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TAKING THE PULSE OF OUR PLANET FROM SPACE

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Aligning MSI and OLCI algorithms for inland water quality

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Global Land Operations

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Contents and Introduction

- Copernicus Land Monitoring - Lake water quality service
- Key differences between MSI and OLCI
- Validation and tuning of algorithms for MSI
- Examples of aligned retrieval results
- How to progress: in situ data requirements

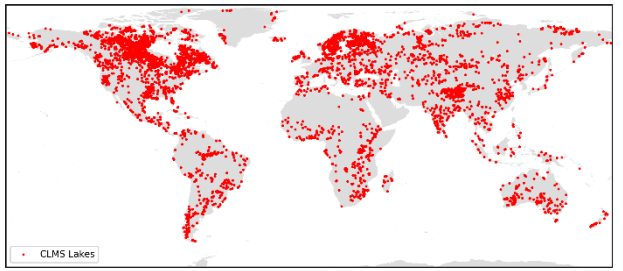
Copernicus Land Service: Lake water quality

CLMS lake water quality is a global service which produces at 300 m:

- Turbidity
- Trophic State Index
- Lake water-leaving reflectance

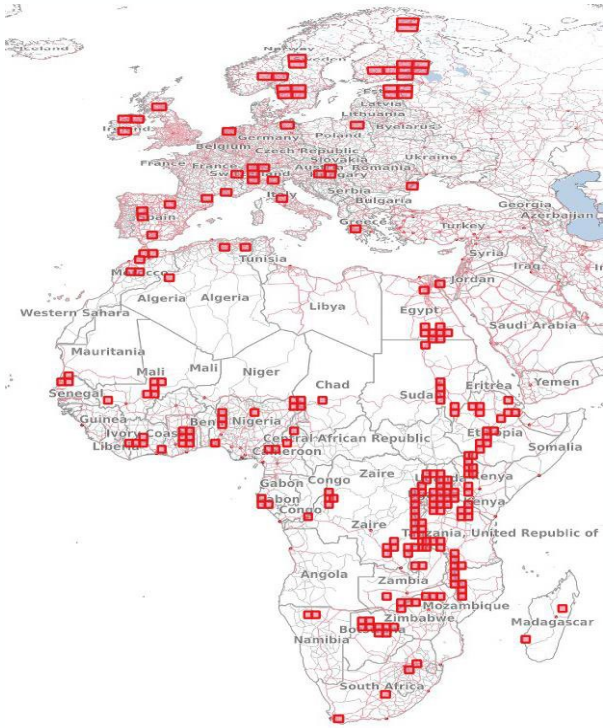
across a collection of 4000+ waterbodies,

produced using OLCI (Sentinel 3A and 3B).



A demonstration service has again started using MSI data at 100 m.

Red squares show the MSI tiles included in the demonstration service.



How do we consolidate information derived from both MSI and OLCI?

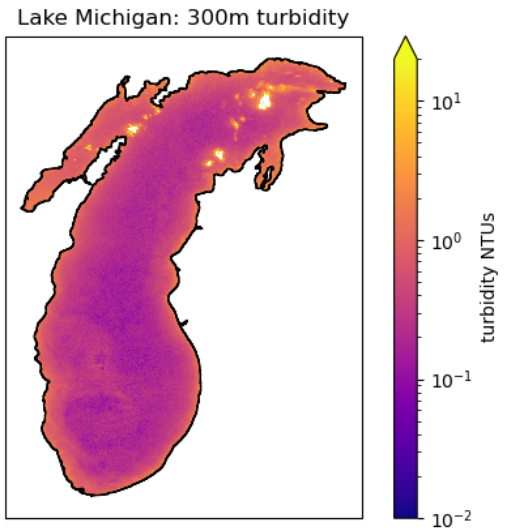
https://land.copernicus.eu/global/content/lake-water-products-100-m-resolution-are-re-entering-demonstration-service

Lake EO challenges

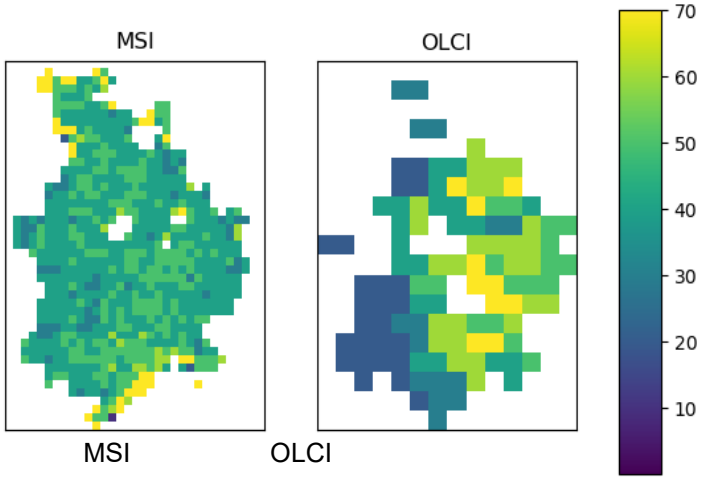
As a global service it is important to be able to handle many different types of waterbodies:

high / mid / low latitudes and altitudes, eutrophic, oligotrophic, large lakes, small lakes, …

OLCI is OK for medium and larger lakes but works less well for smaller lakes, complex shorelines and fine details.

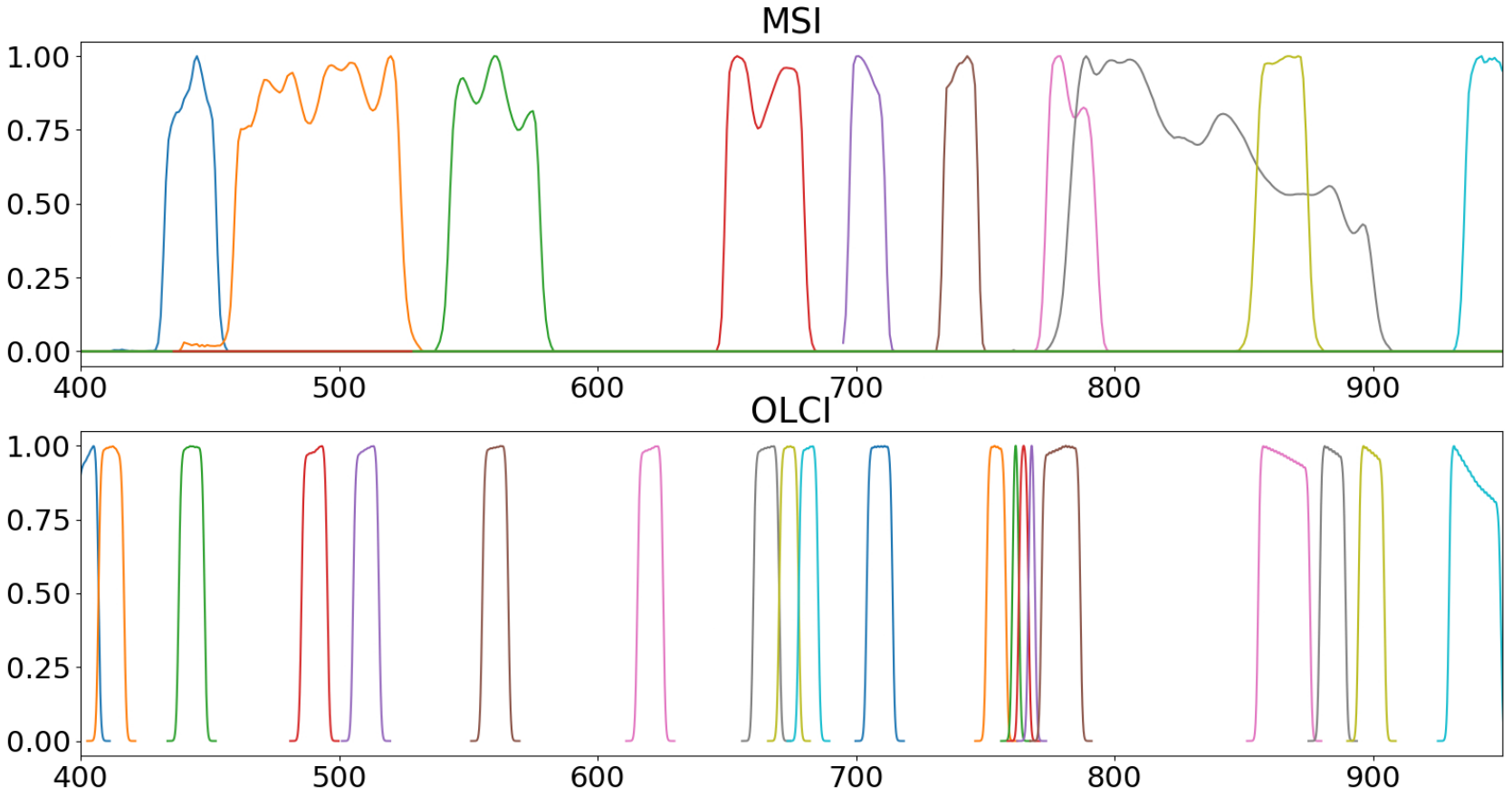


Lake Michigan, USA
OLCI turbidity @ 300 m
Area: 58 000 km^2



Derwentwater, UK
MSI turbidity @ 100 m
OLCI turbidity @ 300 m
Area: 5.18 km^2

OLCI vs MSI

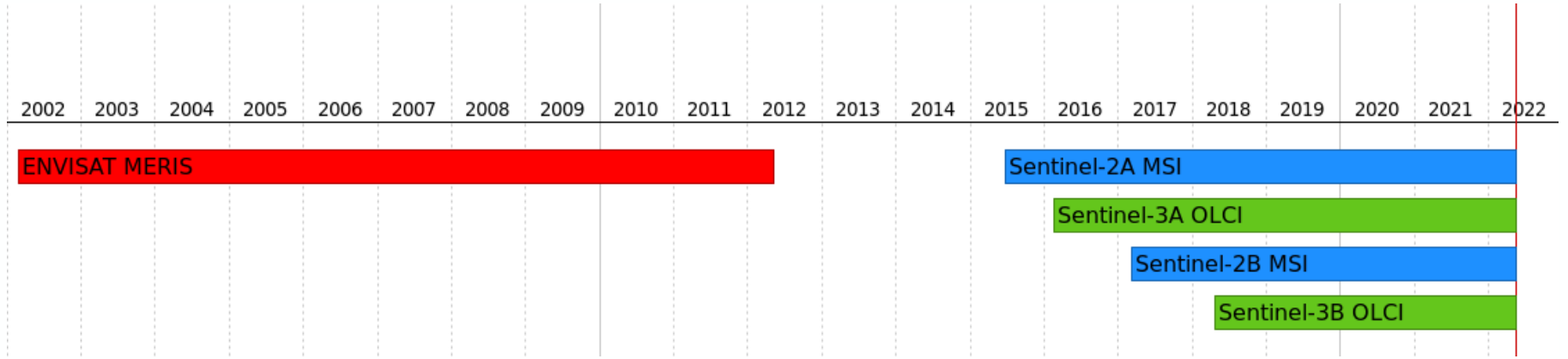


Spectral response differences:
MSI has wider bands.
MSI has fewer bands.

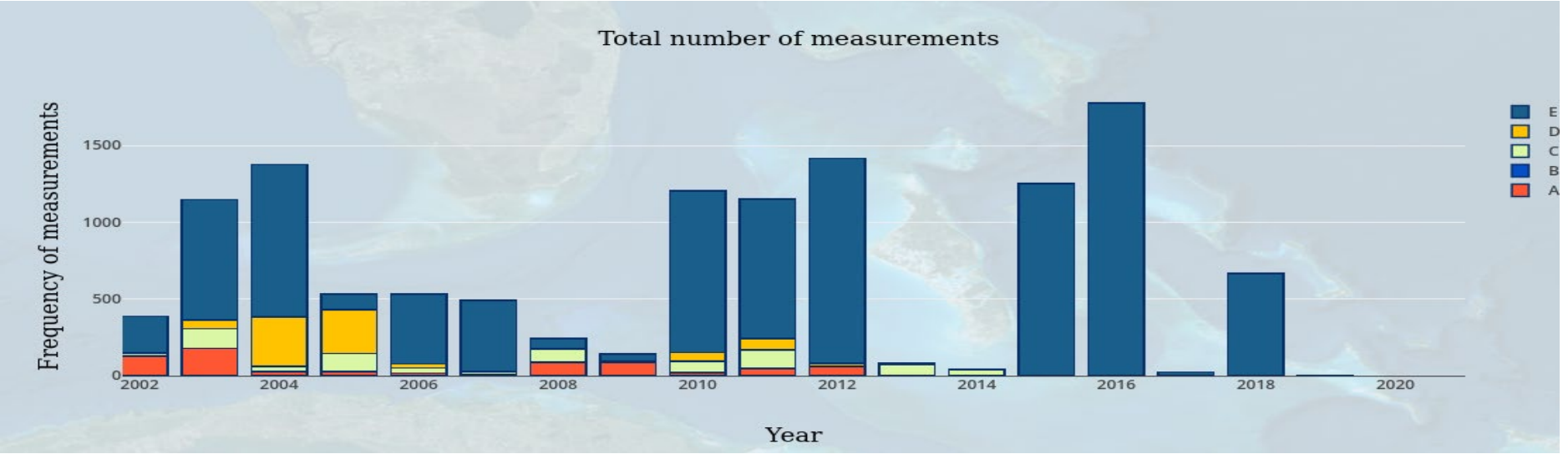
Can we get similar sensitivity, accuracy in Chl-a & turbidity algorithms with MSI as with OLCI?

Requires rigorous validation. Ideally performed using a significant number of in situ observations to cover all the variations of water types and overlap with MSI scenes.

Look at the timelines …



OLCI continues on from MERIS legacy – the validation of OLCI benefits from the 10 years of MERIS.

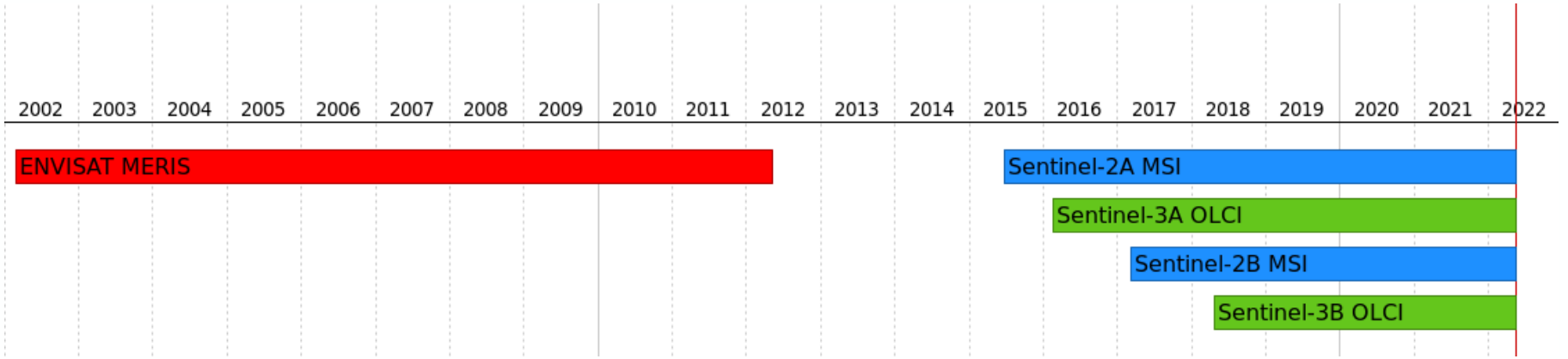


Limnades in situ database entries

A comprehensive dataset of in situ measurements overlapping MSI is not readily available (yet!)

https://limnades.stir.ac.uk/Limnades_login/Statistics/Stats_board.php

Use OLCI as reference



What we *do have* is a coincident dataset of OLCI data from 2016 onwards.

Let's use OLCI products (MERIS legacy) as reference instead of limited in situ data.

Considerations

- Atmospheric correction errors -- use same AC for all scenes. **Algorithm tuning specific to this AC.**
- Sensor anomalies, algorithmic uncertainties propagate -- tuning only as good as the OLCI data used.

Method overview

(i) select a subset of lakes (23) that cover a range of water types.

(ii) derive match-ups between MSI and OLCI
- 2 years of coincident data

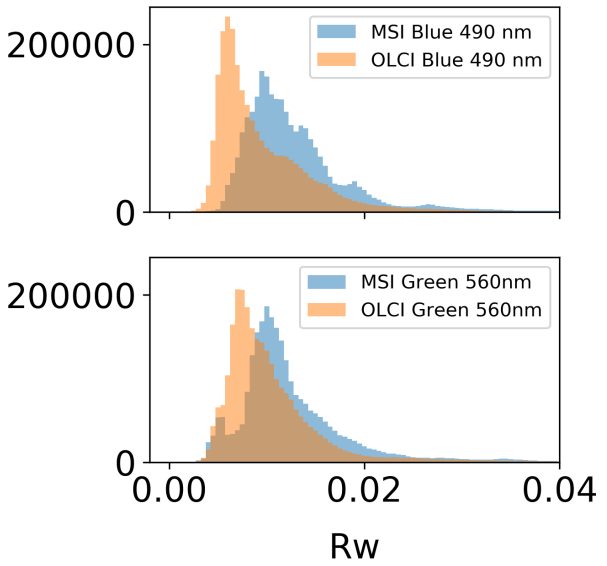
(iii) filtering to tune each algorithm only within its intended scope

(iv) perform optimisation (tune the algorithms)

See for further details: Warren et al, 2021, https://doi.org/10.1016/j.rse.2021.112651.

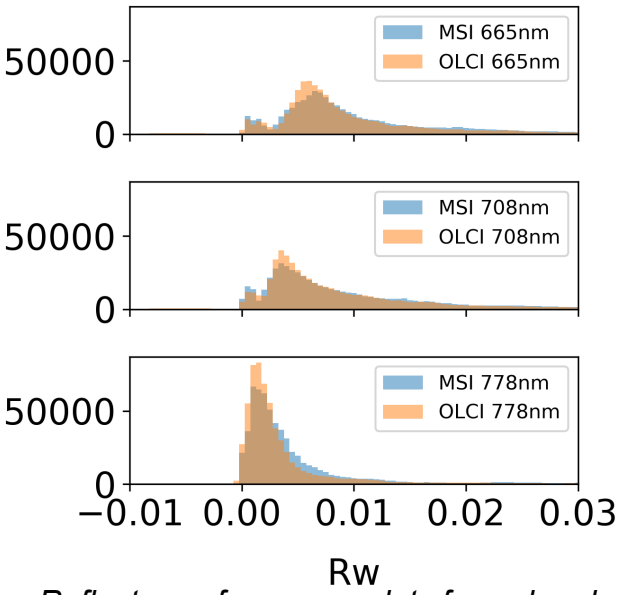
Reflectance match-ups

Reflectance in blue and green bands suggest that MSI overestimates compared to OLCI



Reflectance frequency plots for blue and green wavebands (for OCx type chl-a algorithms)

Reflectance in red and NIR bands suggest that MSI and OLCI distributions agree well

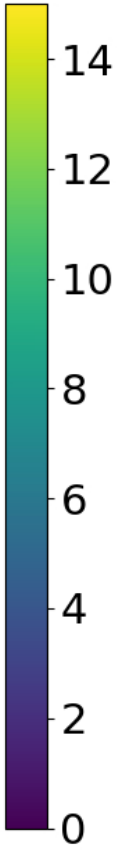


Reflectance frequency plots for red and near infra-red wavebands (for NIR chl-a and Nechad turbidity algorithms)

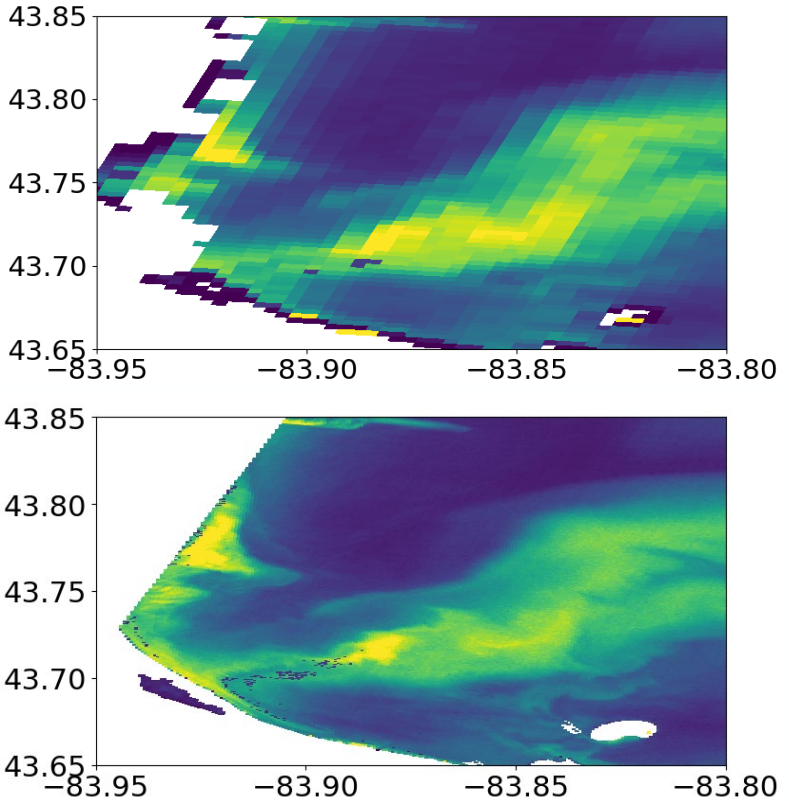
Warren et al, 2021, https://doi.org/10.1016/j.rse.2021.112651.

Examples

Lake Huron, USA



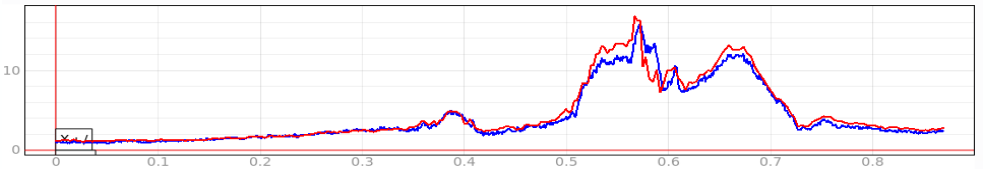
Nechad Turbidity, May 9th 2022



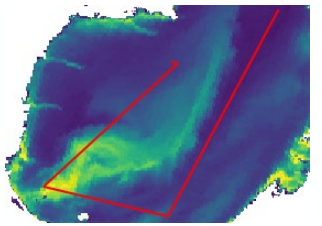
Note: single day scenes are not final CLMS 10-day products. Nechad algorithm not currently in OLCI CLMS product v1.4.

OLCI @ 300m

OLCI vs MSI



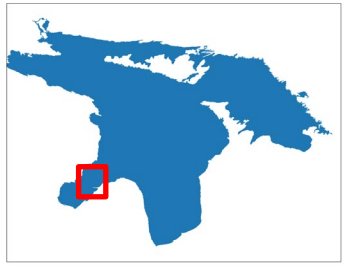
MSI @ 60m



Similar patterns
More detailed in MSI

Examples

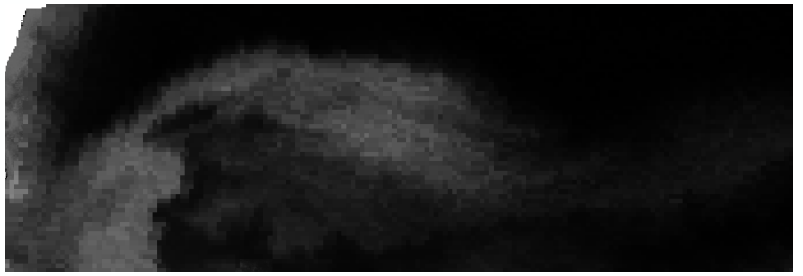
Note: single day scenes not final CLMS products

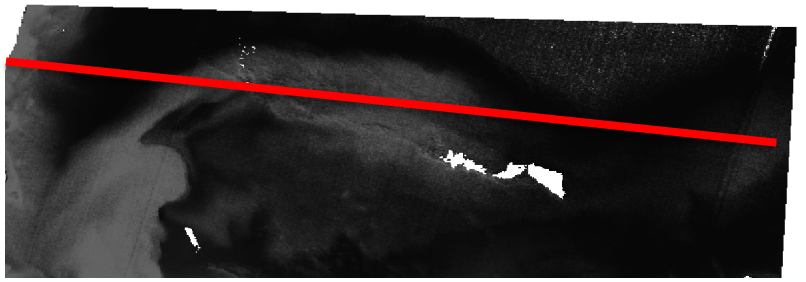


Lake Huron, USA

Chl-a (OC2), May 9th 2022

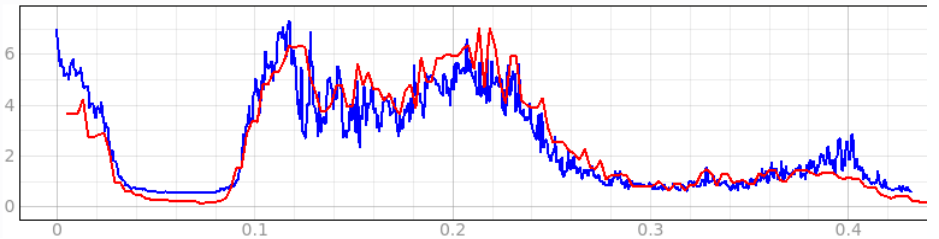
Area of low turbidity





OLCI @ 300m

OLCI vs MSI



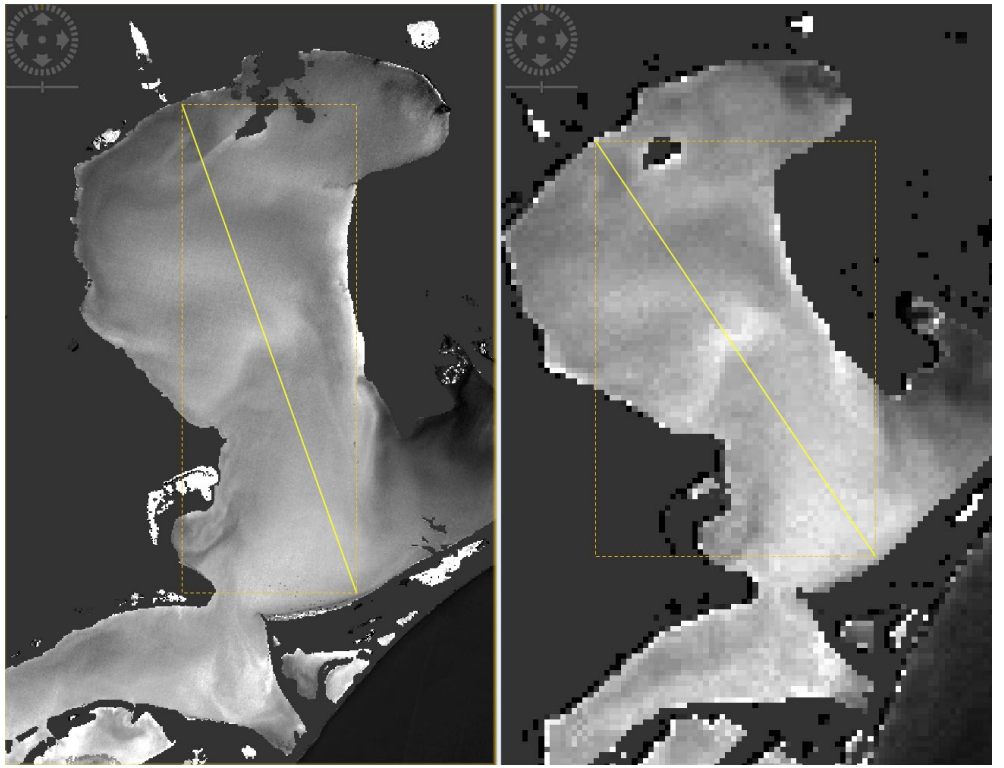
MSI @ 60m

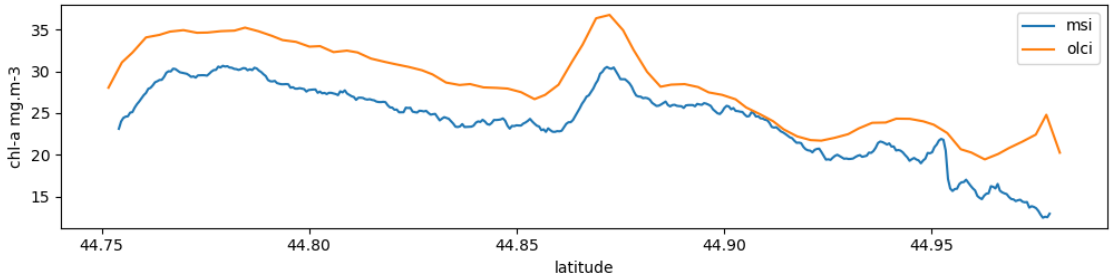
Examples

Lake Razelm, Romania

MSI

OLCI





Note: single day scenes not final CLMS products

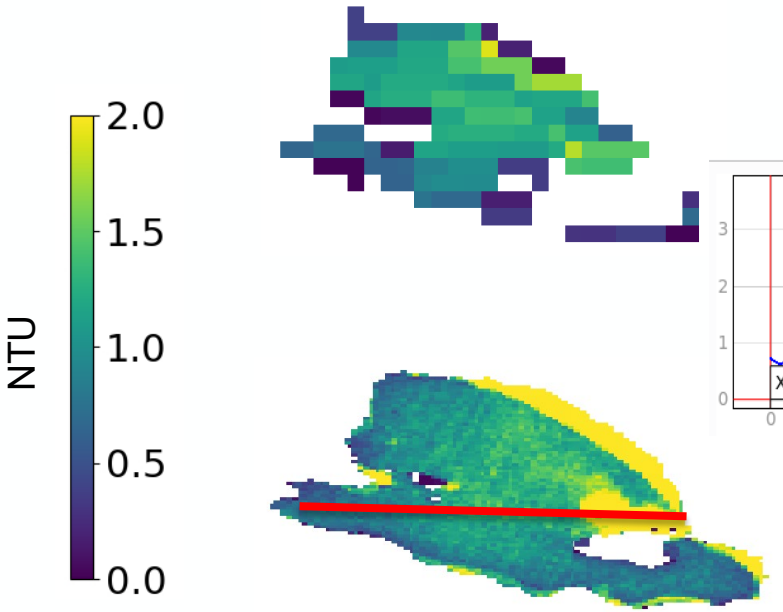
Blended Chl-a product
12 July 2021

Difference of approx.
5 $mg.m^{-3}$ chl-a

Examples

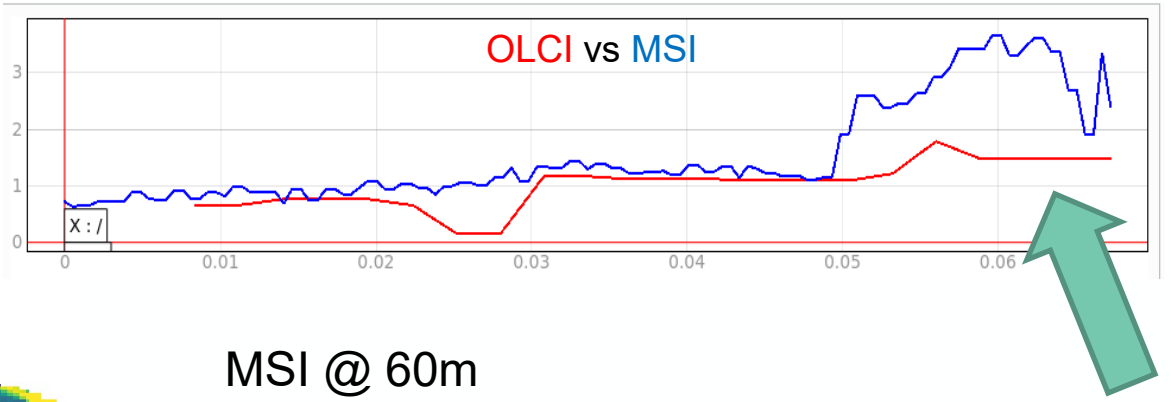
Loch Leven, UK

Nechad Turbidity, 28 March 2022



Note: single day scenes not final CLMS 10-day products. Nechad algorithm not currently in OLCI product.

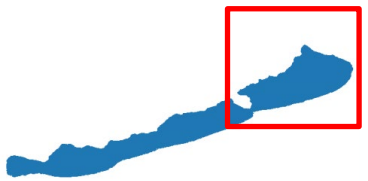
OLCI @ 300m



MSI @ 60m

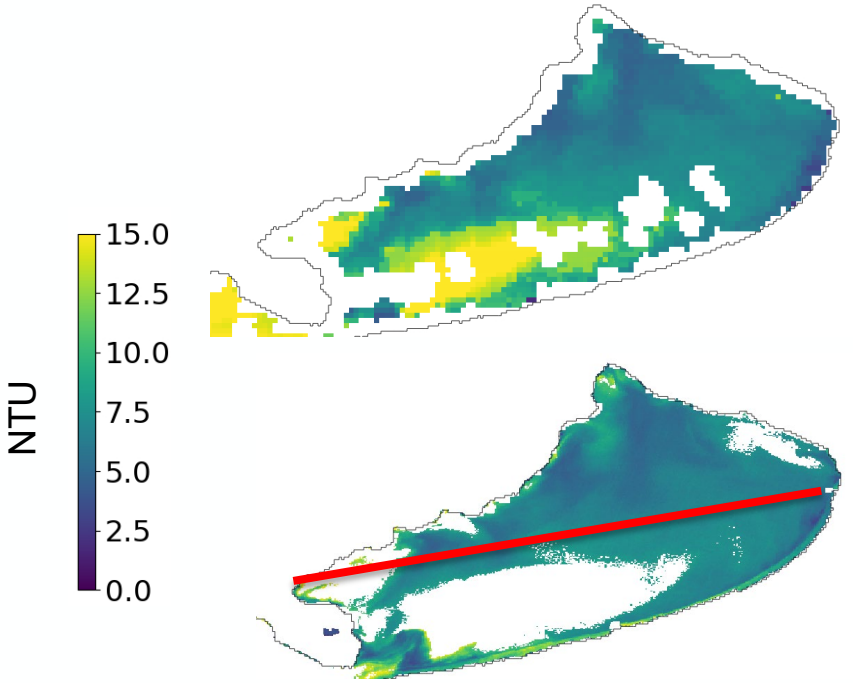
Differences reach 100%

Examples



Lake Balaton, Hungary

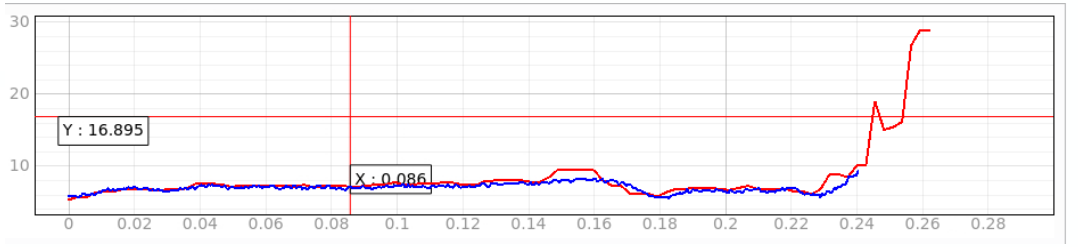
Nechad Turbidity, 24 March 2019



Note: single day scenes not final CLMS products

OLCI @ 300m

OLCI vs MSI



MSI @ 60m

MSI data is accepted (not flagged as bad data) closer to shoreline than OLCI. But most turbid results are masked out in the middle region – AC flags!

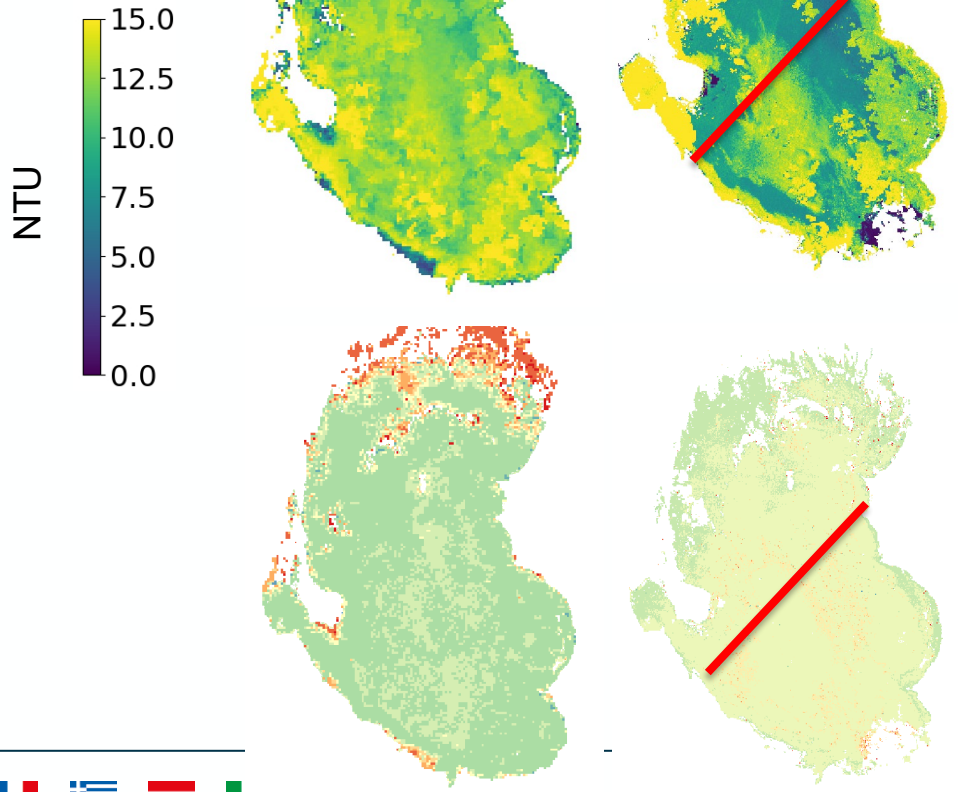
Examples

Comparison of 10-day products currently available.

Lake Chilwa, Malawi

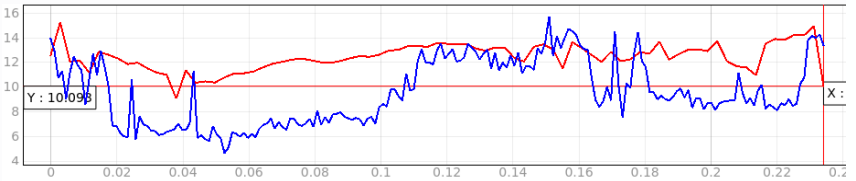
OLCI @ 300m

MSI @ 100m



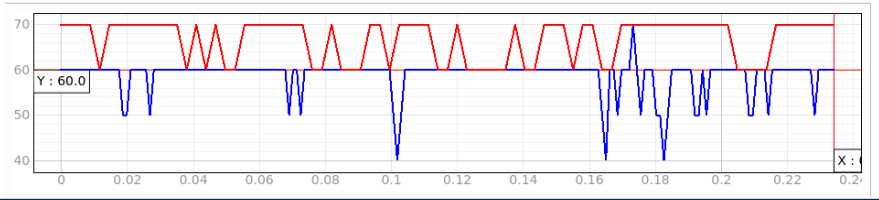
Turbidity

OLCI vs MSI



Trophic index

OLCI vs MSI



Conclusion

Recap: We want to determine the water quality of smaller lakes and features within lakes which are currently not observable with OLCI and need consistent results between MSI and OLCI.

What we've done: Match-up 2 yrs of OLCI/MSI scenes over 23 lakes, tune algorithms using OLCI as reference.

What this means: CLMS MSI level-2 products should be "more like" OLCI level-2 products (on average, across the globe).

This does NOT mean everything is now perfect.
Because:

- Tuned MSI level-2 products can only be as good as the OLCI reference.
- A global-best will not always be best locally.
- Data are not error free (AC, adjacency)

How to progress: request for in situ data

The free Copernicus product is used globally. However, to maintain, improve and build trust in the products there is a need to validate against global inland water measurements [Rrs, TSM, Chl-a] that overlap with MSI sensor (2015 onwards).

A target of CLMS over the coming year is to include additional and more recent validation sources.

Do you have a suitable data repository? Or data collected for a Phd, post-doc or other study that are now sitting on a hard drive somewhere? Are you willing to share?

If the answer is yes or maybe, then **please email**:

calimnos-support@pml.ac.uk

We can help to (re)format any reprocess data to make these suitable for long-term archiving.