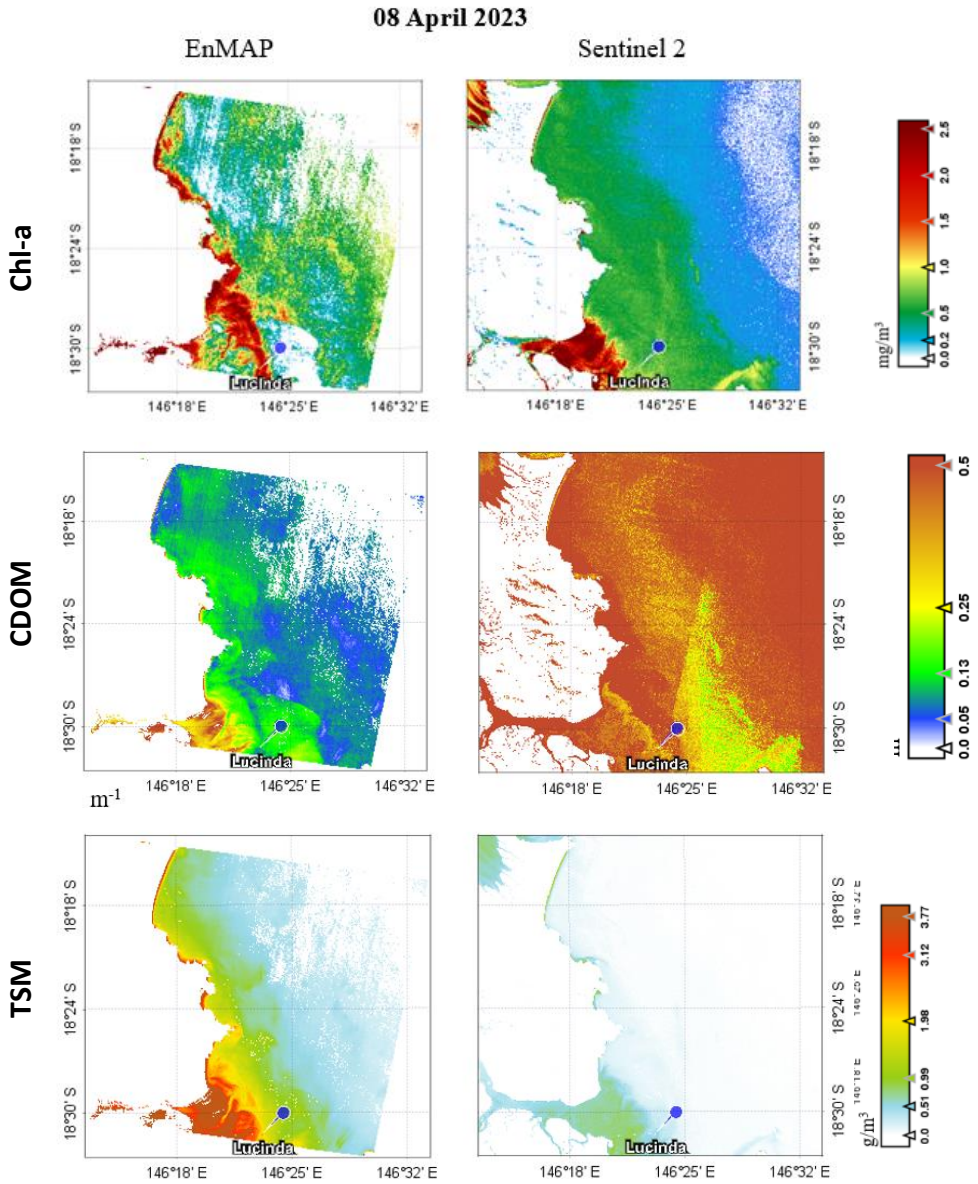
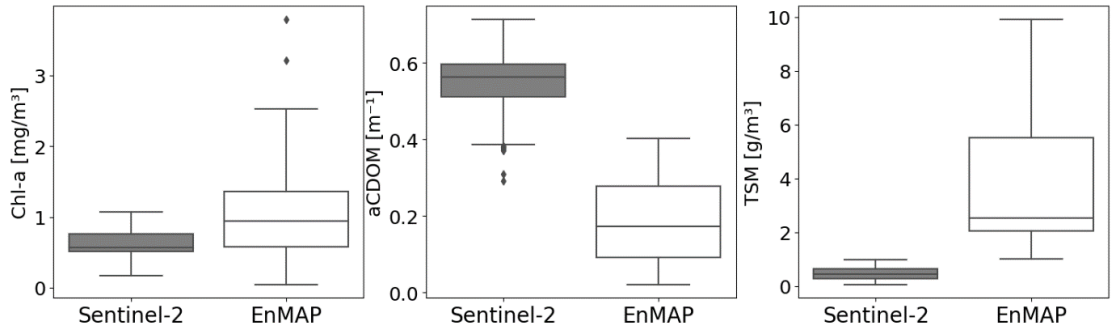
PHYTOPTICS

CENTRE OF EXCELLENCE IN OBSERVATIONAL OCEANOGRAPHY

Intercomparison of EnMAP and S2



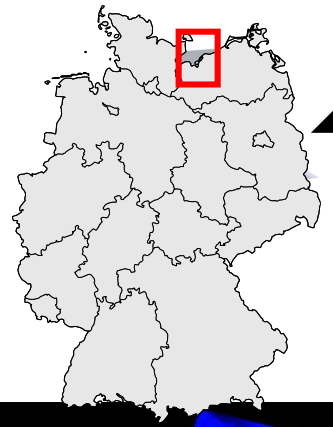


In situ data from 2014 to 2022

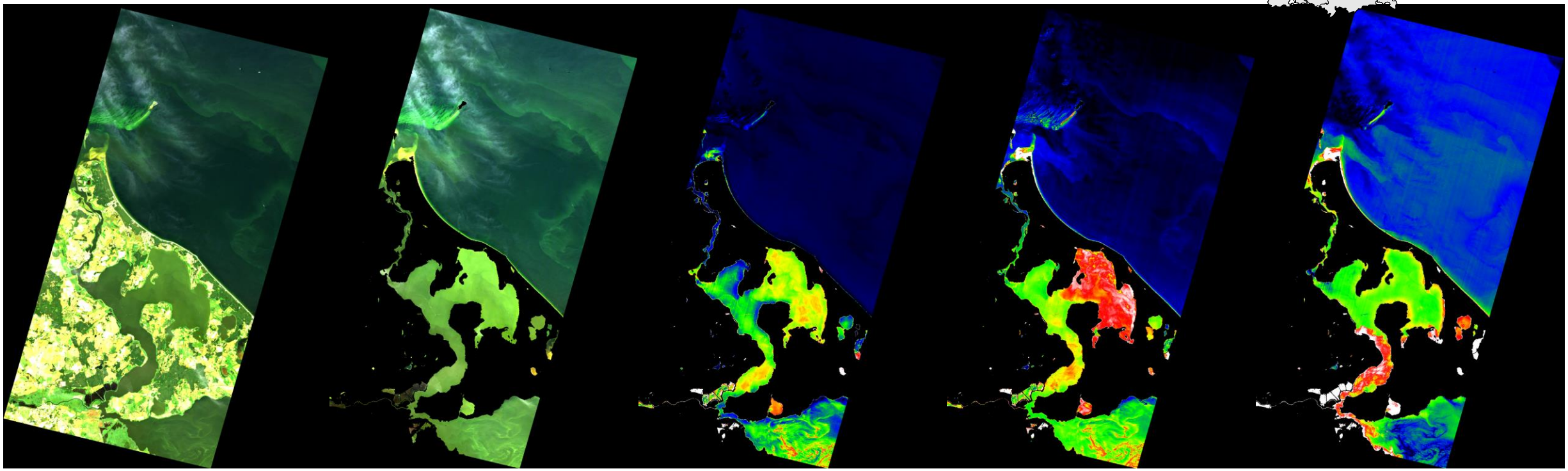
Parameters		Min	Max	Median
Chl-a	In-situ	0.04	6.35	0.78
	EnMAP	0.04	3.80	0.94
	Sentinel-2	0.17	1.07	0.57
a_{CDOM}	In-situ	0.01	1.44	0.10
	EnMAP	0.02	0.40	0.13
	Sentinel-2	0.29	0.71	0.56
TSM	In-situ	1.17	35.71	4.47
	EnMAP	1.01	9.92	2.49
	Sentinel-2	0.06	0.99	0.45

Source: Randrianalisoa et al (2024), (in prep.)

Water Quality

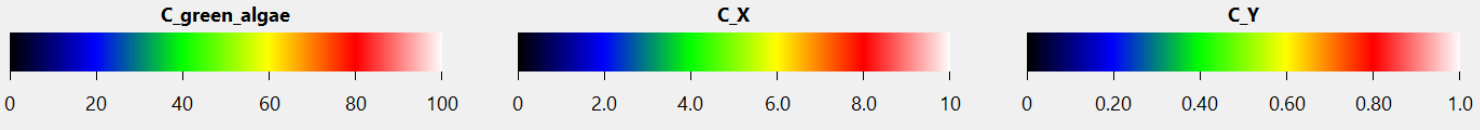


Water quality monitoring at Stettiner Haff (Oder), Germany
Bio-opitical model using WASI-2D (Gege, 2014)



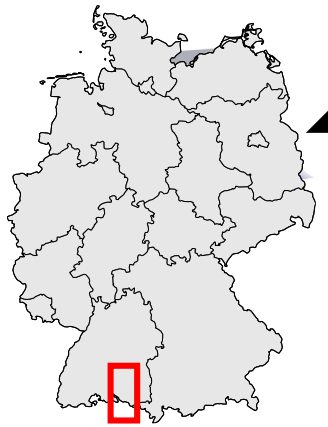
24.07.2022
RGB bands
440 nm, 556 nm, 664 nm

Land-water mask
RGB bands
440 nm, 556 nm, 664 nm



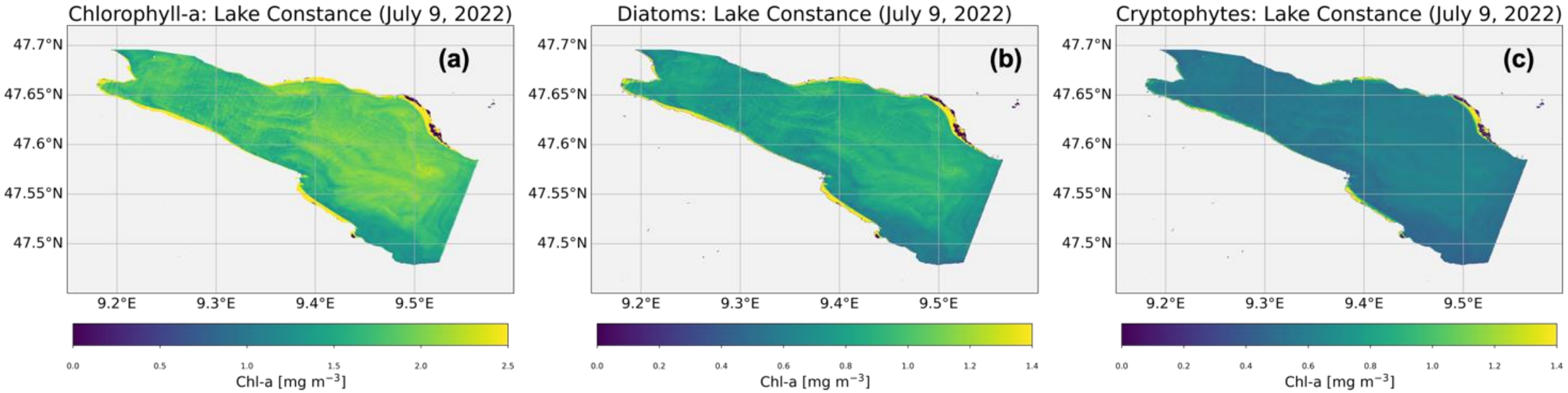
Source: Gege, P.(2023)

Phytoplankton Functional Types (PFTs)



Important proxies of ecosystem functioning

EnMAP Level 1B → **EnMAP-Box-EnPT-ACwater** (Polymer atmospheric correction - HYGEOS) → Chl-a Conc. → **EnMAP-Box OC-PFT** → Chl-a conc. of different PFTs



Also Talk on Wednesday 16:00 (Session 2.11)

Source: Chabrillat et al. (submmited to RSE)

Conclusion and Outlook

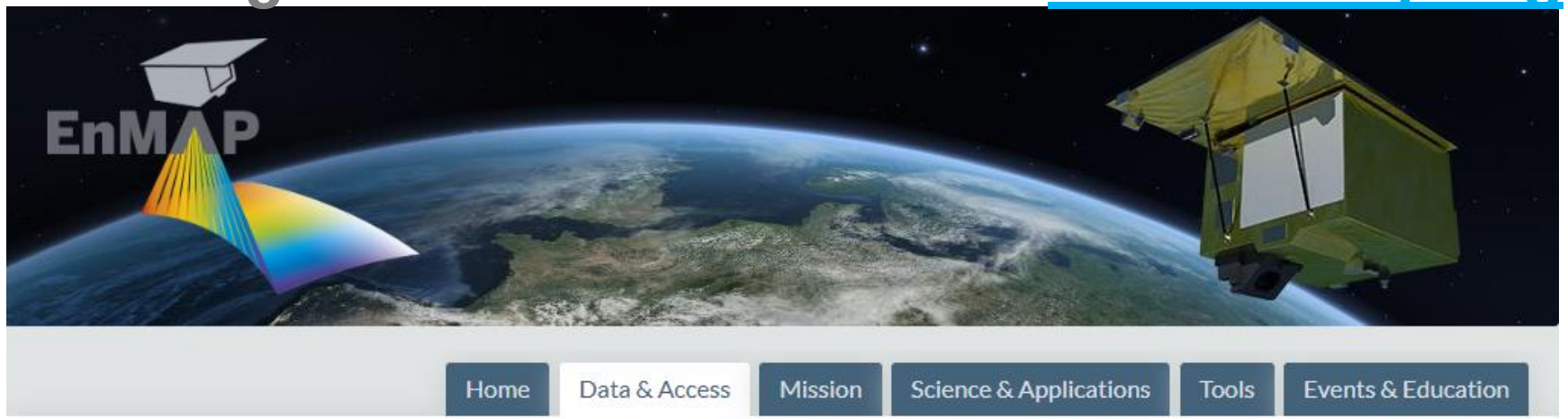
- The split L2A procedure is quite unique in data processing and should give the user the possibility to select the best result according to the area of interest (land or water or combined).
- User feedback about data quality is always welcome
- After two years in orbit first results of L2-water products show reliable results
- Improved acquisition strategy to get more match-ups with field data and other sensors (Prisma, DESIS, EMIT, S-2…)

Acknowledgement

Many thanks for highly valuable contributions and feed-back !

- Dagmar Müller (Brockmann Consult)
- Martin Hieronymi (Hereon)
- Touria Bajouk (ifremer)
- Claudia Giardino (CNR)
- Mariano Bresciani (CNR)
- Alice Fabbretto (CNR)
- Thomas Schröder (CSIRO/IMOS)
- Daniel Scheffler (EnPT)
- EnMAP-Box Team

Getting Information and News: www.enmap.org



Data Access Portal

SCREENCASTS

- How to register and assign to user roles
- How to submit a data proposal
- How to plan and request future observations
- How to search and download data from the archive

Data & Access

Important User Information:

https://www.enmap.org/data_access/ Screen Casts

https://www.enmap.org/mission/ EnMAP Ground Tracks

https://planning.enmap.org/usermanual.pdf

https://planning.enmap.org/EnMAP_FAQ.pdf

Email : enmap_application_sp@dlr.de

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Thank you for your attention !

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