PROGRAMME OF THE EUROPEAN UNION

co-funded with

Sentinel 2 Aquatic Reflectance sen2water

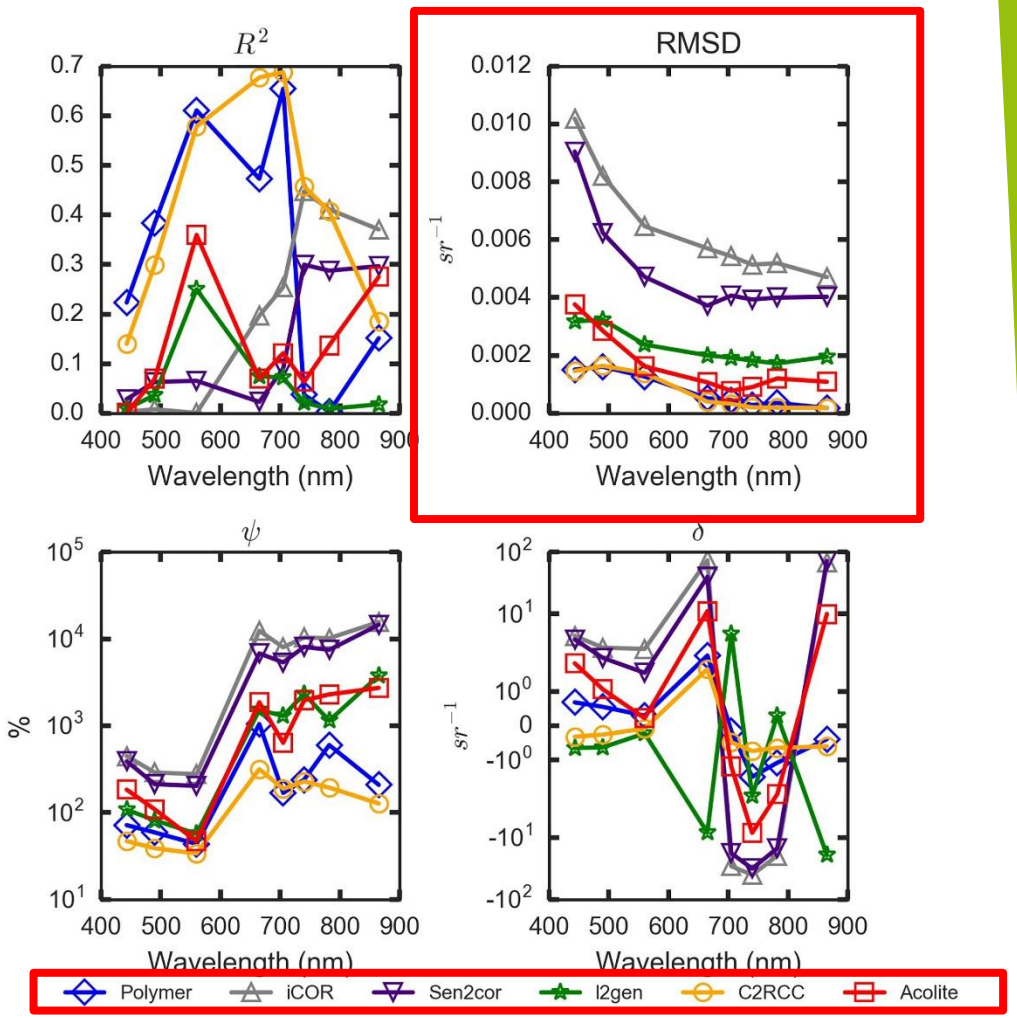
Carsten Brockmann[1], Martin Böttcher[1], Enrico Cadau[2], Jerome Bruniquel[3], Sebastien Leclerc[3], Jerome Louis[4], Francesco Pignatale[4], Francois Steinmetz[5], Dimitry Vanderzande[6], Stefan Simis[7]

[1] Brockmann Consult, Germany
[2] ESA ESRIN, Italy
[3] ACRI-ST, France
[4] Telespazio, France
[5] HYGEOS, France
[6] RBINS, Belgium
[7] PML, UK

Rationale

Water Quality from Sentinel 2

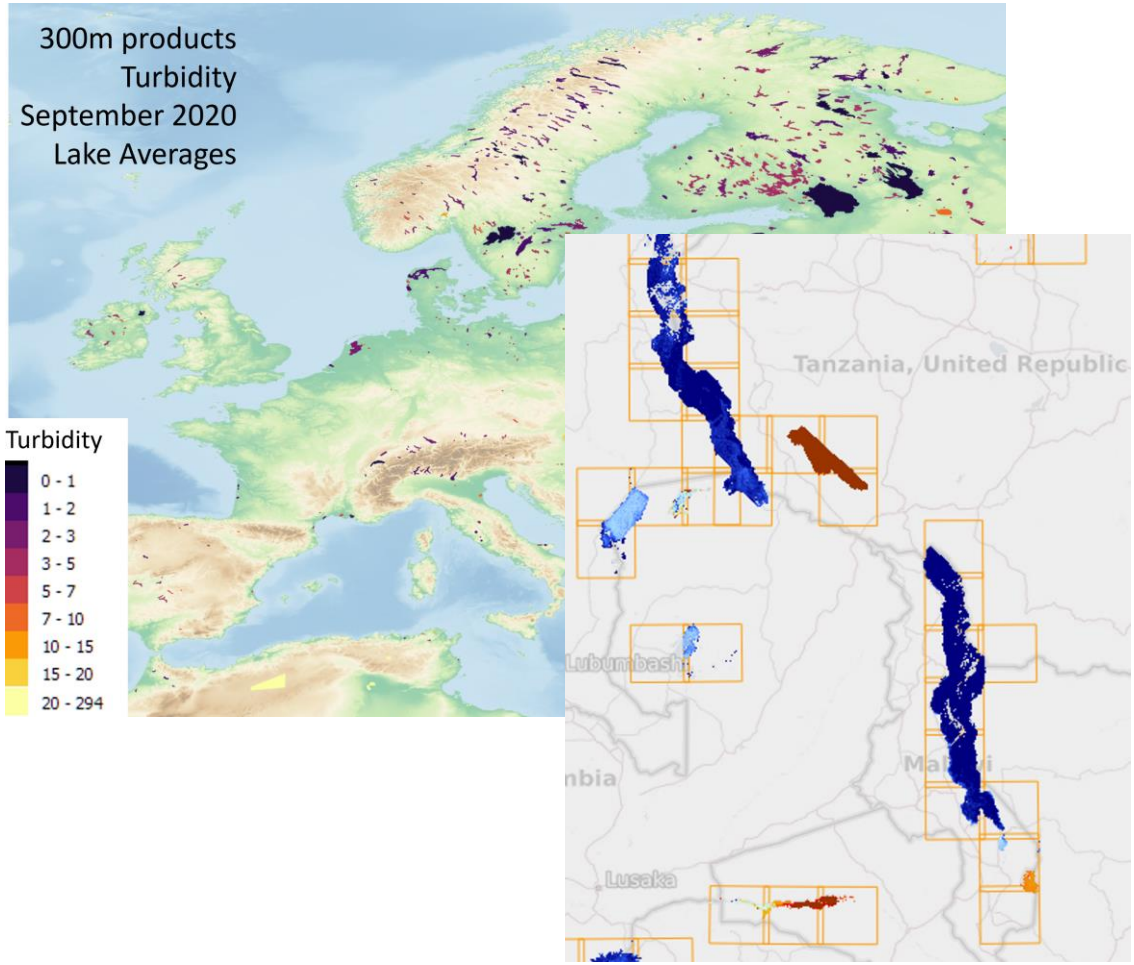
- Sentinel 2 is used for for water (quality) applications
  - ✓ Publications, commercial services
  - ✓ Copernicus Land Service
  - ✓ Copernicus Marine Service
- sen2cor performance over water
  - ✓ Reasonably well performing where aerosol retrieval applies
  - ✓ But does not meet uncertainty requirements for aquatic reflectances, needed for quantitative water quality parameter retrieval (Chl-a, TSM, CDOM, …)
- Conclusion:
  - ✓ provide an aquatic reflectance products as part of the Level 2A product using a dedicated water AC approach
  - ✓ Focus: Copernicus Services



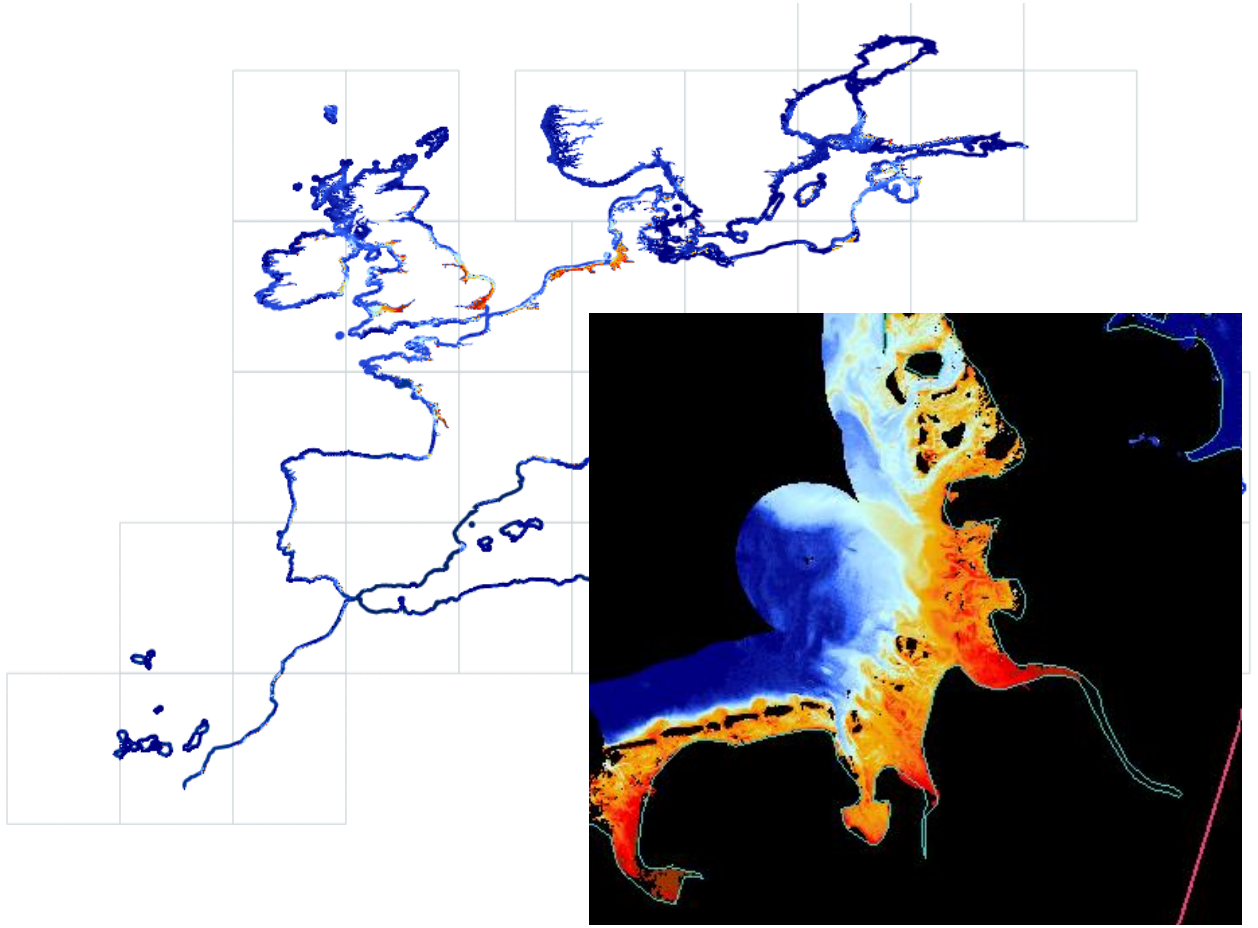
From Warren et al 2019, Assessment of atmospheric correction algorithms for the Sentinel-2A MultiSpectral Imager over coastal and inland waters
Fig. 13. Plot of the statistics for the common match-ups

Copernicus Services

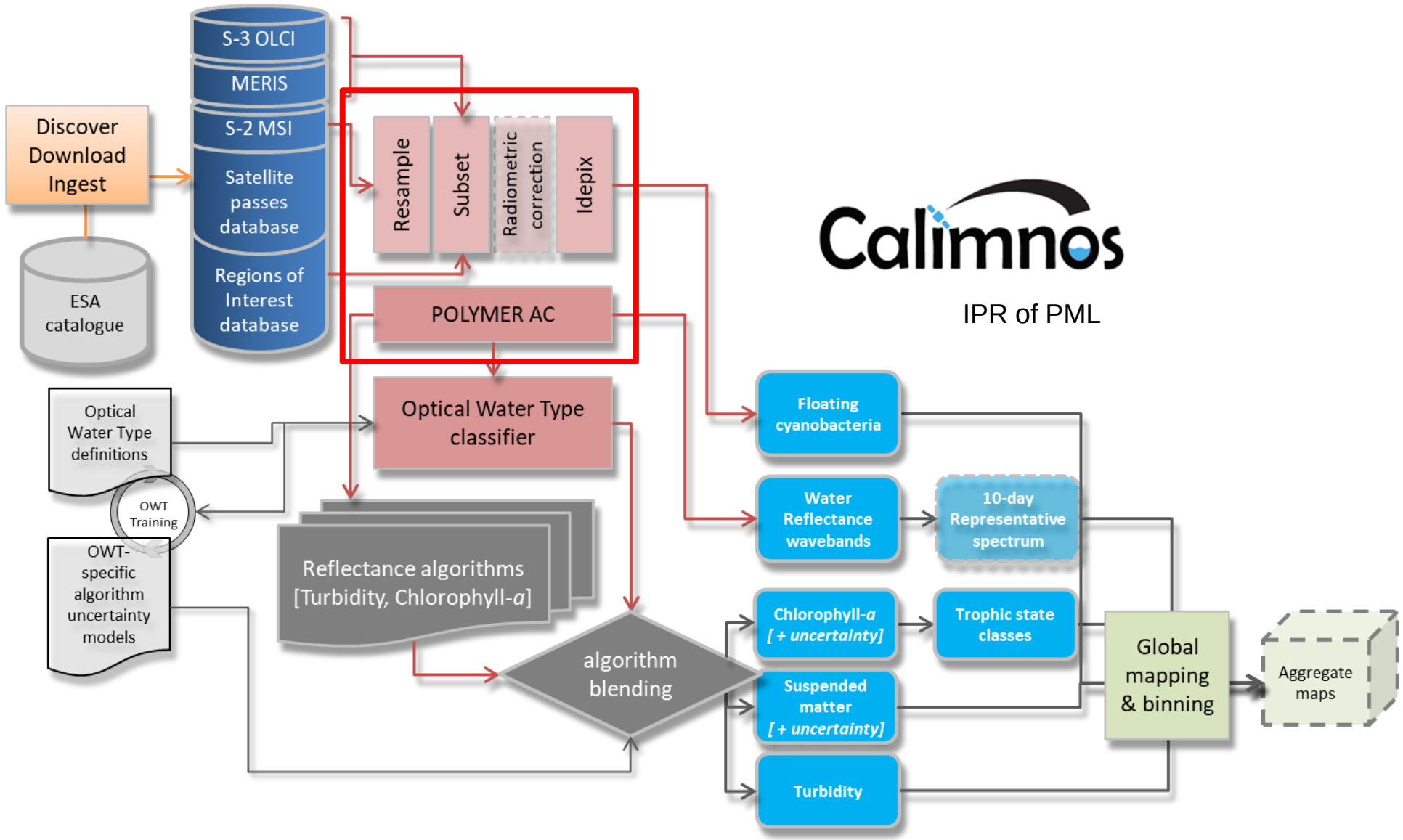
Land Service – Quality of Inland Waters



Marine Service – Quality of Coastal Waters



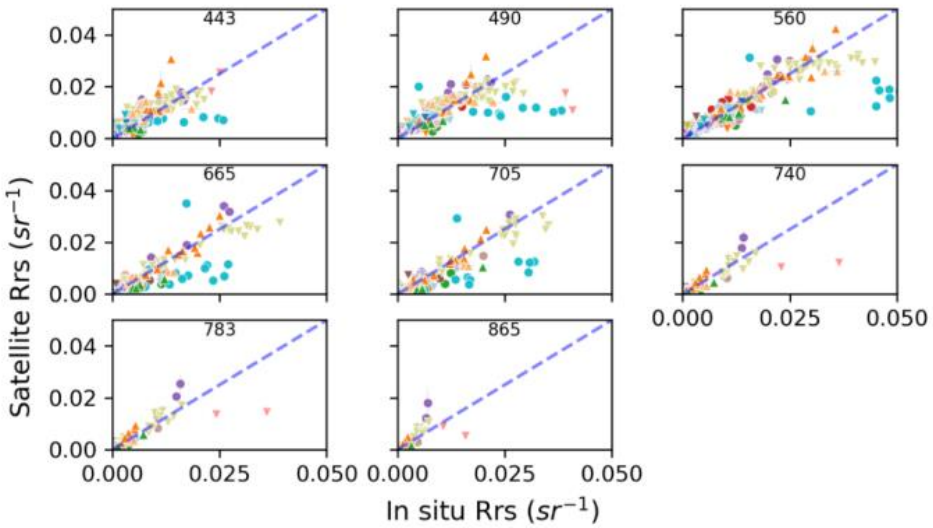
Land Service (CGLOPS Inland Waters)



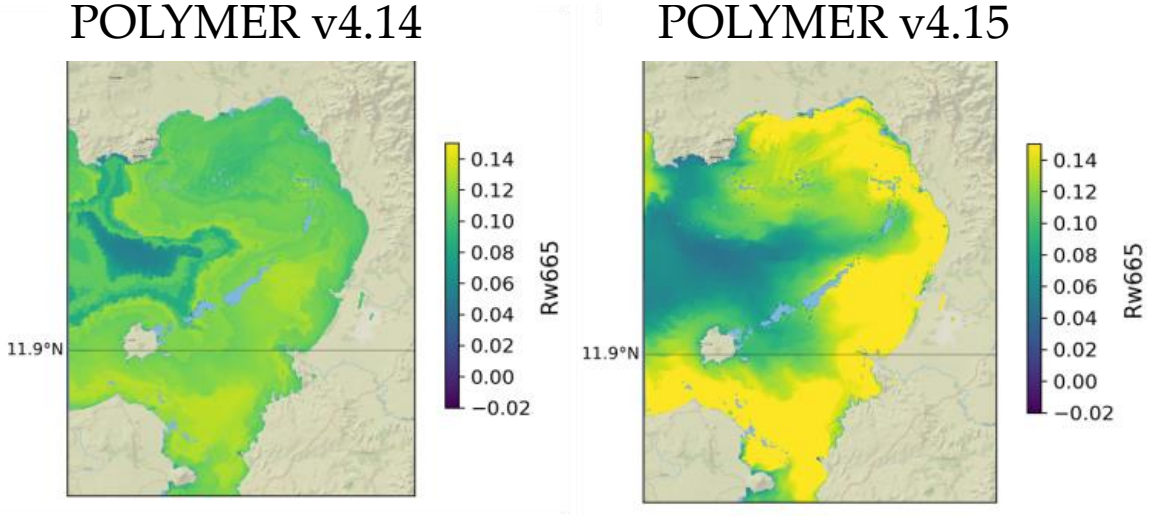
Calimnos

IPR of PML

CGLOPS Calimnos AC Validation Results



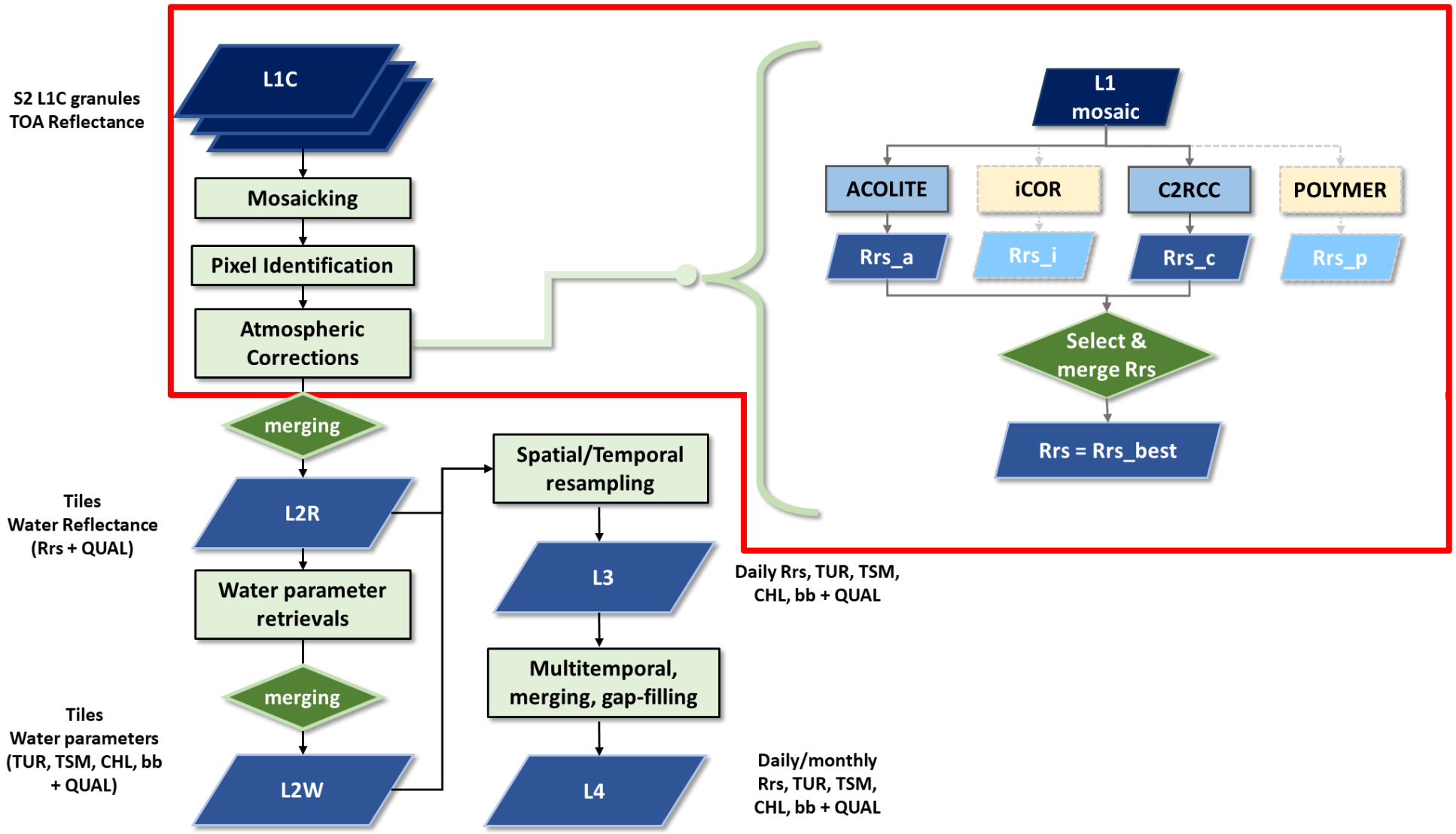
Current AC (Polymer v4.14) already gives reasonable results against global match-up databases (45 waterbodies)



AC algorithm improvements and validation underway - large corrections in highly turbid water (lake Tana shown) which are not well represented in match-up databases.

More detail provided in presentation by Mark Warren

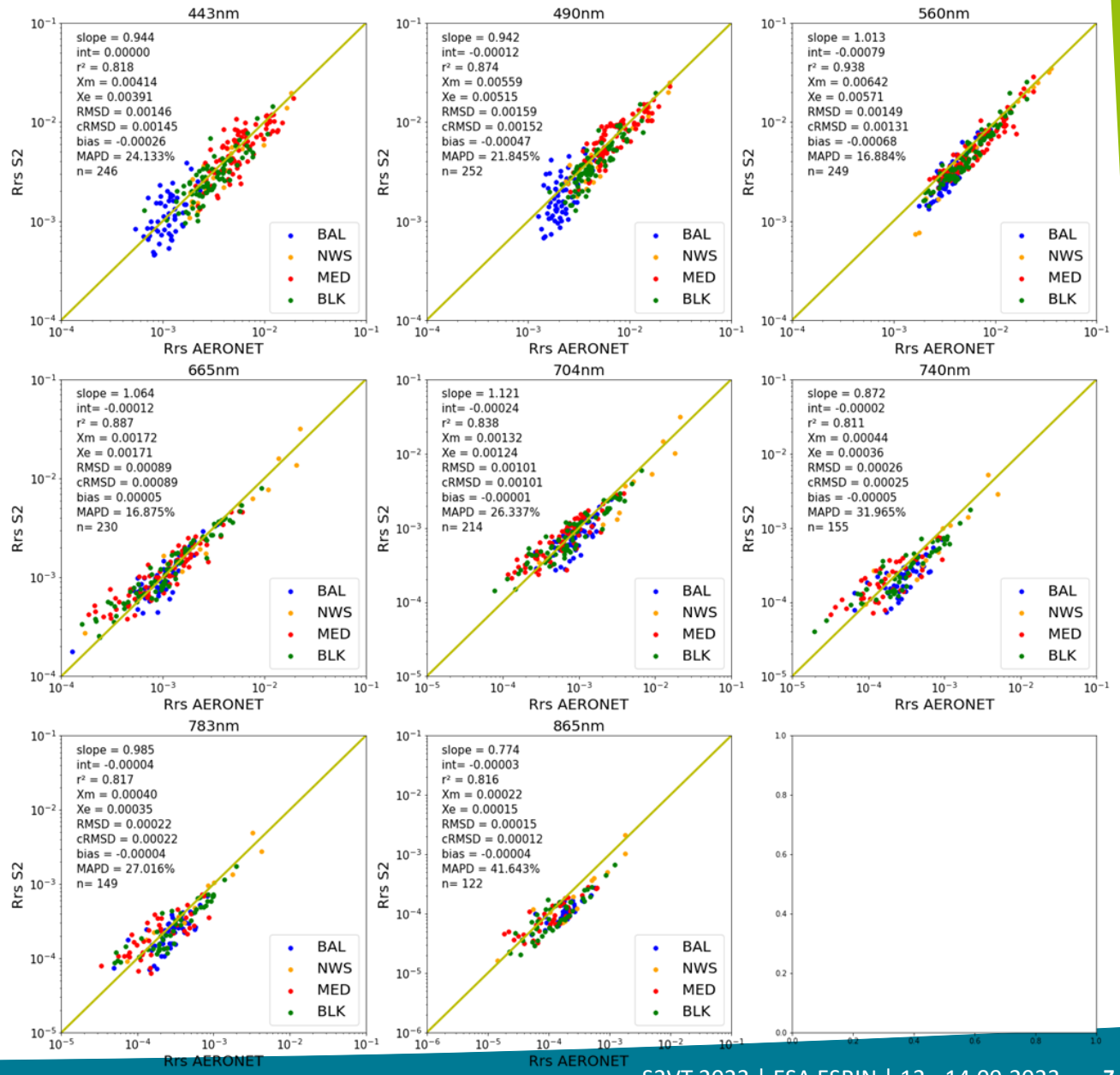
Marine Service (OCTAC – HROC)



HROC AC Validation Results

AERONET-OC network for **11** stations located in **4** CMEMS regions: BAL, NWS, MED and BLK.

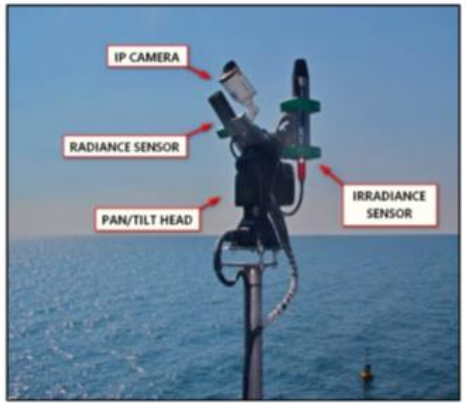
...

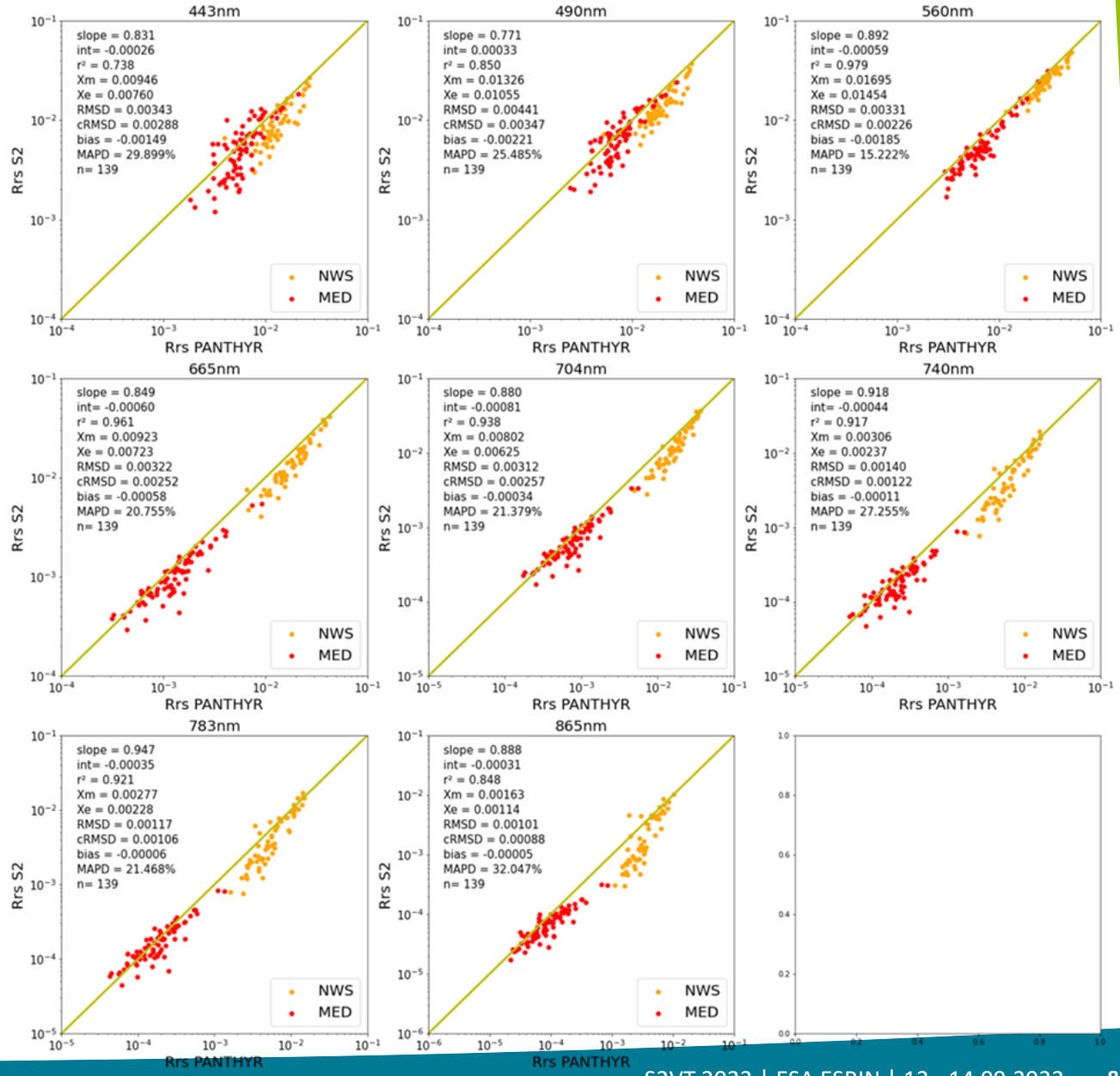


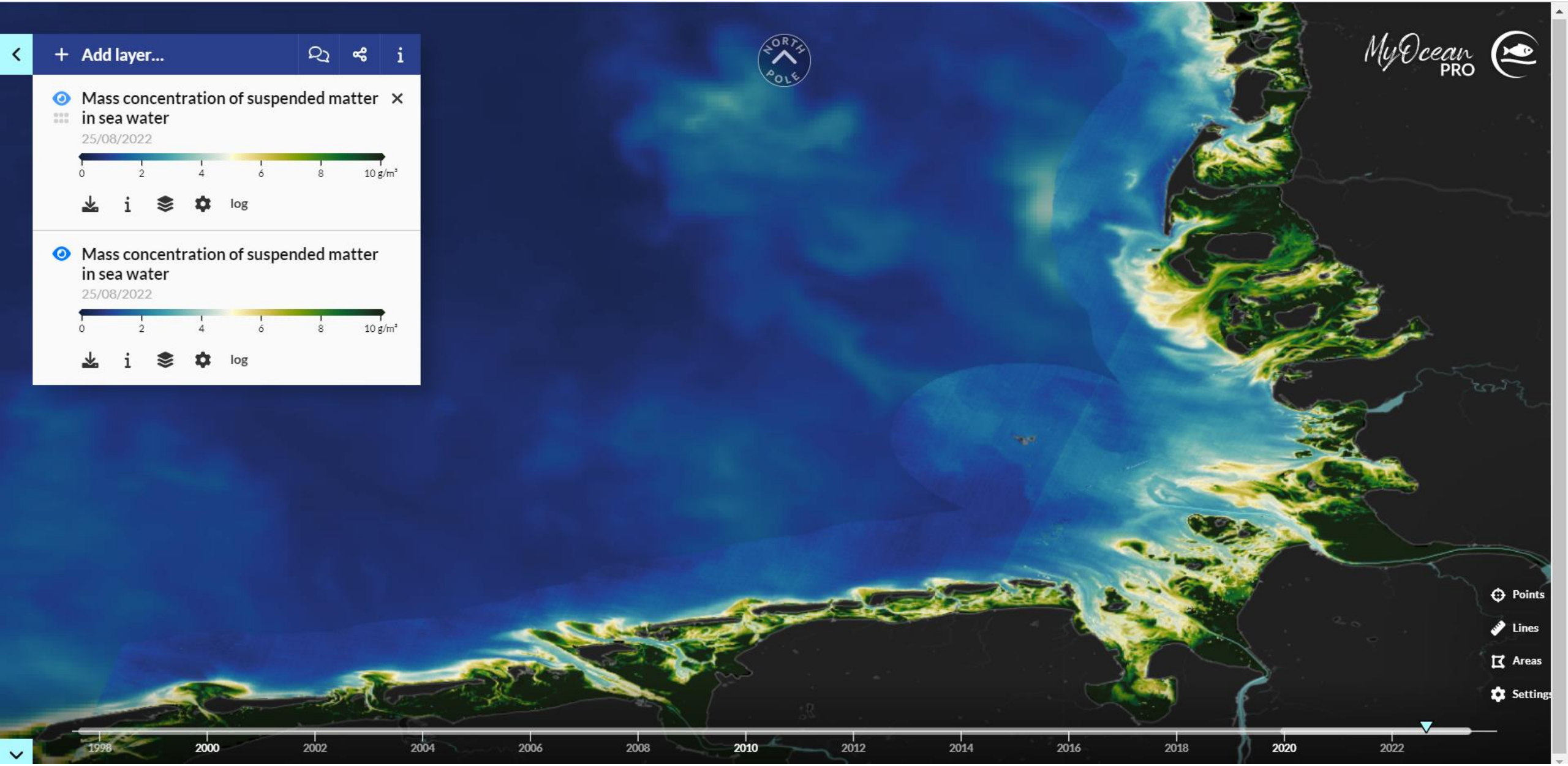
HROC AC Validation Results

PANTHYR network for **2** stations located in **2** CMEMS regions: NWS and MED

Oostende (BEL; PI: VLIZ)
Aqua-Alta (IT, PI: CNR)
2020-2023 operational product validation






Add layer...
Mass concentration of suspended matter in sea water
25/08/2022
0
2
4
6
8
10 g/m³
log
Mass concentration of suspended matter in sea water
25/08/2022
0
2
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NORTH POLE
MyOcean PRO
Points
Lines
Areas
Settings
1998
2000
2002
2004
2006
2008
2010
2012
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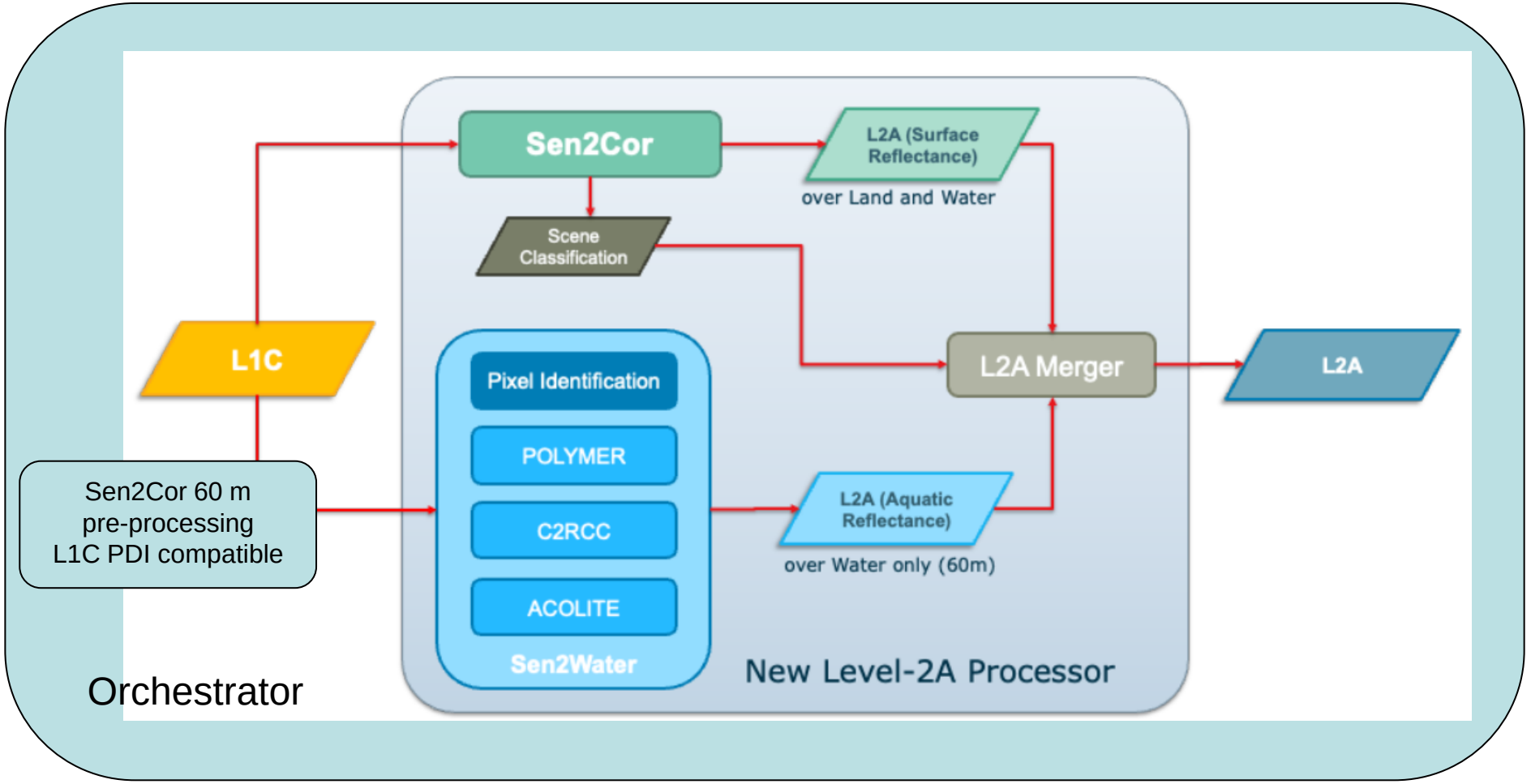
2018
2020
2022

Sen2water Overall Concept



Water AC Harmonisation

Current AC in CMEMS HR-OC (Marine Service)	Current AC in CGLOPS (Land Service)
✓ SNAP S2Resampling	✓ SNAP S2Resampling
✓ Idepix	✓ Idepix
✓ C2RCC	✓ Polymer
✓ Acolite	
✓ Parameterisation	
✓ Fusion of C2RCC and Acolite	✓ Parameterisation
✓ Coastal area optimisations	✓ Aux data handling (NCEP)
	✓ Subsetting and masking
✓ CMEMS HR-OC product formatting	✓ CGLOPS product formatting

sen2water Development

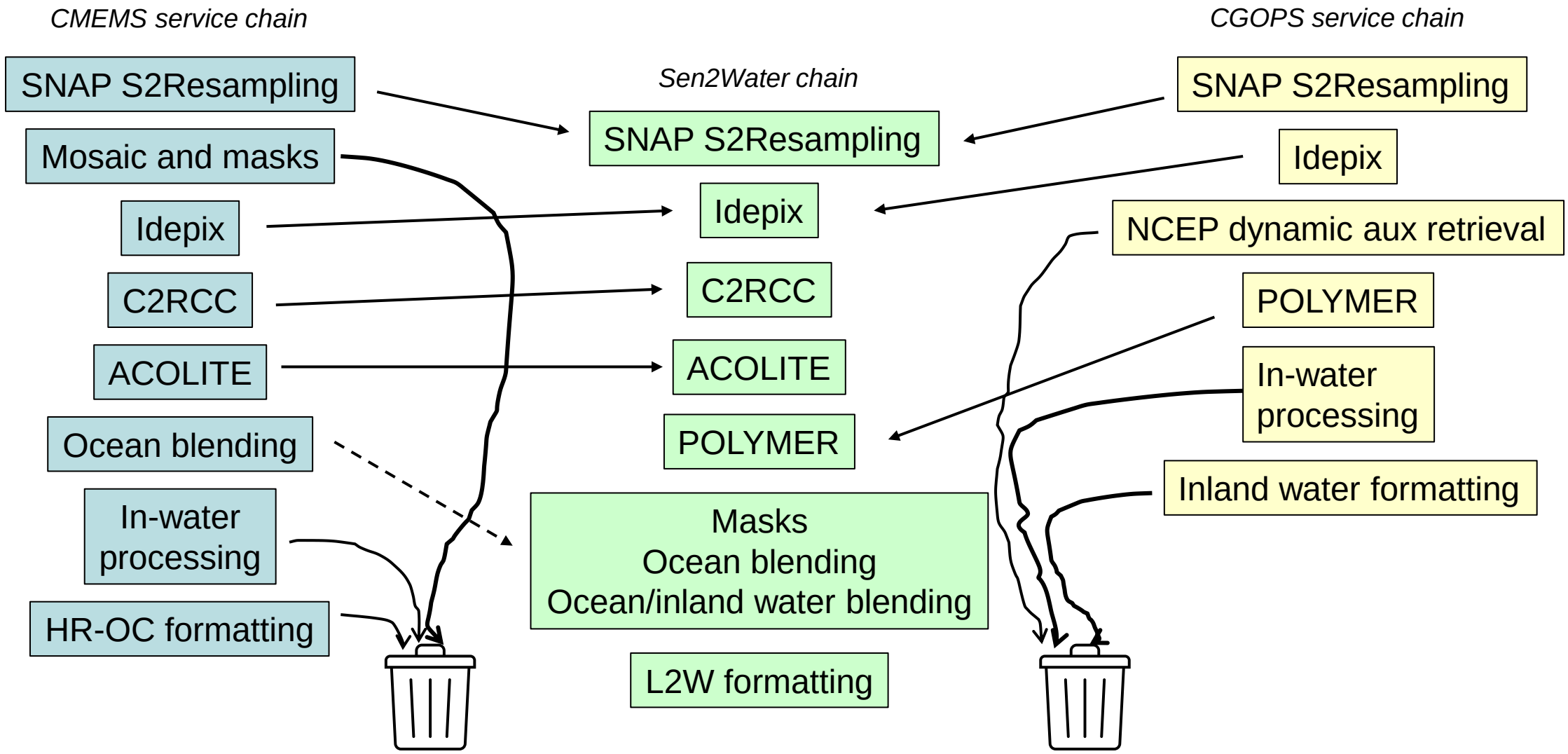
Algorithmic developments

- Transition from coastal (HROC blending C2RCC/acolite) to CGLOPS AC (polymer)
- Harmonising pixel classification (HROC and CGLOPS), check consistency with sen2cor SCL
- Orchestrator optimisation to avoid calling of sen2water for tiles with no water (e.g. deserts)

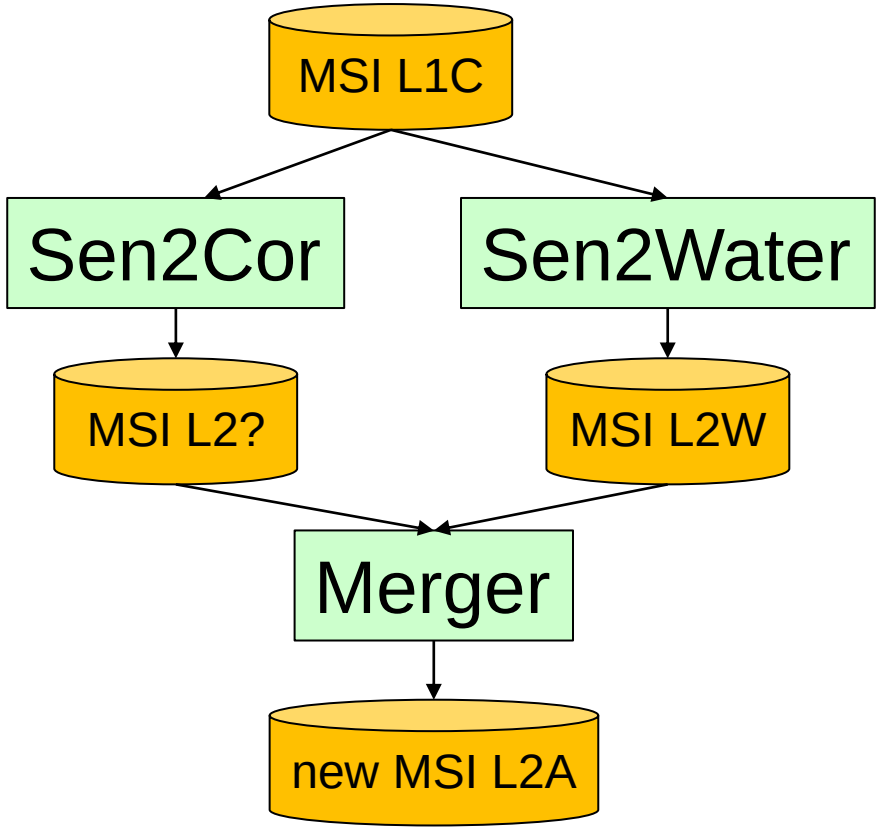
Software

- sen2water stand-alone processor; distributed freely like sen2cor
  - ✓ Input: L1C; output netCDF
  - ✓ Aquatic reflectance for all detected water pixels
  - ✓ Specific masks: water based on radiometry, floating vegetation, sea ice, clouds over water, algorithm merge, …
  - ✓ license agreements with different AC processors included; GPL for IdePix, C2RCC and acolite, restricted license for polymer (free for non-commercial use)
- L2A merger
  - ✓ Adding aquatic reflectances as additional bands in Sentinel 2 L2A product
- Ground Segment integration
  - ✓ PDI and Safe reader
  - ✓ Safe converter or Safe writer
  - ✓ Standard parameterisation according to CGLOPS and HROC requirements
  - ✓ Package Sen2Water software for installation into operational PDGS IPF

Water AC integration



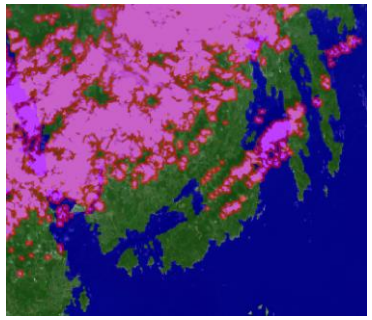
Sen2Cor and Sen2Water integration



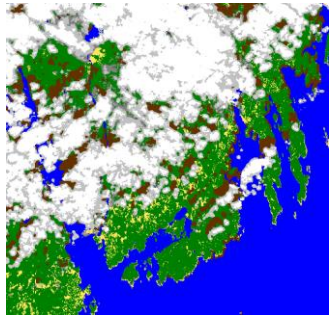
concurrent execution

Content of former L2A
+ water leaving reflectances
+ water-specific flags (see following slides)
+ extended metadata

Merging Sen2Water masks



RGB, Oslo Fjord 2023-08-13



idepix_pixel_classif_flags

IDEPIX_INVALID	
IDEPIX_CLOUD	
IDEPIX_CLOUD_AMBIGUOUS	
IDEPIX_CLOUD_SURE	
IDEPIX_CLOUD_BUFFER	
IDEPIX_CLOUD_SHADOW	
IDEPIX_SNOW_ICE	
IDEPIX_BRIGHT	
IDEPIX_WHITE	
IDEPIX_COASTLINE	
IDEPIX_LAND	
IDEPIX_CIRRUS_SURE	
IDEPIX_CIRRUS_AMBIGUOUS	
IDEPIX_CLEAR_LAND	
IDEPIX_CLEAR_WATER	
IDEPIX_WATER	
IDEPIX_BRIGHTWHITE	
IDEPIX_VEG_RISK	
IDEPIX_MOUNTAIN_SHADOW	
IDEPIX_POTENTIAL_SHADOW	
IDEPIX_CLUSTERED_CLOUD_S...	

c2rcc_flags

acolite_l2_negatives

polymer_bitmask

each with ist own legend

blending

which algo has been used?

sen2cor_scene_classification

NODATA	0
SATURATED_DEFECTIVE	1
TOPOGRAPHIC_AND_CASTED_SH...	2
CLOUD_SHADOW	3
VEGETATION	4
NOT_VEGETATED	5
WATER	6
UNCLASSIFIED	7
CLOUD_MEDIUM_PROBA	8
CLOUD_HIGH_PROBA	9
THIN_CIRRUS	10
SNOW_ICE	11

Flags the chain produces

Flags the L2W and L2A will contain

L2W

pixel_classif_flags

expert quality flag masks that can be combined (used by the services)

sen2water_flags

pixel_class

easy-to-use set of alternative classes

L2A

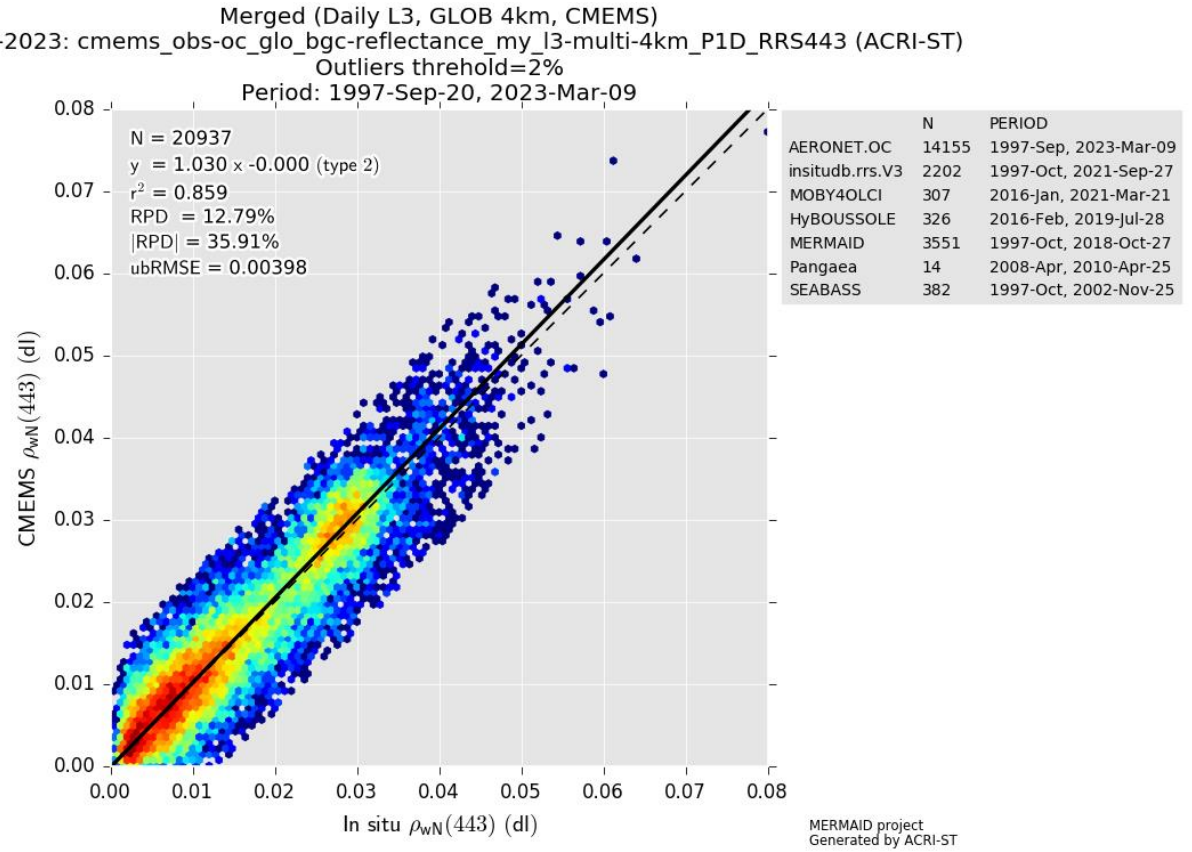
scene_classification

easy-to-use set of alternative classes

sen2water Development

Validation

- Objective
  - ✓ Ensure quality of Sen2water product is in line with current Copernicus Services products
- Methodology
  - ✓ Follow ACIX AQUA recommendations
- Data sets
  - ✓ ACRI-ST CMEMS database for coastal waters
  - ✓ ACIX-AQUA Community Validation Dataset



Example of validation results of CMEMS L3 daily composite against reference in-situ measurements. Note that only a small fraction of the in-situ database can be used for the present Sen2Water activity

sen2water Development

Coordination

- Regular reports at S2QWG
- Close interaction with Copernicus Land and Marine Services
  - ✓ Informing the services about technical specification and schedule
  - ✓ Gathering feedback on product format, timelines, …
  - ✓ Passing test data to the services
  - ✓ Gathering feedback on test data and updating processor where applicable
  - ✓ In parallel to our own validation, passing data for validation to Services and QWG members as
  - ✓ Allow for updating final releases of the processing with feedback from QWG

Sen2water Summary

Objectives:

Develop the sen2water processor as an integral part of the ground segment processor as well as stand-alone version. Link with the Copernicus Services to prepare for uptake.

Duration

- Mid May 2023 – mid November 2024 (18 months)

Team

- BC (Martin Böttcher, Carsten Brockmann)
- Telespazio (Jérôme Louis, Francesco Pignatale)
- ACRI-ST (Alexis Deru, Marion Piccinelli, S. Clerc, J. Bruniquel)
- Associated MPC members: RBINS and Hygeos

Link with Copernicus Services

- Reporting from MPC to Copernicus Land and Marines Services
- Provision of draft document for comments
- Provision of early test data for comments

Key Output (for users)

- L2A product with additional aquatic reflectances
  - ✓ Starting early 2025
- Sen2Water standalone version
  - ✓ Executable + source code (flow-down of licences of IdePix, C2RCC, polymer and acolite)
- ATBD
  - ✓ Referring to publication of the used ACs and Pixel Classification
  - ✓ Detailing the additional elements (merging, additional tests, …)
- Product Specification Document (PSD)
- Software Installation and User Manual
- Validation Report
- Future Maintenance and updating via OPT-MPC