PROGRAMME OF THE EUROPEAN UNION

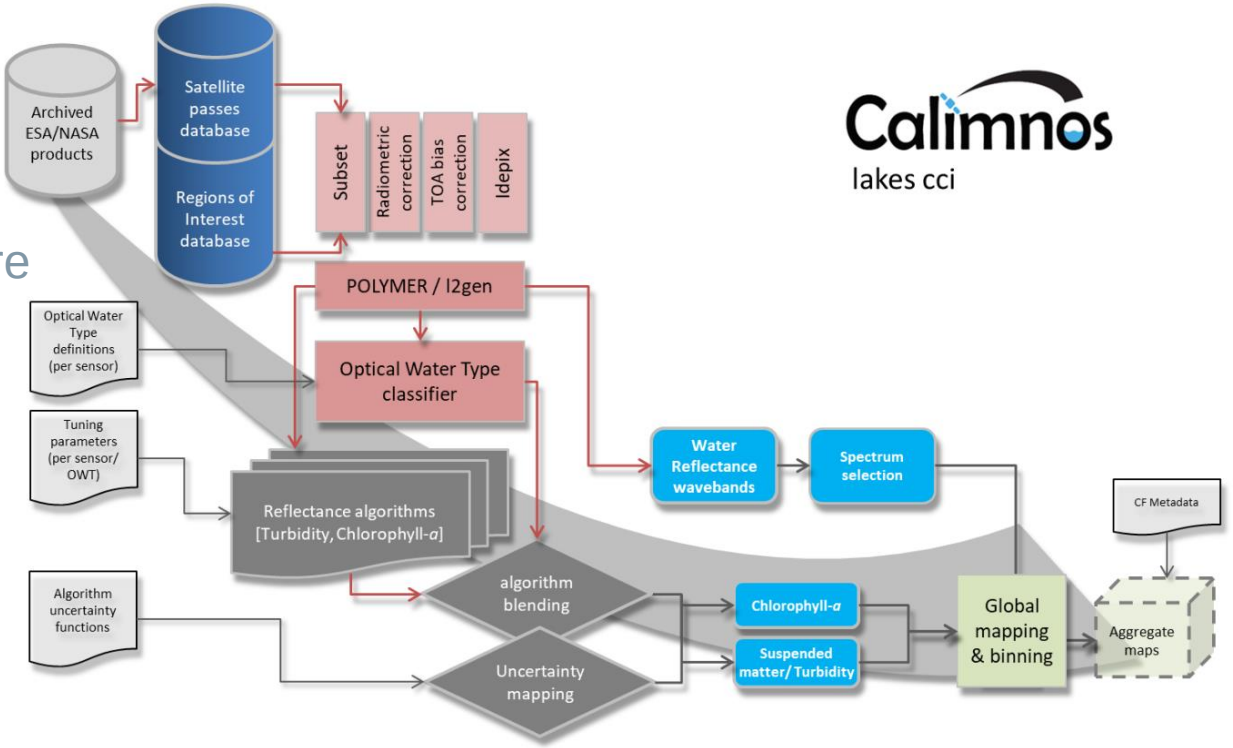
co-funded with esa

Lake colour validation

Mark Warren, Xiaohan Liu, Nick Selmes, Stefan Simis – Plymouth Marine Laboratory
Dagmar Mueller, Kerstin Stelzer – Brockmann Consult

Context

- Copernicus lake water quality and ESA Lakes_CCI LWQ climate data records are produced using the *Calimnos* software package
- POLYMER is used for the atmospheric correction
- requires careful validation if chain is updated
- reprocessing archive expensive in time (& money) - there is no standard L2 inland water product.



Challenge

The optical diversity of lakes is very high and in situ validation datasets are sparse (regionally and temporally). How do we evaluate this performance sufficiently?

Overview of presentation

Brief description of the *Calimnos* processing

Modifications in POLYMER atmospheric correction

Validation of POLYMER version
- In situ match-ups
- Results

Summary

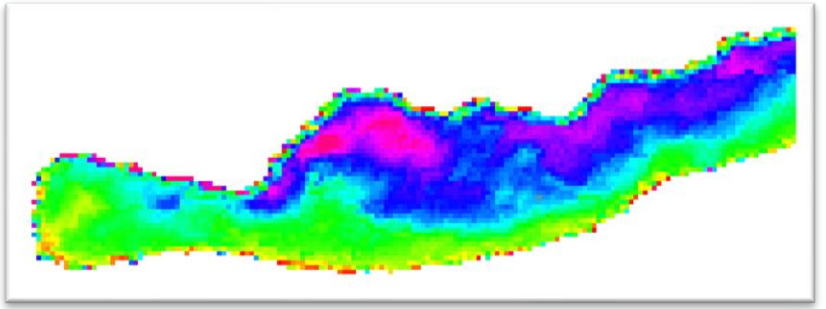
Conclusions

Calimnos for CLMS and ESA Lakes_CCI

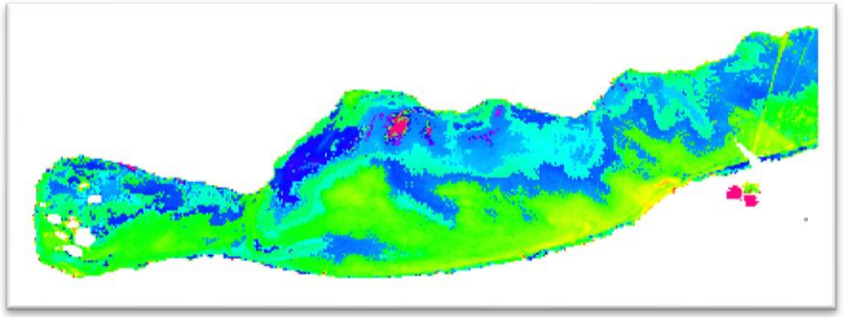
Calimnos processes data for the operational CLMS level-2 (L2) water quality products from MSI and OLCI for more than **4200 lakes** in the form of global coverage **10-day aggregated** products, and daily products **> 2000 lakes** for ESA Lakes_CCI.

- Normalised Water Leaving Reflectance
- Trophic state index (or chlorophyll-a concentration)
- Turbidity

Currently products are created from POLYMER v4.13 atmospheric corrected reflectance.



OLCI Turbidity 300m: 2023-07-21
10-day product

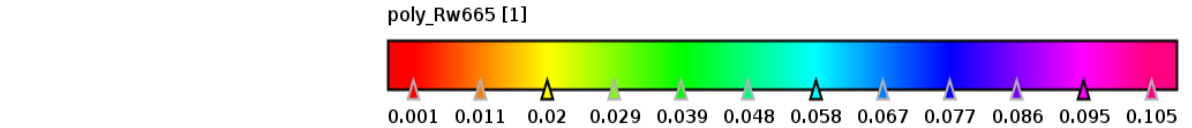


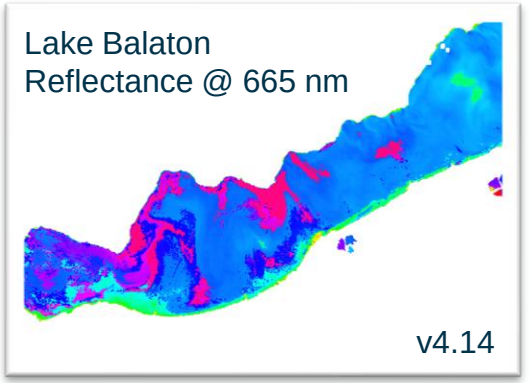
MSI Turbidity 100m: 2023-07-21
10-day product

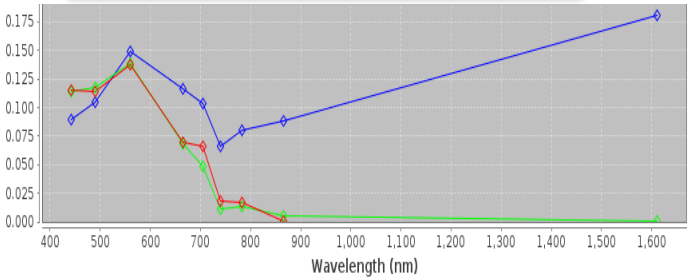
POLYMER Atmospheric Correction Improvements

Over the past year, POLYMER has been updated to address discontinuities seen particularly in highly turbid waters.

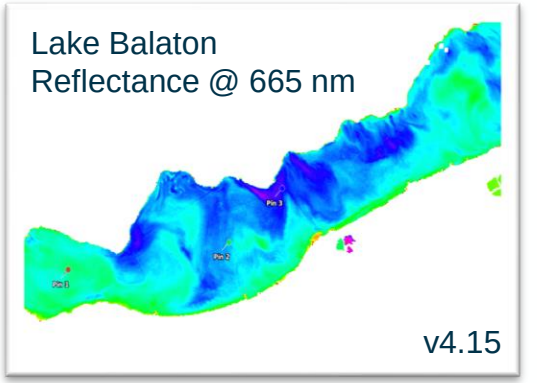
To bring these changes into the service it's important to carry out validation to ascertain how products may be affected.

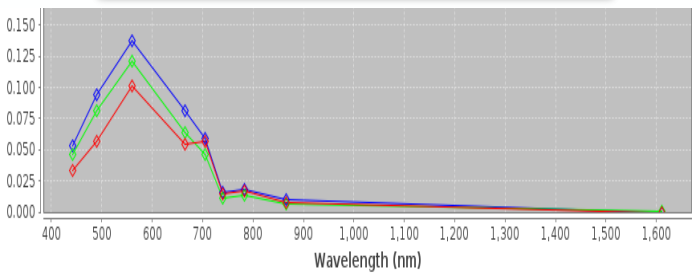






Polymer v4.14
665 nm

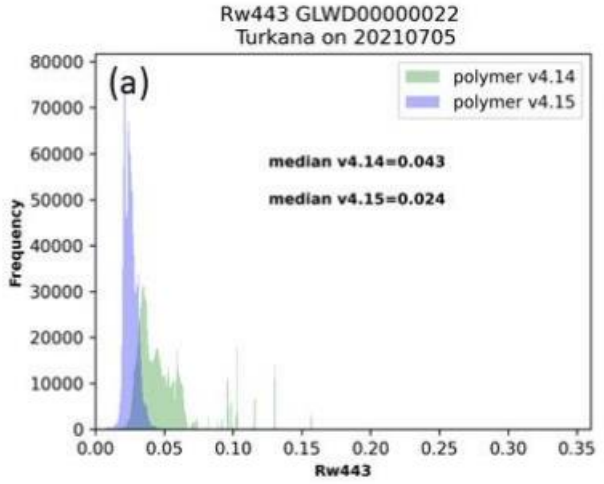


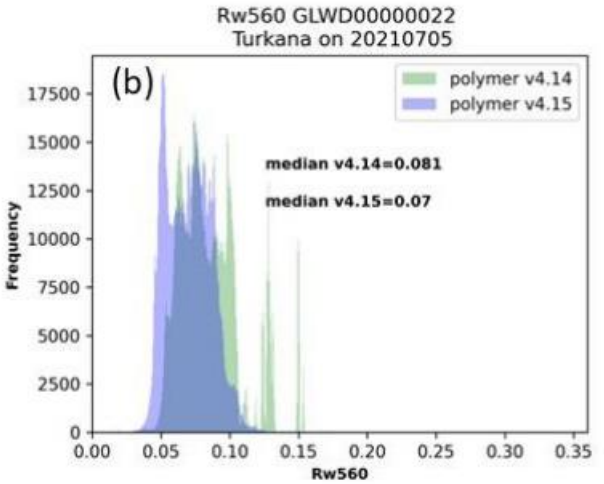


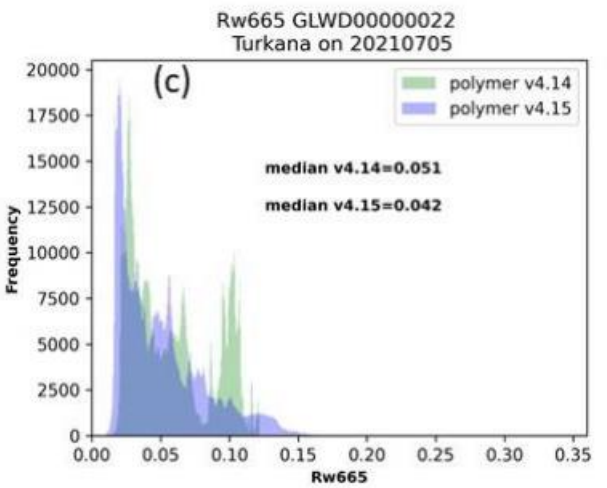
Polymer v4.15
665 nm

Reflectance frequency plots of two very turbid lakes

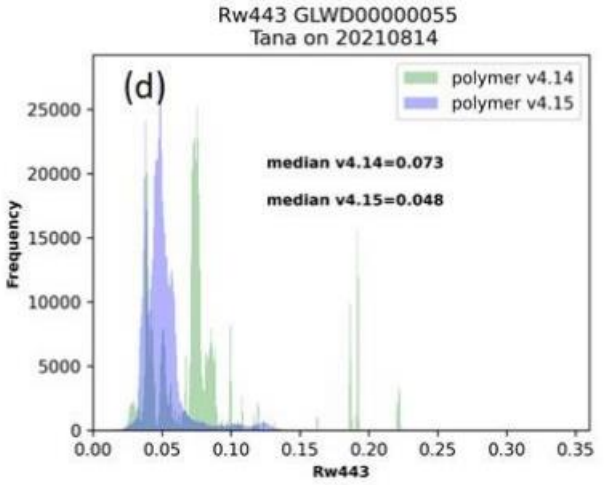
Lake Turkana

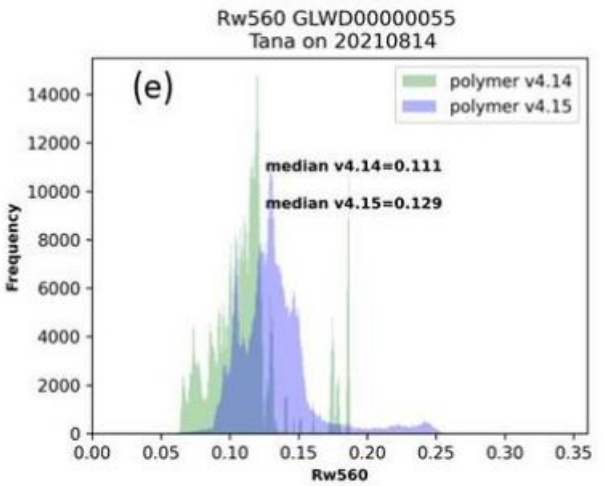


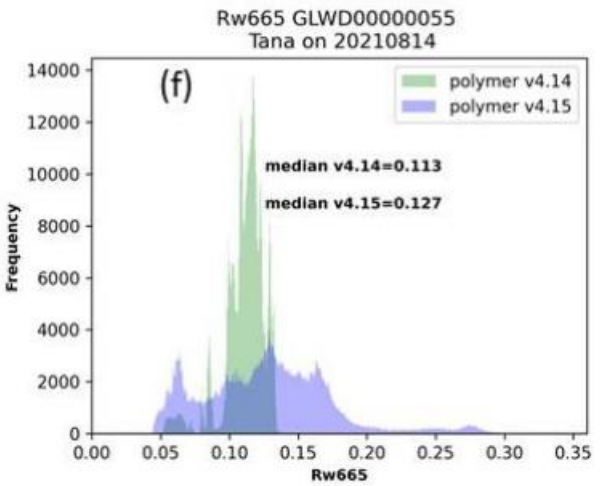




Lake Tana







Green = POLYMER v4.14
Blue = POLYMER v4.15

Note: POLYMER v4.15 shows a continuous multi-peaked distribution, whereas the v4.14 distribution is fragmented.

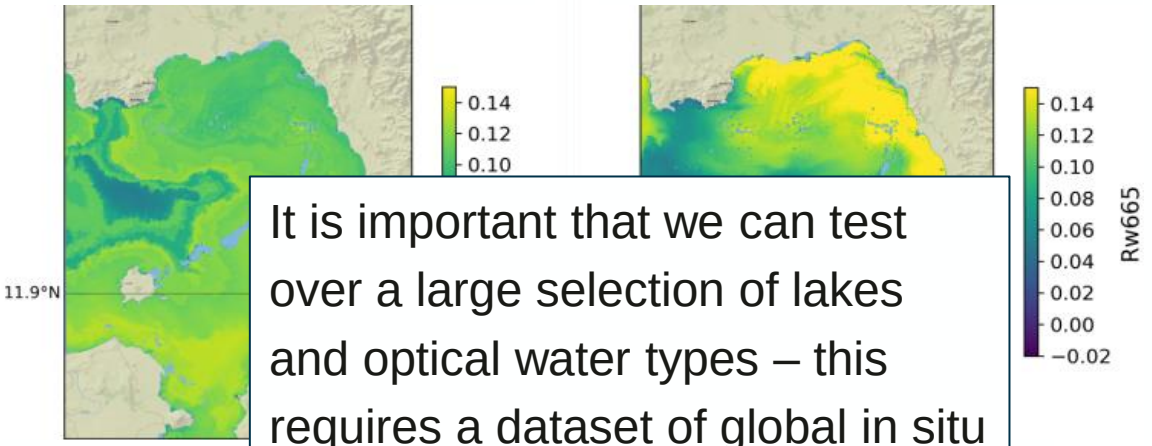
Discontinuities in reflectance

Lake Tana:
turbid waters

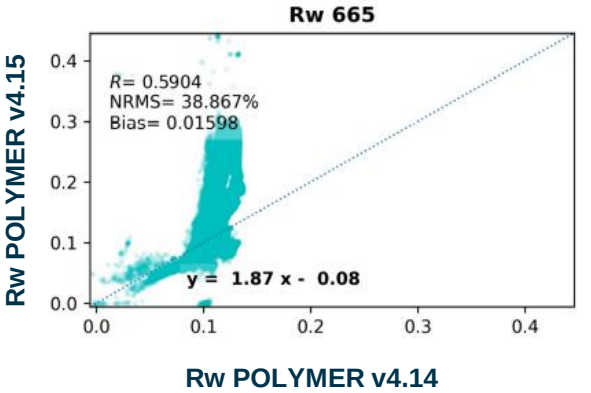
Shows discontinuities in v4.14, and large differences in scatter plot.

POLYMER v4.14

POLYMER v4.15

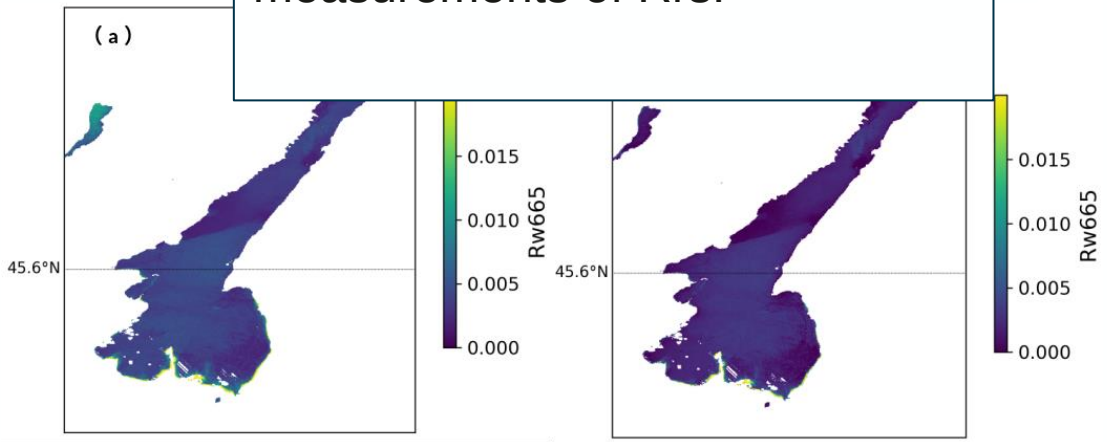


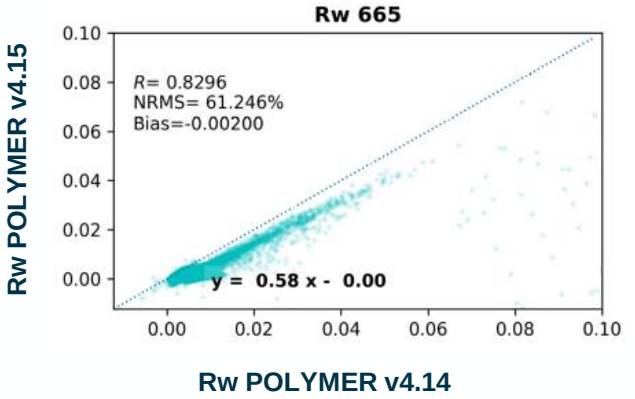
It is important that we can test over a large selection of lakes and optical water types – this requires a dataset of global in situ measurements of Rrs.



Lake Garda:
clear waters

Similar performance between versions.



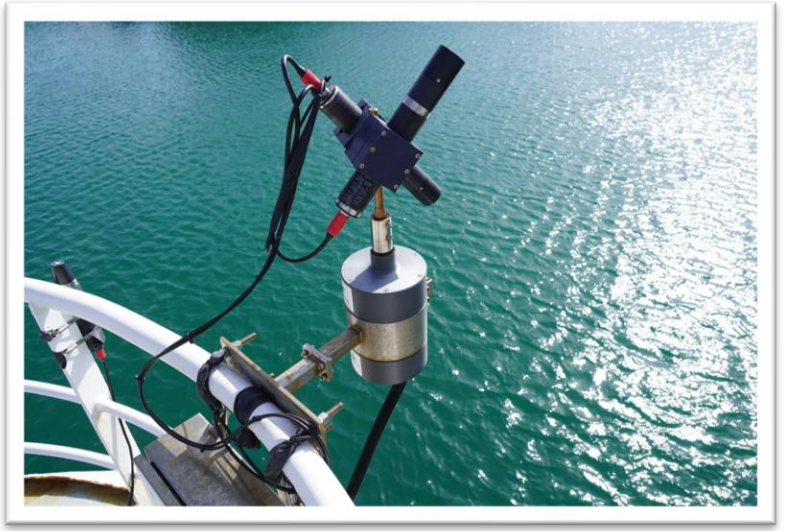


In situ Dataset Searches

In 2022 we started a search for (open) databases that can be used to validate the MSI L2 products. Ideal is to have global coverage over all seasons. We used:

GLORIA: collection of QCed campaigns, includes >2300 points 2016 onwards.
WISPCloud: 7 stationary fixed instruments with data over 1014 days.
So-Rad: shipborne measurements from 6 European sites.

Datasets are evaluated independently, rather than combined, allowing inspection of dataset-specific uncertainties.



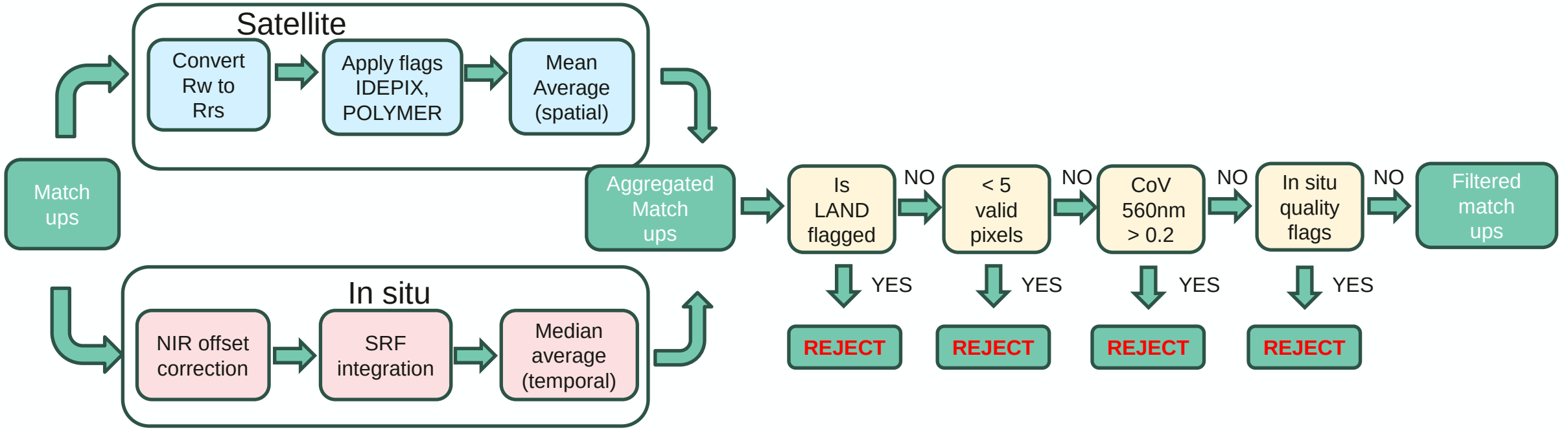
SORAD system set up for MONOCLE project

Match-up creation overview

Need to match up in situ data with MSI L2 data.

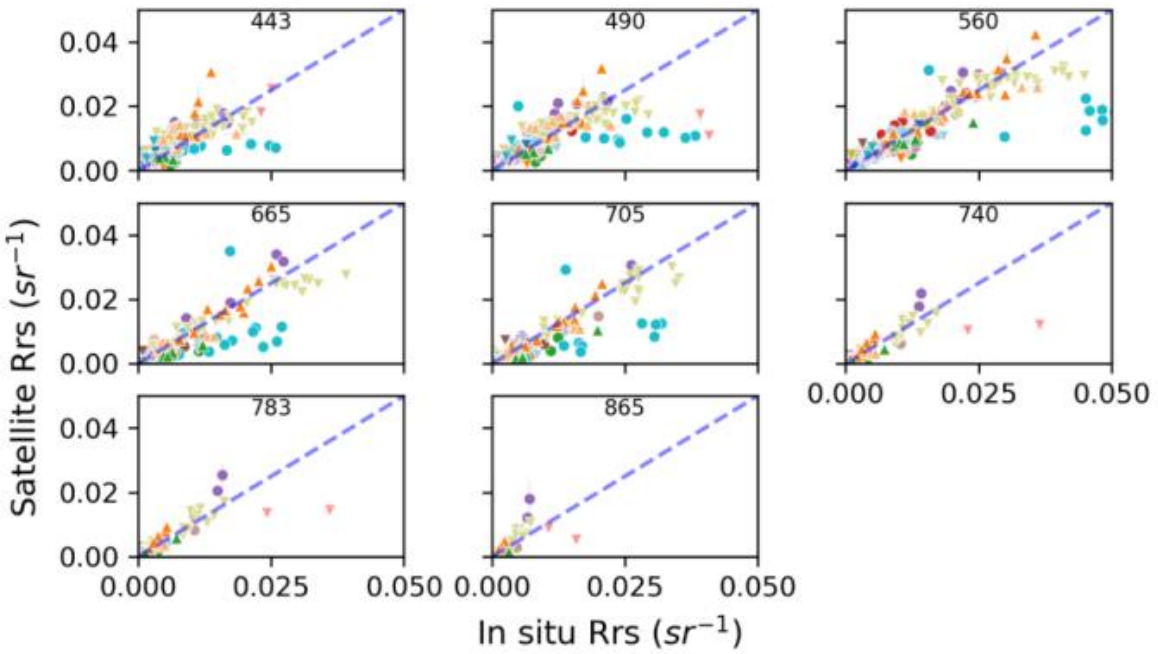
- **Date**: image within ±12 hours of in situ observation
- **Location**: extract a 3x3 macropixel centred on in situ location

Then enter the following algorithm and apply filters to leave only "good" data:

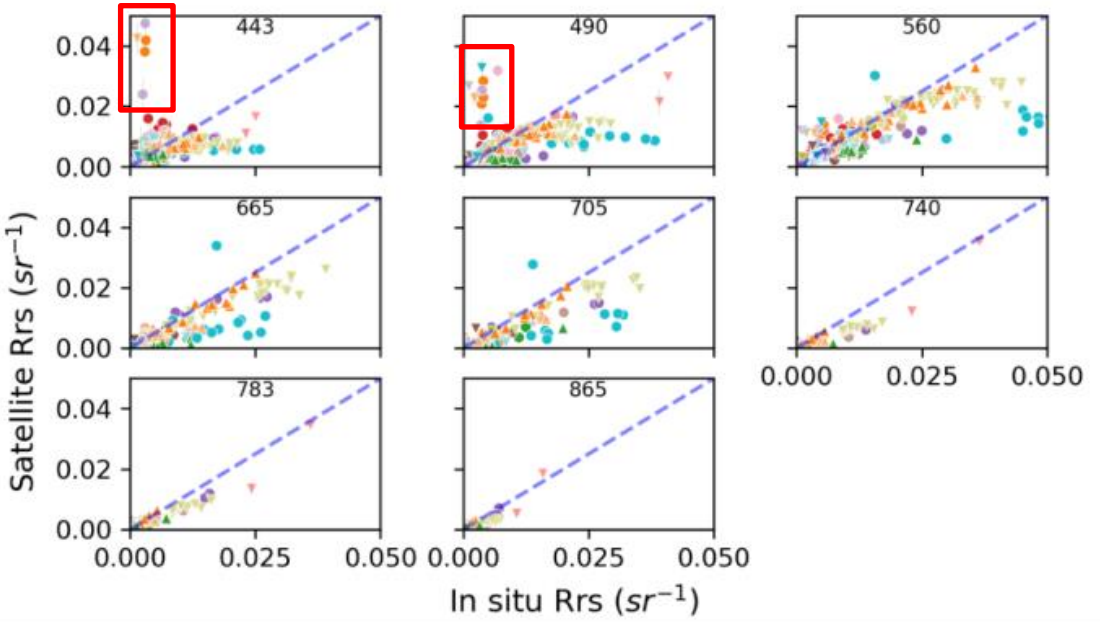


Results: using GLORIA

POLYMER v4.14

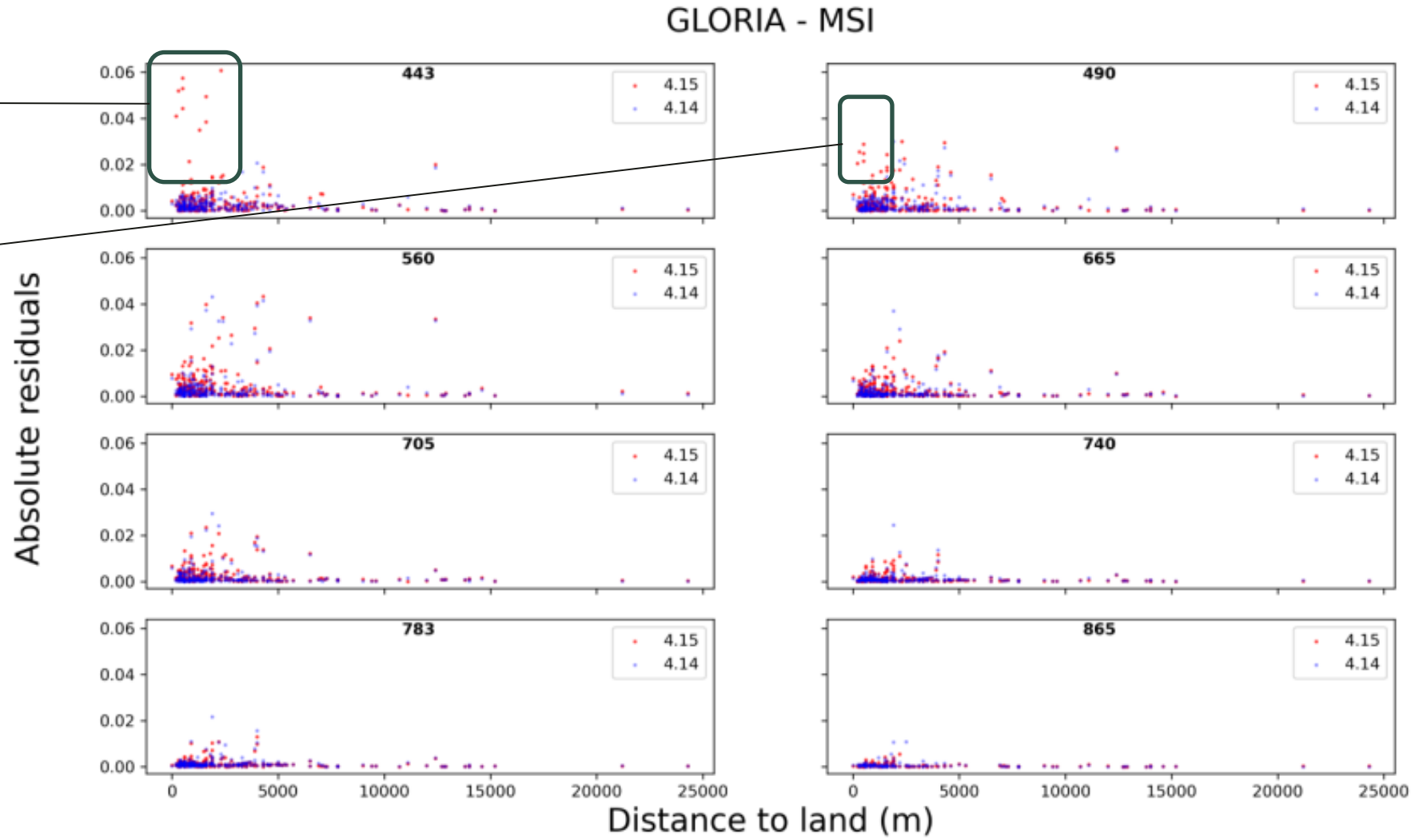


POLYMER v4.15



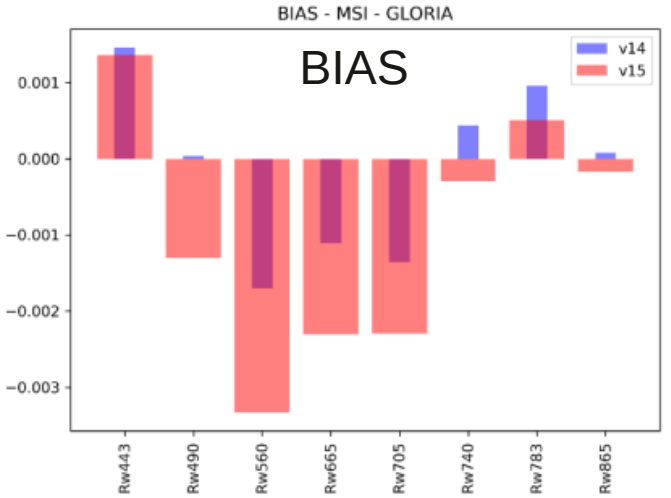
258 match-ups from 45 water bodies.
Similar performance qualitatively – some higher POLYMER Rrs in v4.15 in the blue (443, 490) bands

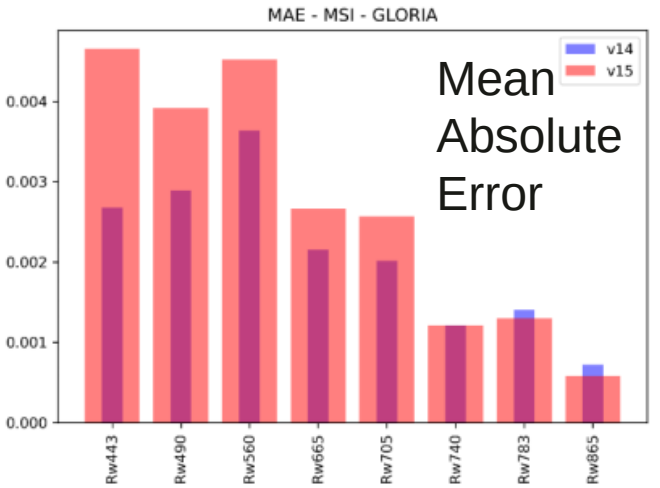
Larger errors in POLYMER v4.15 in the bluer bands (443, 490 nm) near the shoreline.

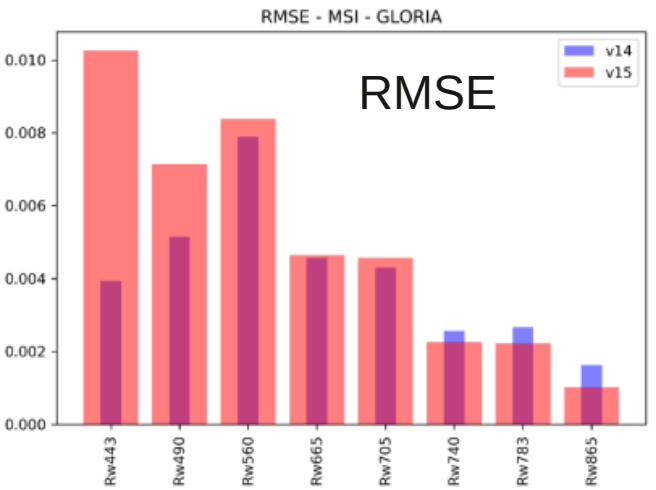


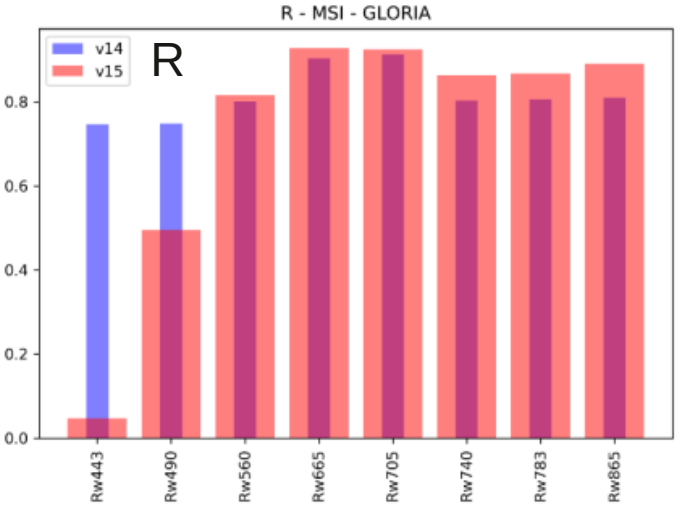
from a static maximum water extent map.

Results: using GLORIA





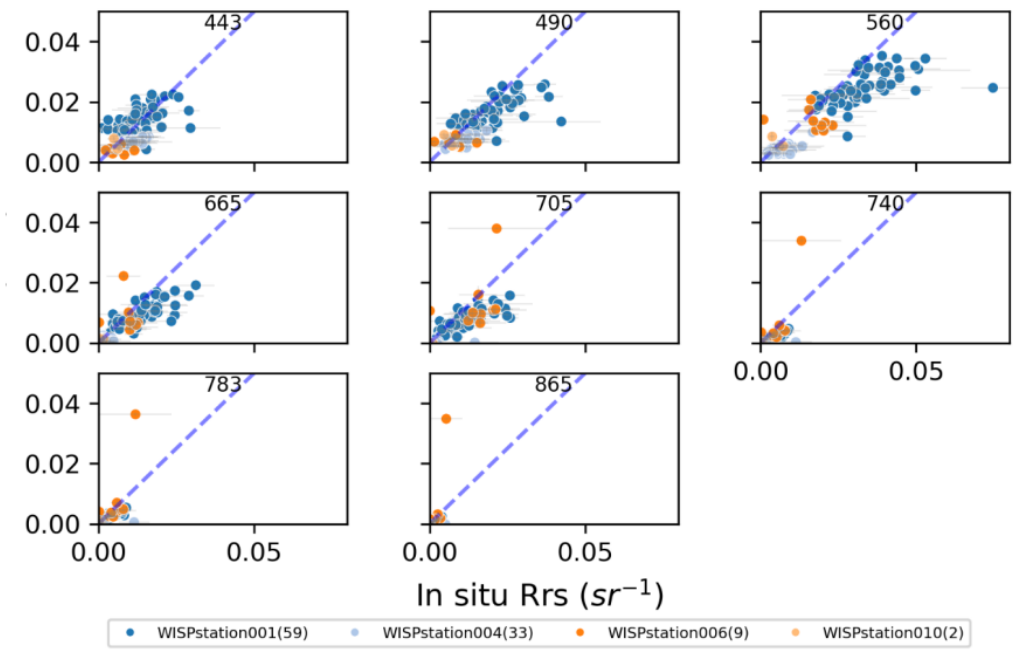




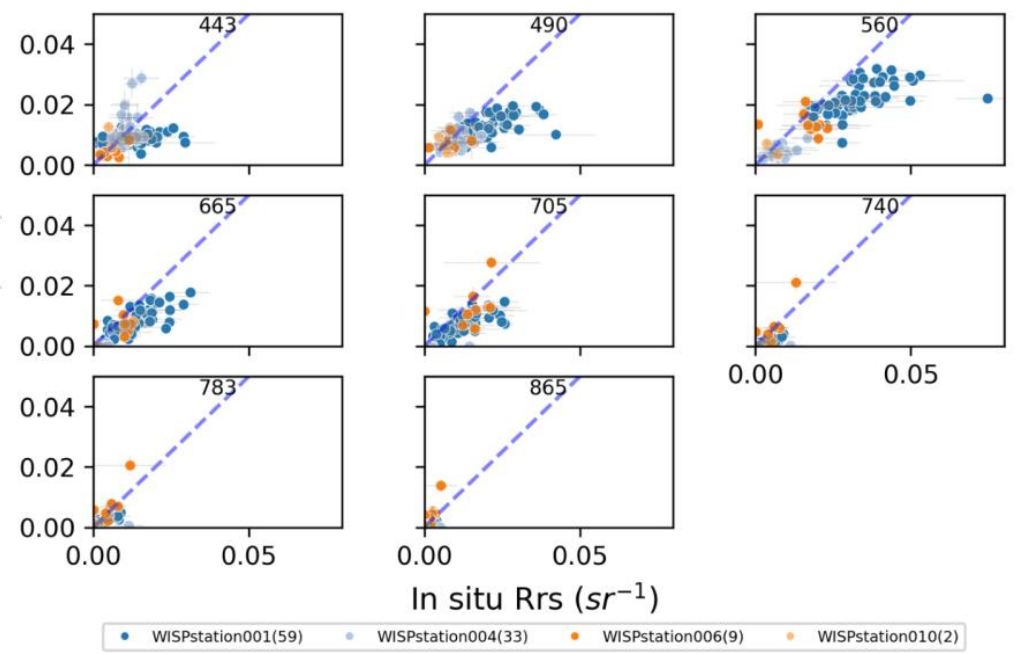
POLYMER v4.15 performs slightly less well in blue bands and slightly better in NIR

Results: using WISPcloud

POLYMER v4.14

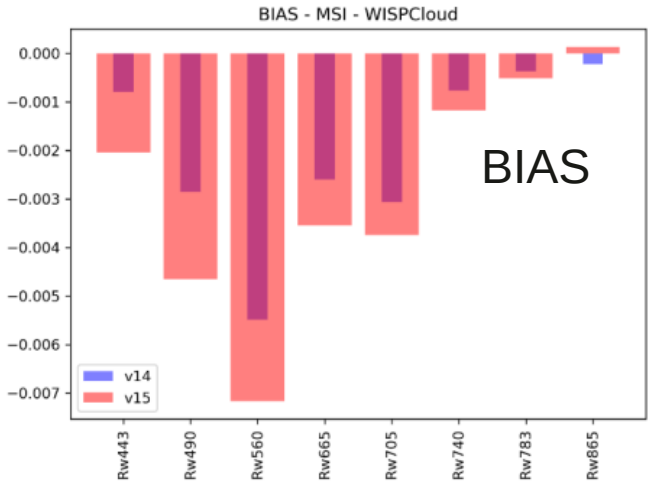


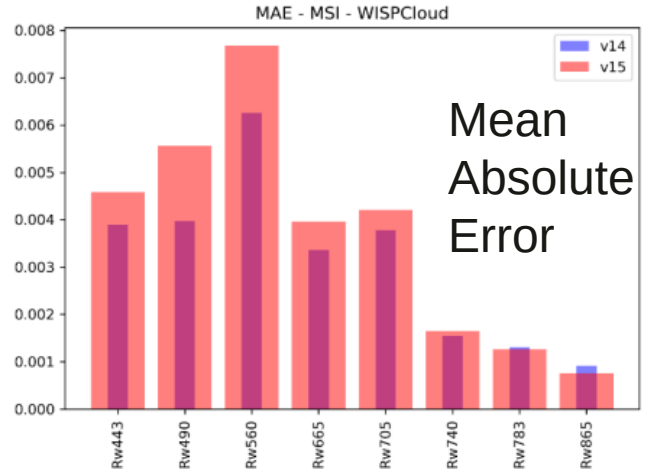
POLYMER v4.15

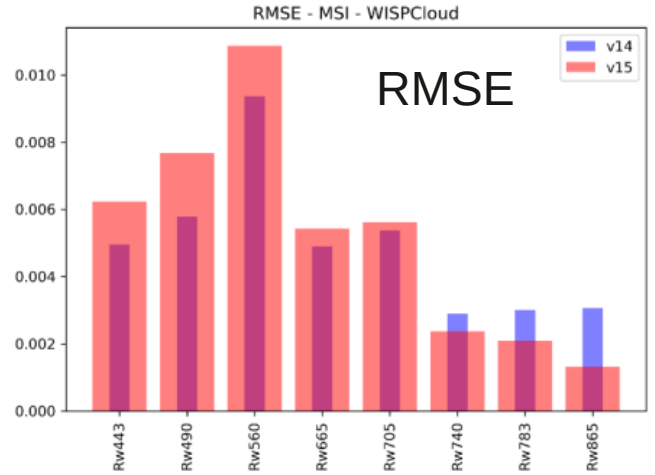


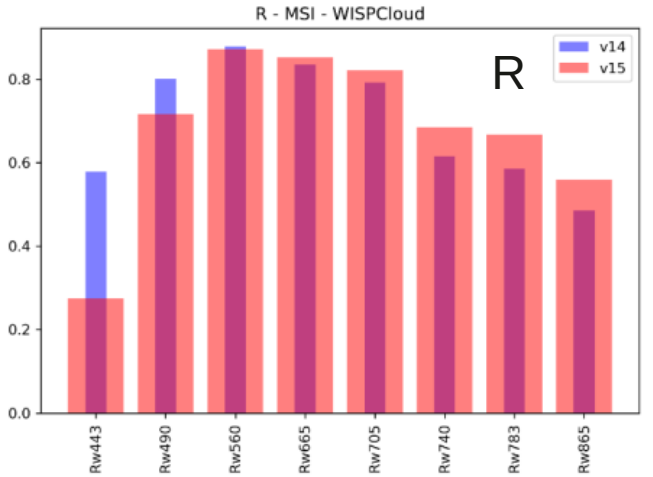
103 match-ups from 4 WISPstations.
Qualitatively similar with some higher POLYMER Rrs in v4.15 in blue (443) band

Results: using WISPcloud



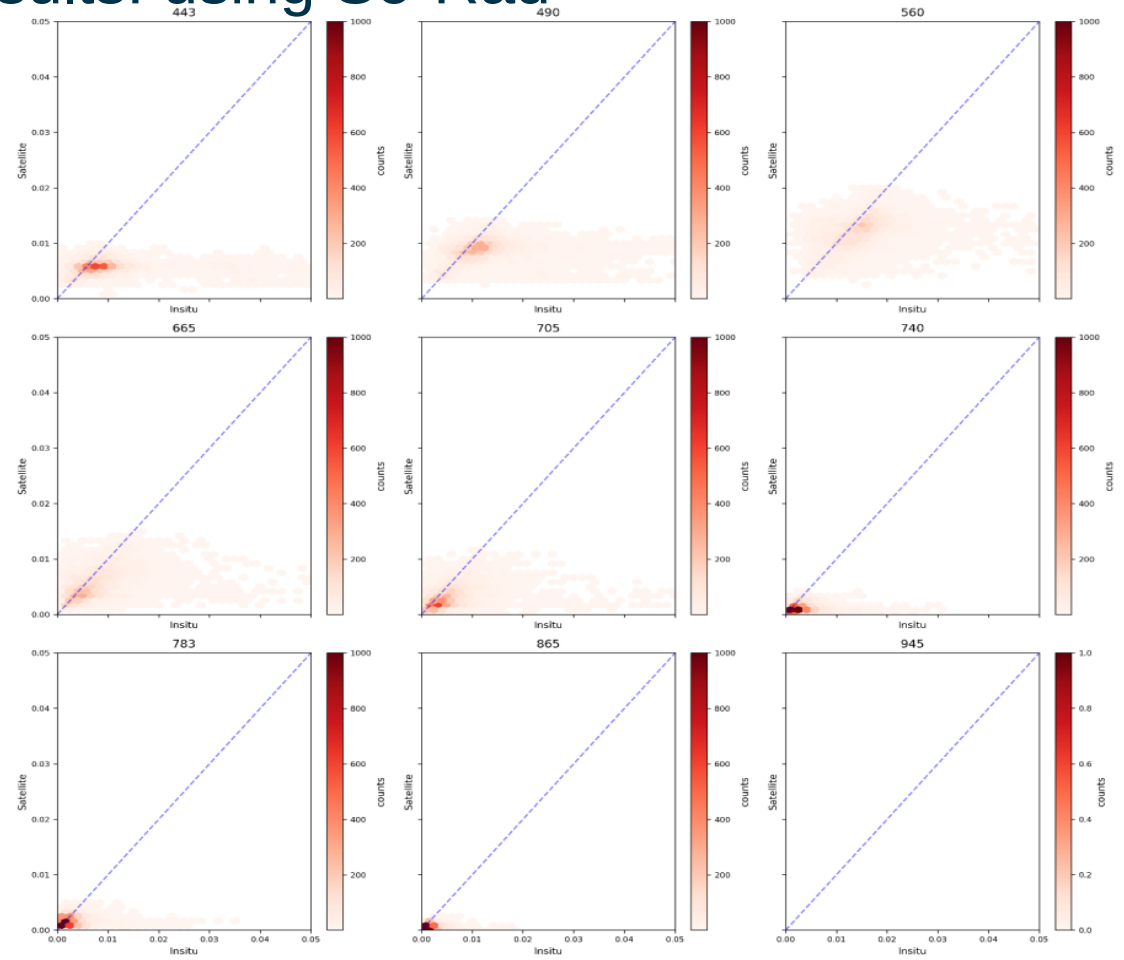


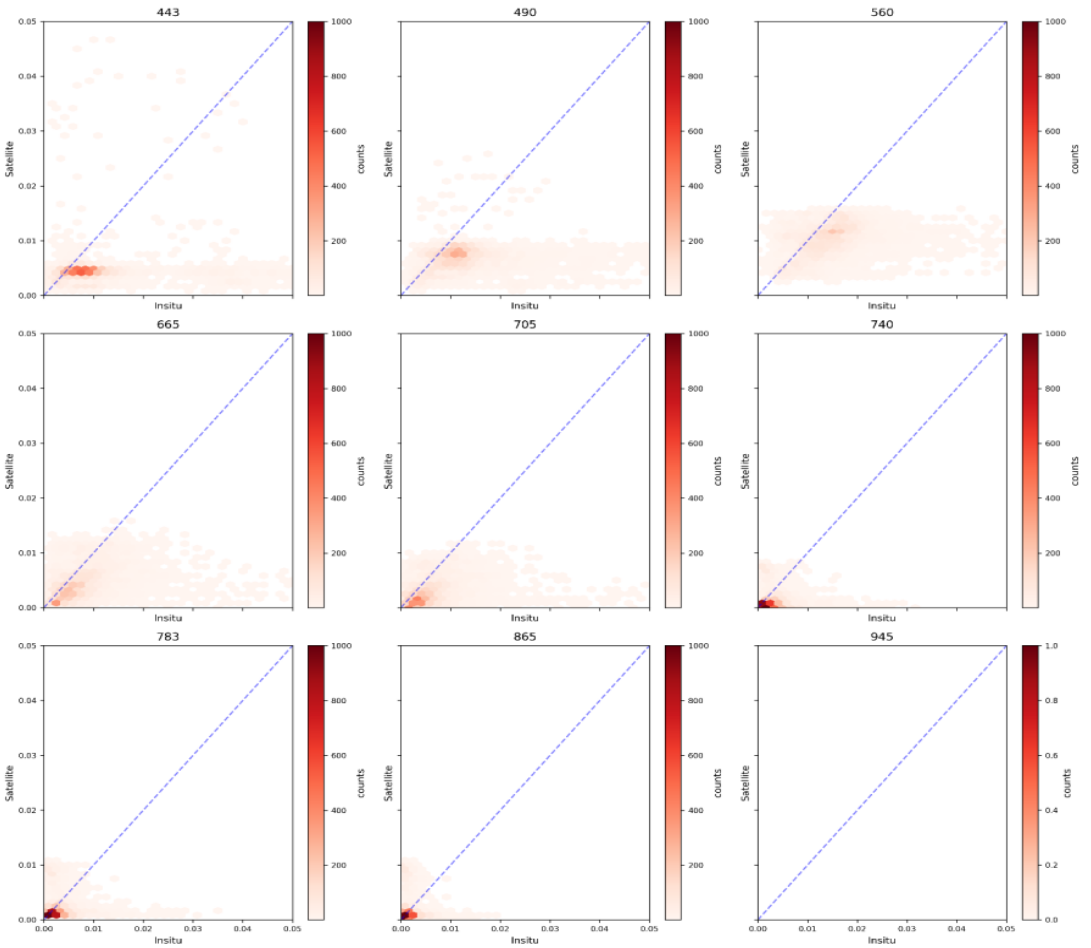




POLYMER v4.15 performs slightly less well in blue and slightly better in NIR

Results: using So-Rad

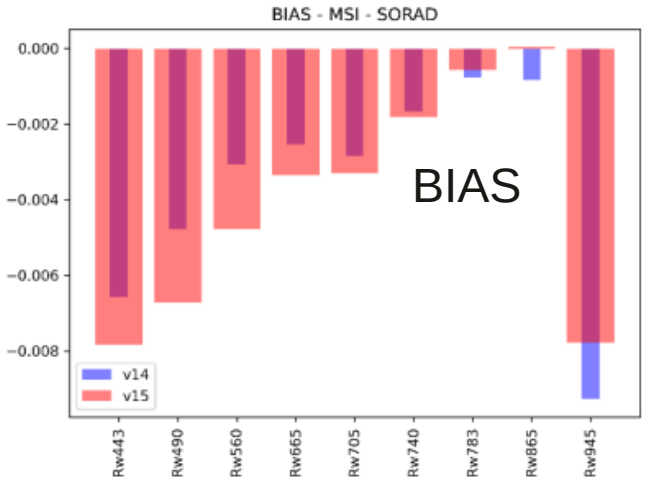


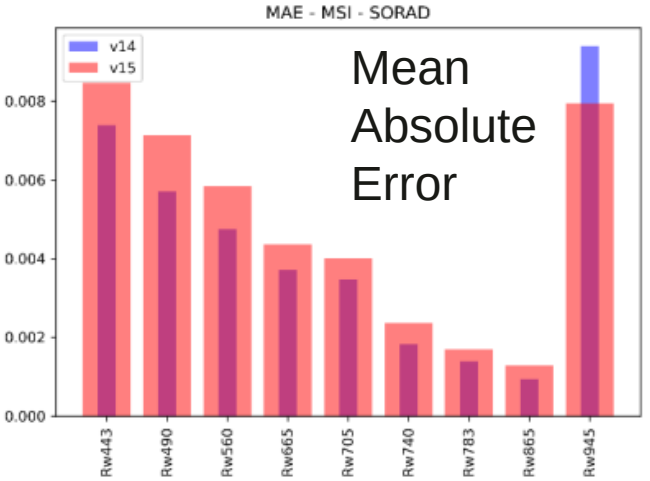


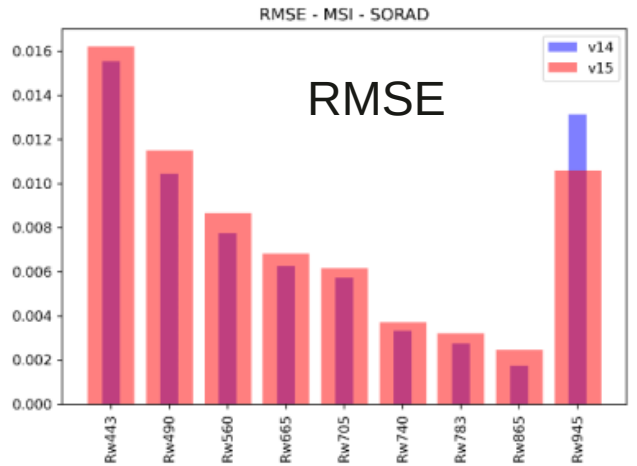
7157 match-ups in Tagus Estuary.

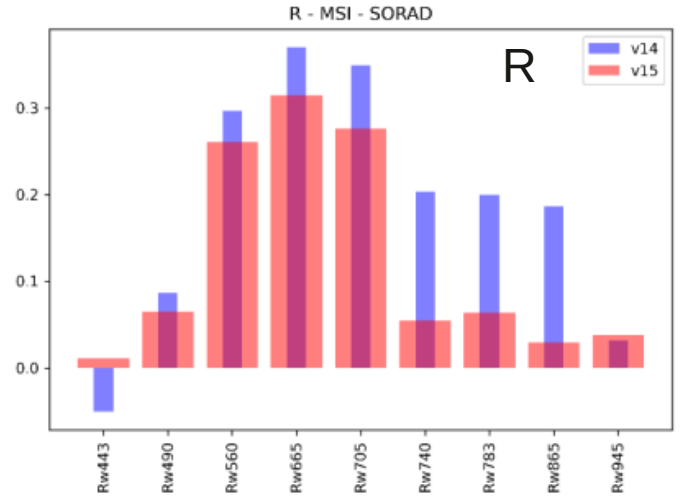
Qualitatively similar with more 'scatter' in POLYMER v4.15 blue bands (443, 490).

Results: using So-Rad









POLYMER v4.15 performs consistently but lower R values.

Summary of results

Slightly paradoxical:

- relatively similar performance between the two POLYMER versions across each database
- larger residuals in POLYMER v4.15 in the blue bands particularly near the shore – adjacency effect?
- POLYMER v4.15 gives a more "realistic" spectra in the areas of high turbidity & removes most spatial discontinuities

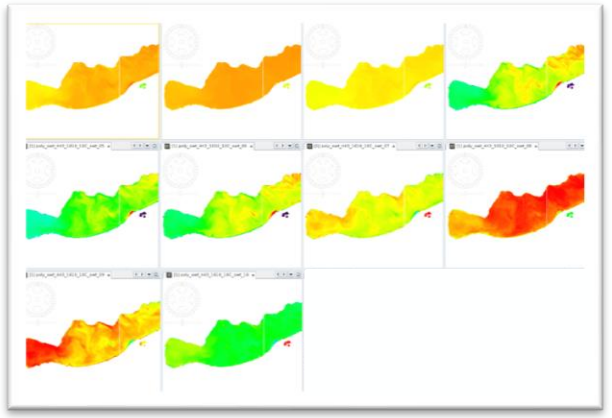
=> **Overall: more realistic horizontal patterns but extreme results near-shore**.

Accepting POLYMER v4.15 into version 2.0 of CLMS product means:

- Downstream algorithms (chl-a, turbidity) will need (re)tuning to give best performance
- (Hopefully) leading to more consistency between OLCI and MSI CLMS products

Downstream algorithm tuning

Multiple algorithms are used and blended together per pixel depending on the optical water types. This requires multiple retuning procedures and reassigning of algorithms to optical water types.



OWT membership scores

Chl-a	Turbidity	Optical water types
OC2 Ev6	Nechad et al 2010 @ 665 nm	1
Gilerson et al 2010	Nechad et al 2010 @ 705 nm	2
Gons et al 2005	Nechad et al 2010 @ 783 nm	3
	Nechad et al 2010 @ 865 nm	4
		5
		6
		7
		8
		9
		10

Outlook

- As always, we need more in situ data across varied water bodies to improve validation and calibration.
- Automated radiometry stations are a great source of data but tend to be located in "difficult" regions for remote sensing, such as near to the shore.
- We need more *in situ transects* travelling from shore-line to open water to better qualify performance across spatial surfaces.
- We should also consider aerial drones with hyperspectral radiometric sensors onboard.

Full validation results will be available in QAR linked @ https://land.copernicus.eu/global/products/lwq soon