



Global Observatory of Lake Response to Environmental Change

Water Quality Information for the Benefit of Society | University of Stirling, 29-31 August 2018

The validation of biogeochemical algorithms for remote sensing of lake water quality at the global scale

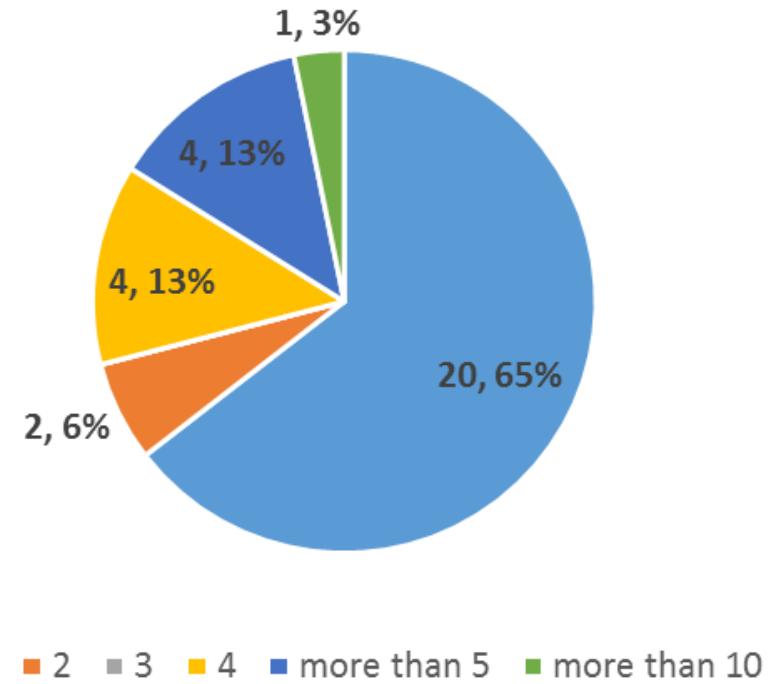
Peter Hunter, Vagelis Spyros, Claire Neil, & Andrew Tyler | University of Stirling
Stefan Simis & Steve Groom | Plymouth Marine Laboratory



The challenge

- Many algorithms developed for retrieval of biogeochemical properties in inland waters
- Performance varies due to high diversity in optical properties over space and time
- Development of global scale products requires an adaptive approach allowing optimal selection of algorithms and/or coefficients

Number of lakes considered in previous validation studies (up to 2015)



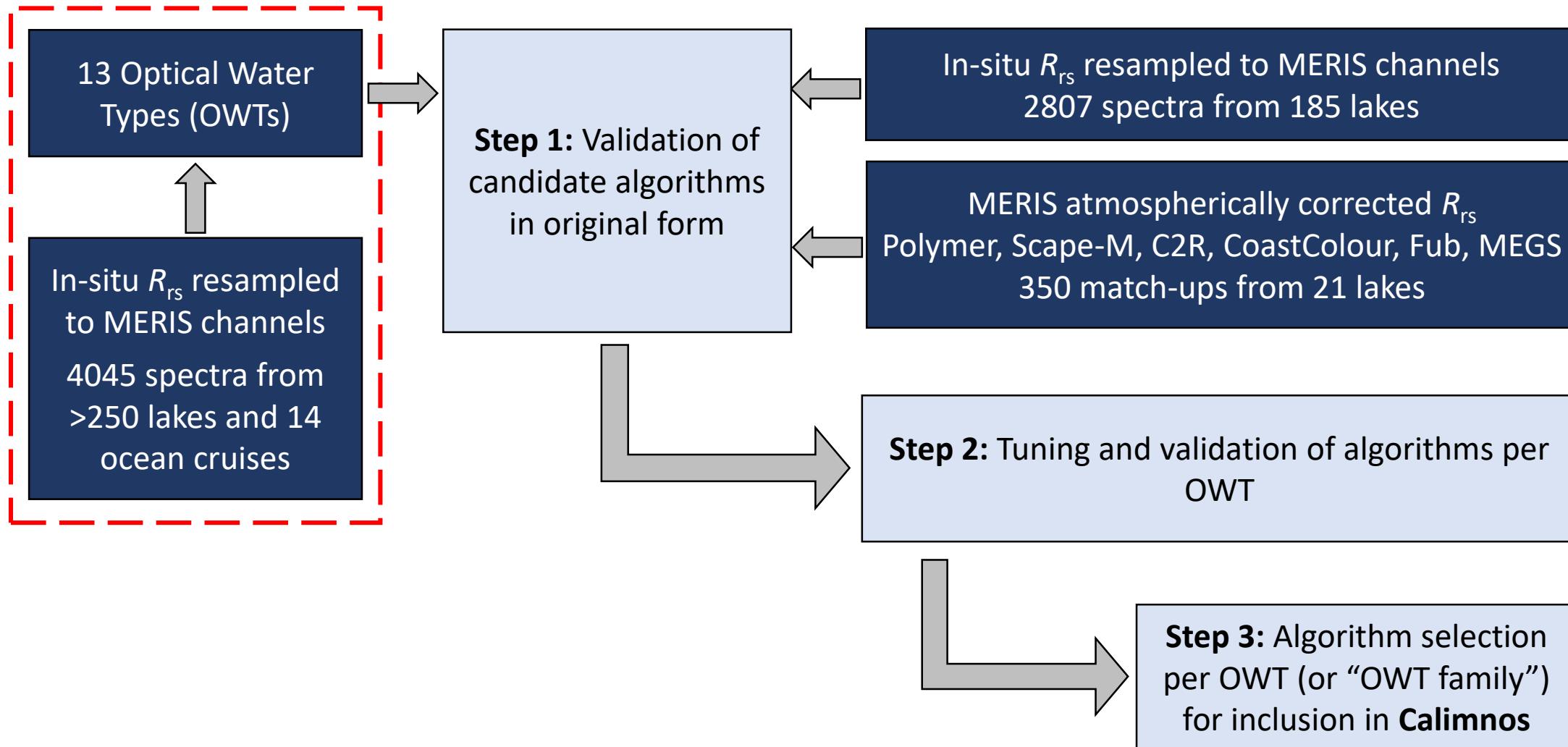
Search terms: remote sensing; water quality; lakes.

Candidate algorithms

- Extensive literature search
 - Formula / code openly available
- Shortlist of candidate algorithms
 - 15 chlorophyll
 - 13 total suspended matter
 - 6 phycocyanin
 - 12 coloured dissolved organic matter
- Chlorophyll algorithms
 - Empirical band ratios (blue/green, NIR/red)
 - Semi-analytical (e.g. QAA)
 - Neural networks (e.g. C2R)

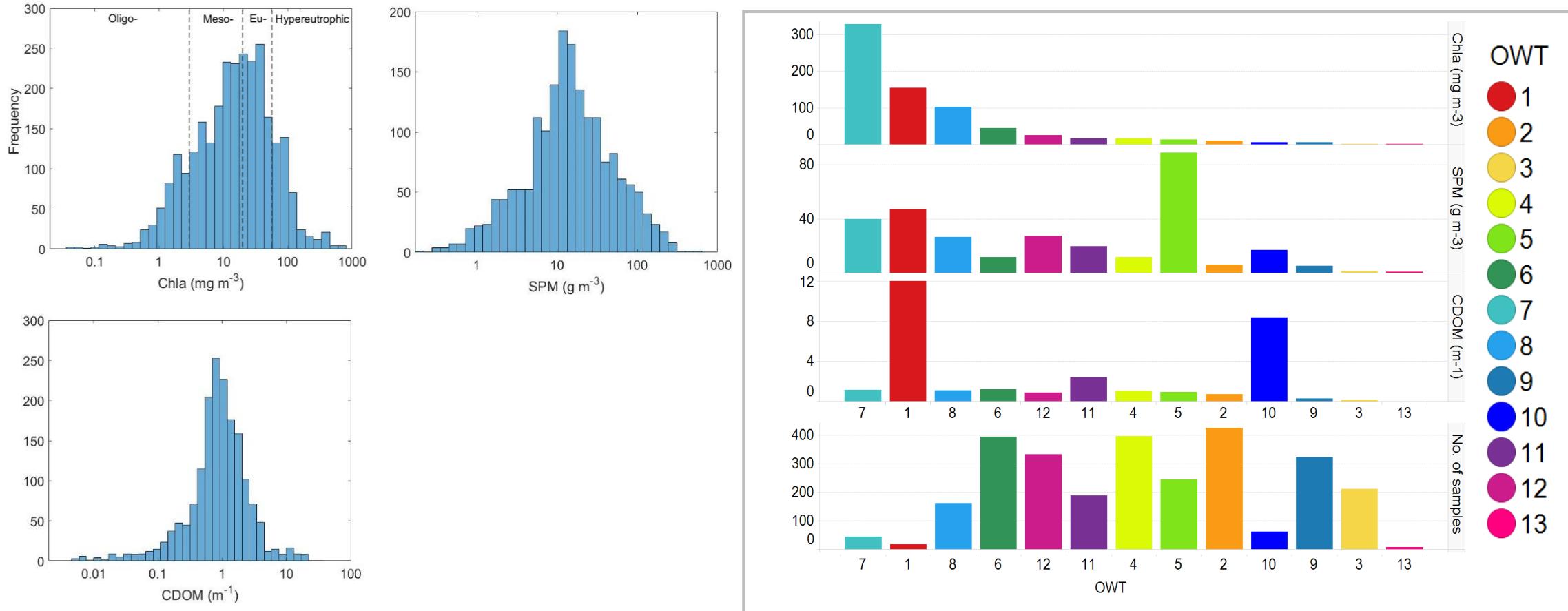
Constituent	Type	Model	Reference
Chlorophyll	Empirical NIR-red BR	MERIS 2-Band 708/665	Gilerson et al., 2010, Gurlin et al., 2011, Gons et al., 2005.
		MERIS 2-Band 753/665	Gilerson et al., 2010, Gitelson et al., 2011, Moses et al., 2009.
	MERIS 3-Band		Gitelson et al. 2008, Gitelson et al. 2011, Gurlin et al., 2011, Moses et al., 2009.
	MERIS NDCI		Mishra et al. 2012.
Empirical OC	MERIS OC2E MERIS OC3E MERIS OC4E		O'Reilly et al. 2000.
Neural Network	NN_Chl NN_IOP		Ioannou et al., 2013.
Analytical	MERIS QAA [Turbid]		Mishra et al., 2013.
	MERIS GSM		Maritorena et al., 2002.
	MERIS Matrix Inversion		Boss & Roesler, 2006.
	Peak Height Method	MPH	Matthews et al., 2012.

Overview of our approach





Optical complexity within the dataset

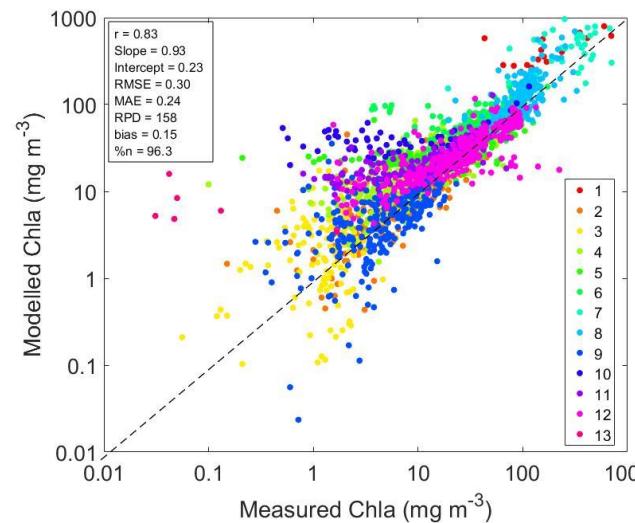


Chlorophyll retrieval using in-situ R_{rs} data

Best performing single algorithm

NIR/red ratio (Gurlin et al., 2011)

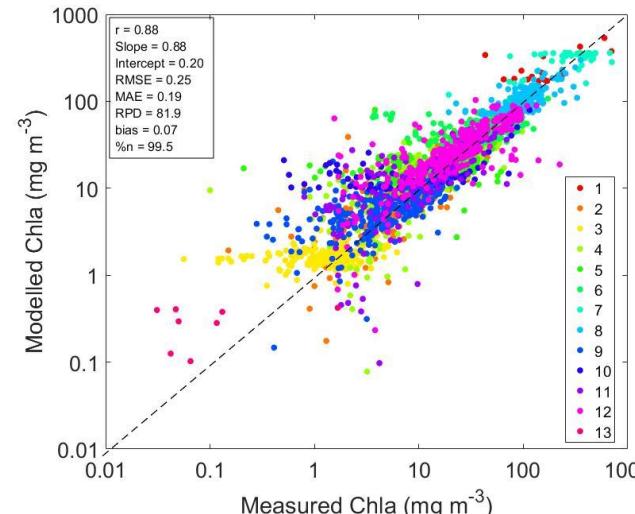
$r = 0.83$
MAE = 0.24 mgm⁻³



Best performing single algorithm
re-tuned per OWT

NIR/red ratio (Mishra et al., 2012)

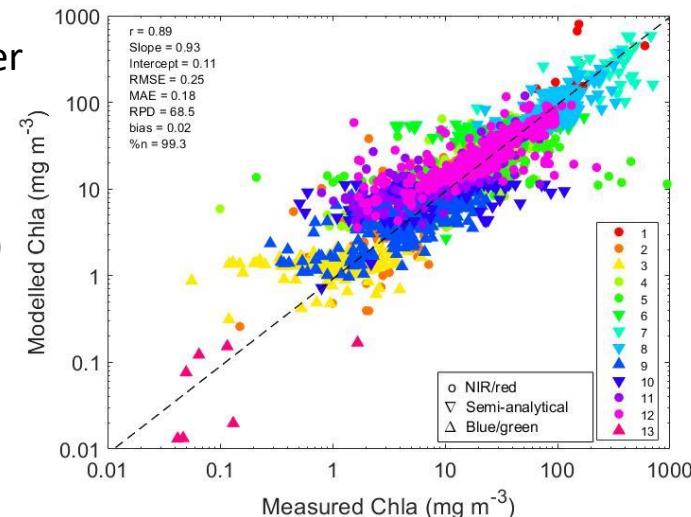
$r = 0.88$
MAE = 0.19 mgm⁻³



Best performing algorithms per OWT

NASA OC3 (O'Reilly et al 2000)
NIR/red ratio (Gurlin et al., 2011)
QAA (Mishra et al., 2013)

$r = 0.89$
MAE = 0.18 mgm⁻³



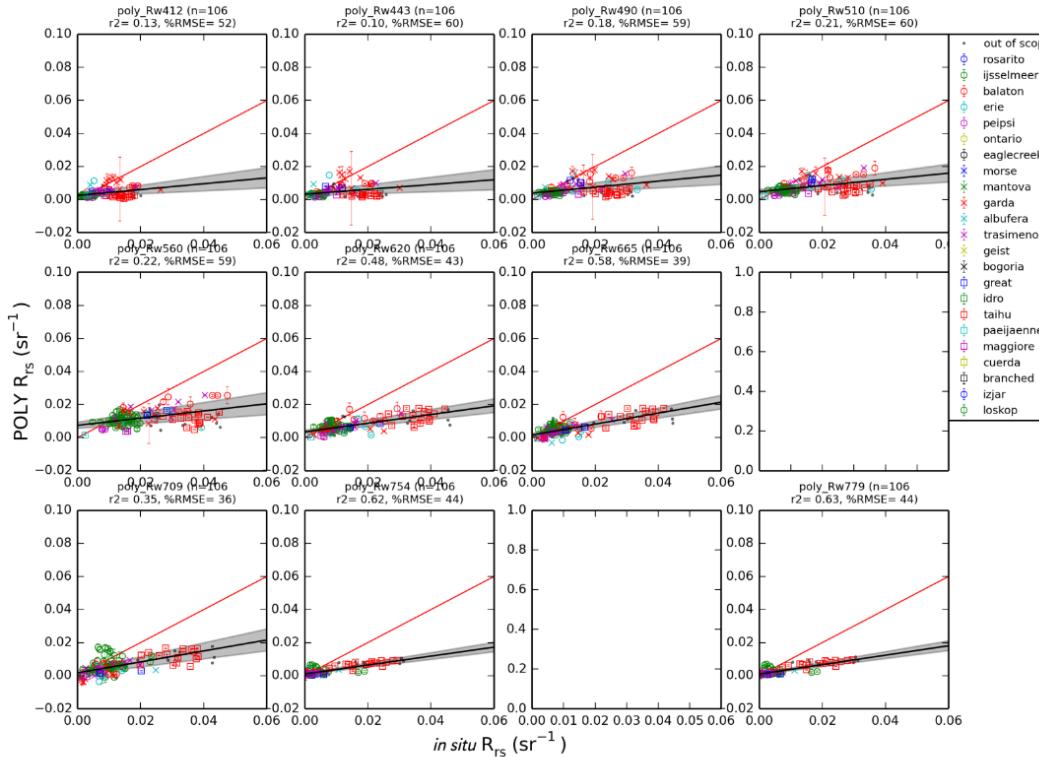
- Tuning algorithms per OWT significantly improves overall retrieval accuracy
- Dynamic selection of algorithms resulted in modest improvement but important for specific OWTs

MERIS atmospheric correction

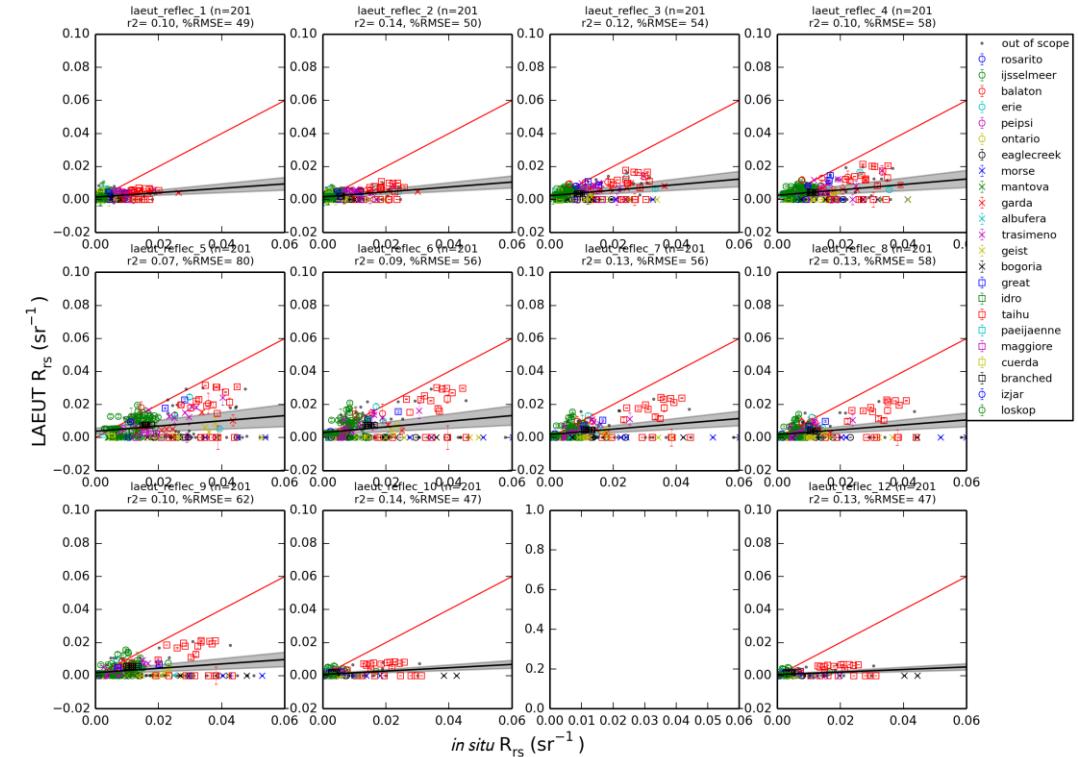
Evaluation of six AC models (Polymer, Scape-M, C2R, CoastColour, Fub, MEGS)

>200 R_{rs} match-ups from 21 lakes

Polymer ±7d, 3x3 pixel window



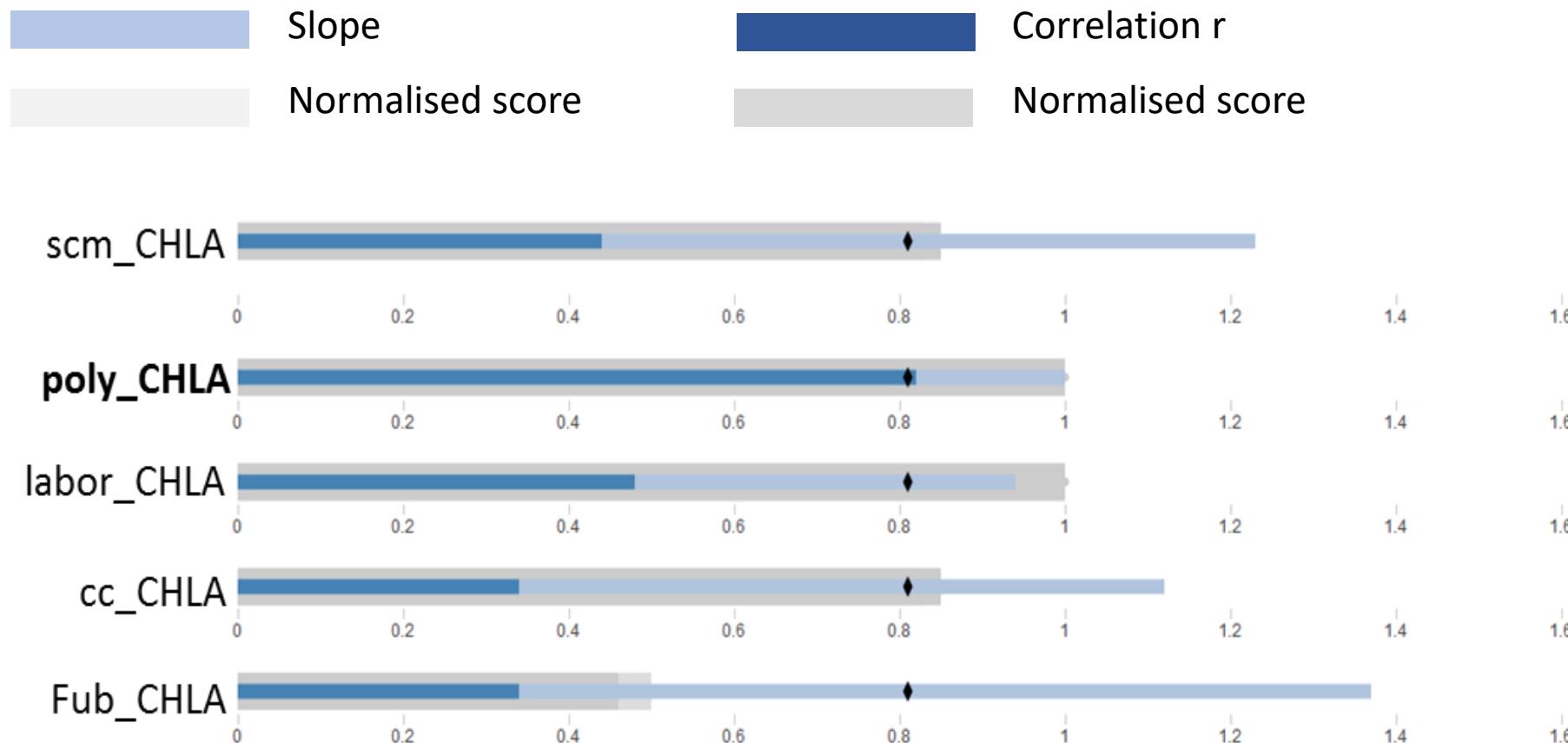
C2R Lakes ±7d, 3x3 pixel window





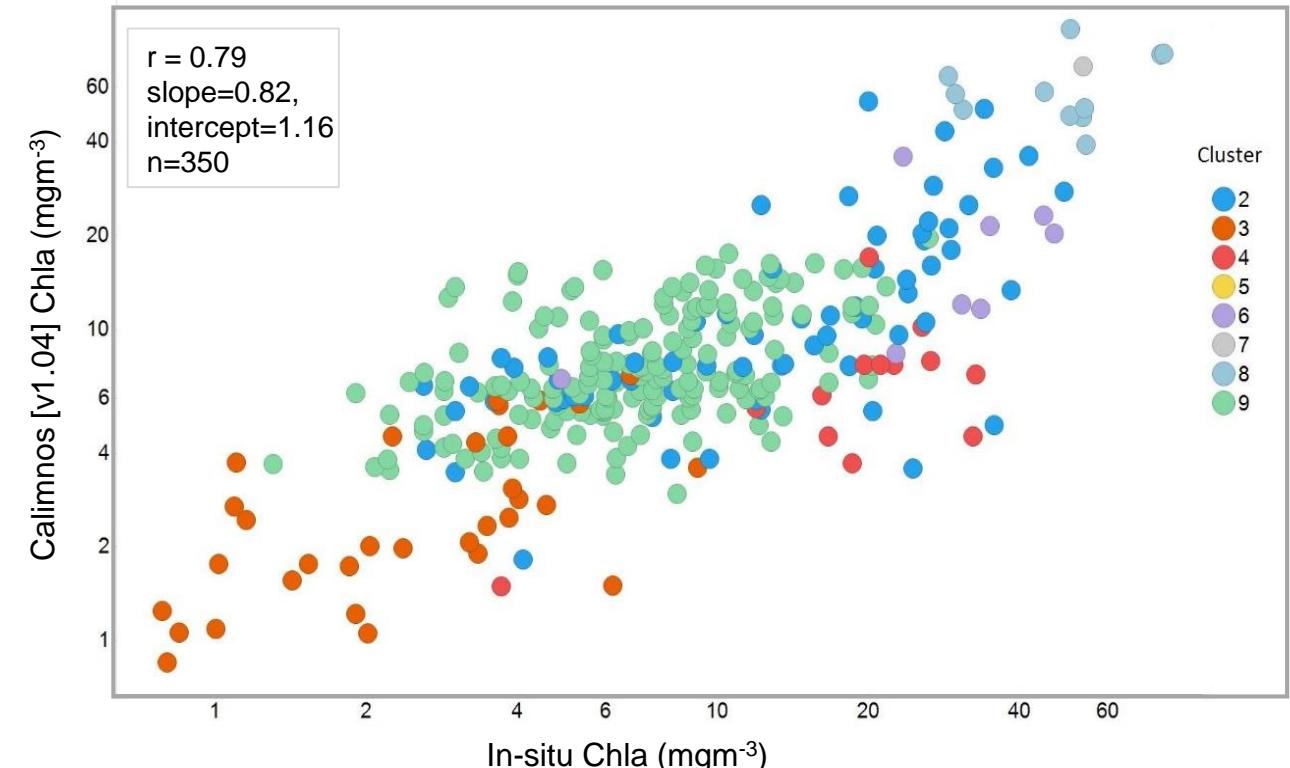
MERIS atmospheric correction

Chlorophyll retrieval using different AC models



Chlorophyll retrieval using MERIS data

- Ensemble of four algorithms used to retrieve Chla from Polymer reflectances
 - OC2E [OWT: 3, 9, 10, 13]
 - $R_{rs}[708] \times R_{rs}[665]^{-1}$ [OWT: 2, 8, 11, 12]
 - Gons et al. 2005 [OWT: 1, 4, 5, 6]
 - QAA [OWT: 7]
- Final Chla product blended using weights derived from OWT membership
- Retrieval accuracy only slightly poorer than for in-situ R_{rs} (albeit with reduced dataset)

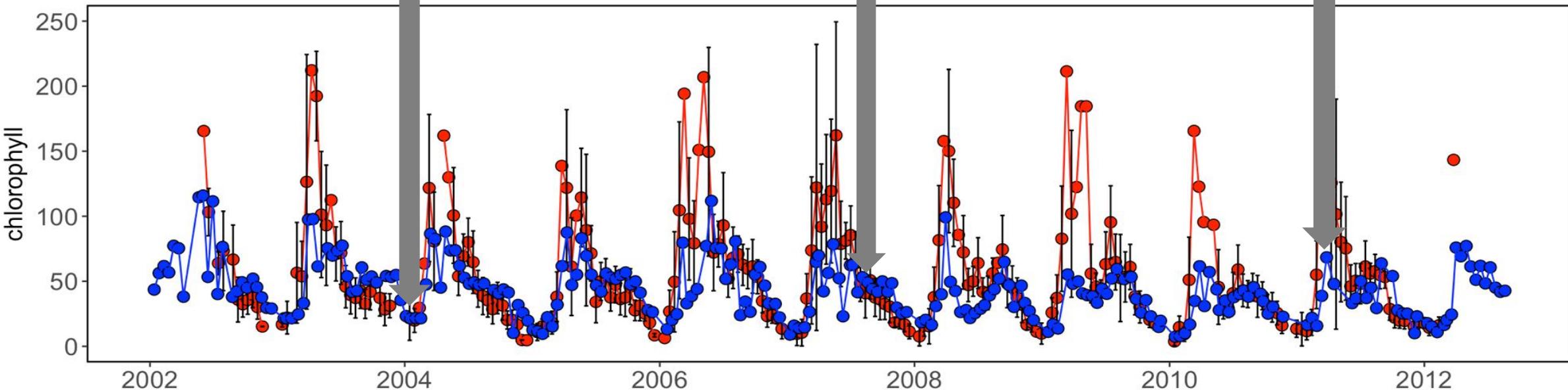
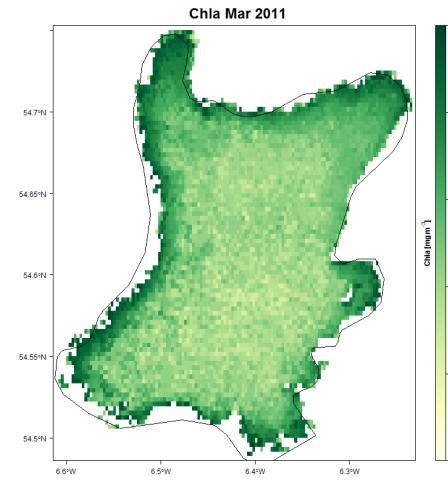
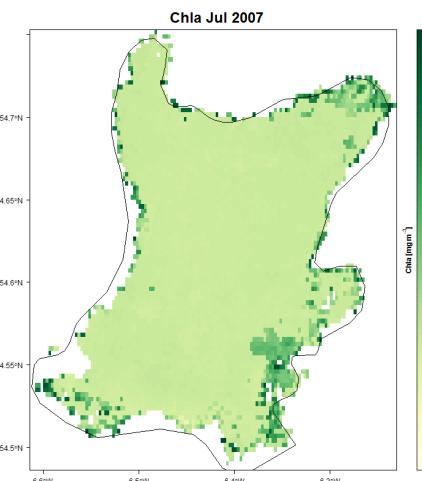
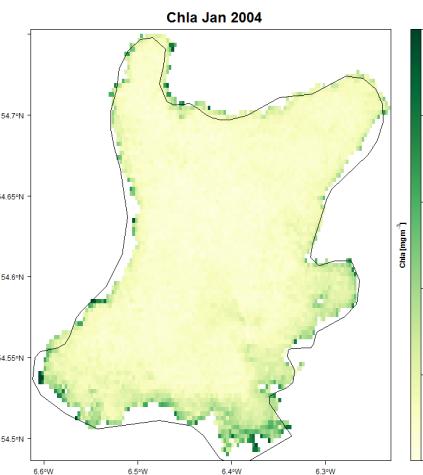




Comparison with in-situ time-series

Lough Neagh [NI]

— In-situ
— Satellite

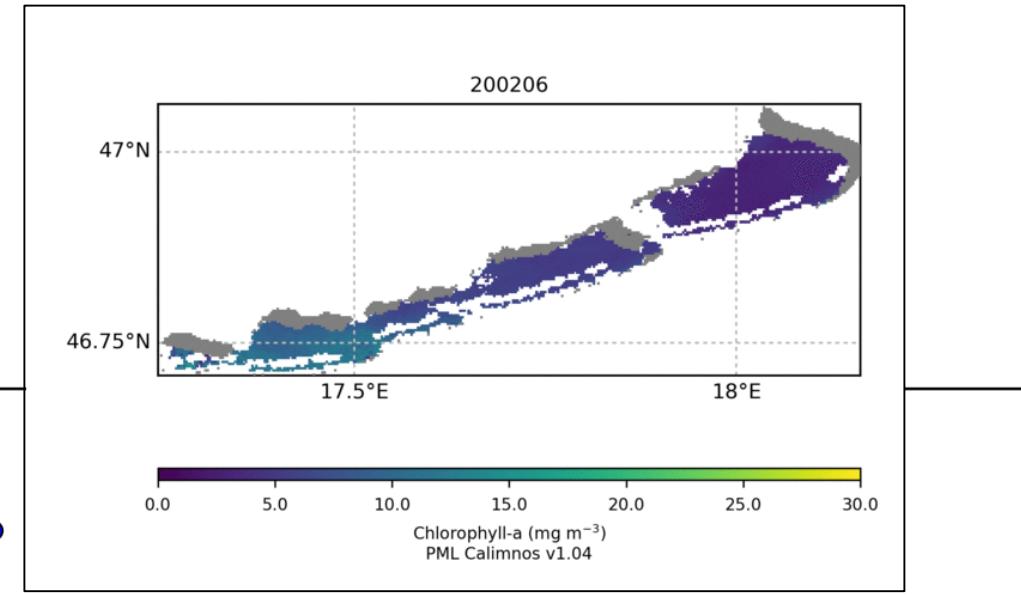
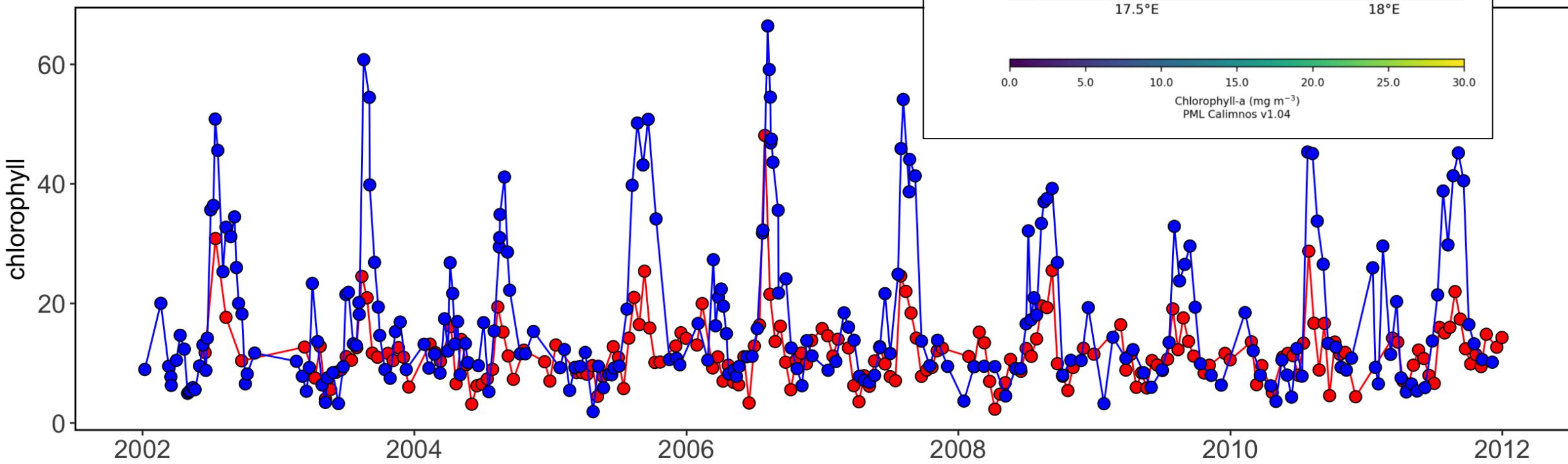




Comparisons with in-situ time-series

Lake Balaton [HU]

— In-situ
— Satellite





Concluding remarks & research priorities

- Product accuracy at the global-scale is improved with an ensemble of algorithms
- OWTs provide framework for tuning and dynamic selection of algorithms
- The approach needs evaluation for other sensors (e.g. S2 MSI, S3 OLCI) (work ongoing)
- Atmospheric correction remains an issue; further improvements needed for both non-operational and operational sensors
- Validation data are biased towards OWTs with moderate to high Chla; more focus needed on low biomass waters

Thank you

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