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GloboLakes – WP1: Progress and planning

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Objectives and deliverables

WP1 objectives

1. To evaluate and benchmark algorithms for the correction of atmospheric and land adjacency effects over inland water bodies according to lake type and location
2. To evaluate and benchmark algorithm architectures and parameterisations for the retrieval of BGC parameters according to lake type
3. To obtain a more complete understanding of the factors that affect algorithm performance to facilitate the construction of error and uncertainty budgets for retrieved parameters

WP1 Deliverables

1. Improved understanding of space-time variability in lake optical properties
2. Inter-comparison and benchmarking of algorithms for different lake types, conditions and settings
3. Development of an ensemble algorithm for the estimation of lake biogeochemical parameters capable of operating at a global scale.

Algorithm testing & validation

1. Simulated water-leaving reflectances from radiative transfer modelling

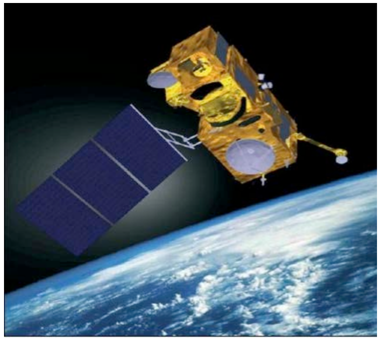
Space-time variability in lake SIOPs in UK and international lakes for modelling and error propagation studies in Hydrolight/Ecolight

2. *In situ* water-leaving reflectances from sampling cruises on UK and international lakes

Using subsurface and above-surface radiance reflectances from Satlantic HyperSAS and HyperOCR systems deployed during lake sampling cruises

3. Satellite water-leaving reflectances from MERIS and Sentinel-3 OLCI

Using *in situ* monitoring data from UK and international project partners (LIMNADES) for validation



Sampling campaigns

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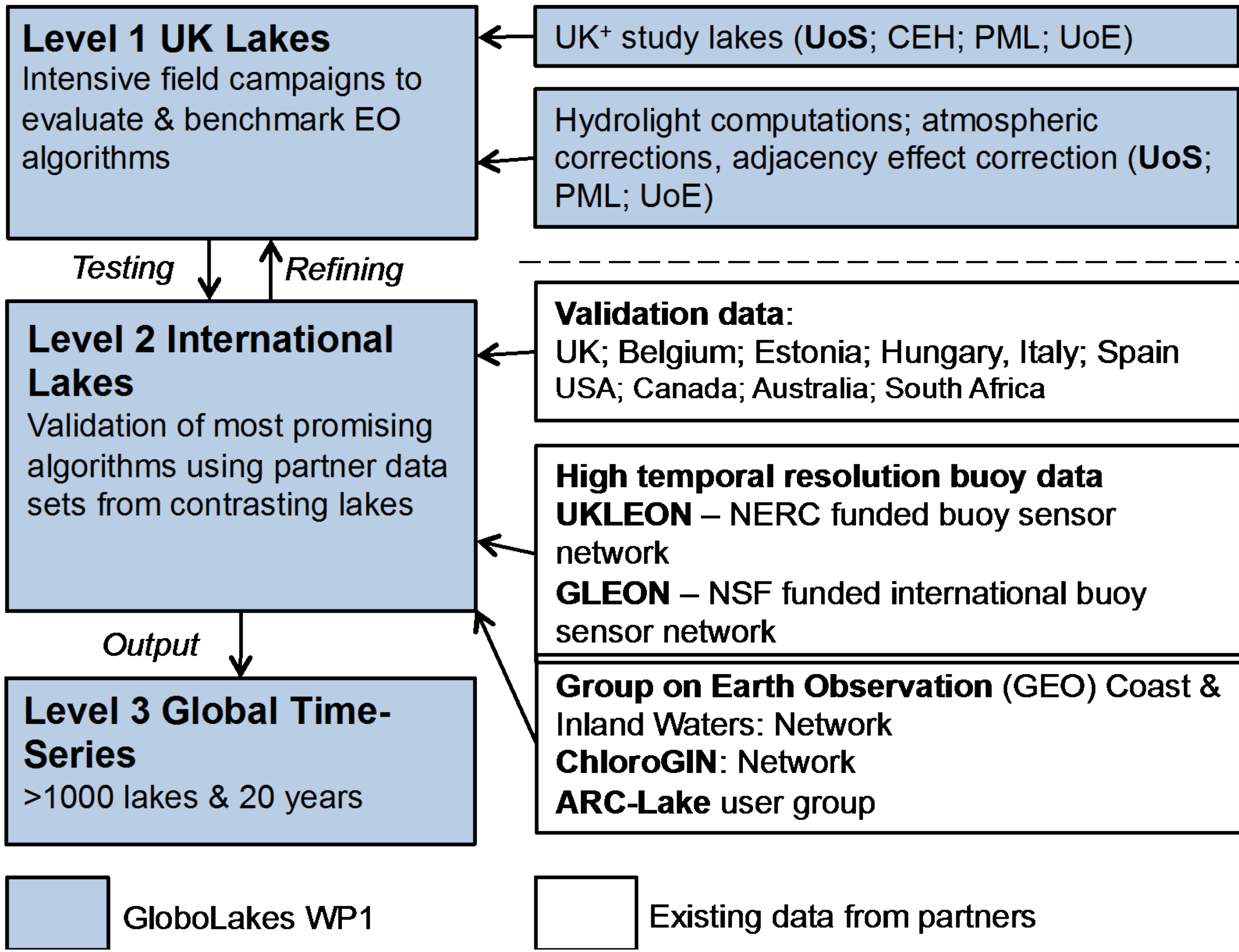

WP1 progress so far

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Key activities

1. R/V commissioning and sampling protocols
2. Lake sampling campaigns
    1. UK lakes
    2. Lake Balaton
3. LIMADES database
4. Preliminary algorithm validation studies
5. Draft work plan for 2014

GloboLakes R/V

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- 7m Predator 165 Sea Angler with 80HP engine
- Commissioned April 2013

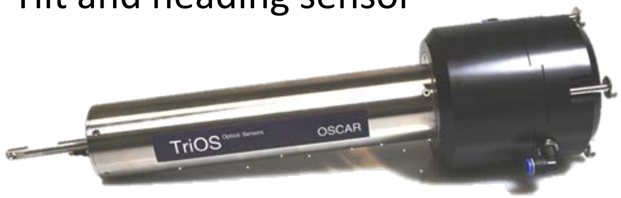
Instrumentation

Satlantic HyperSAS radiometers
Surface and sky radiances; solar irradiance
Remote sensing reflectance (Rrs(0+))
Tilt and heading sensor

Wetlabs AC-S *in situ* spectrophotometer
Spectral attenuation (*c*)
Spectral absorption (*a*)
Spectral scattering ($b = c - a$)
80 channels: 400-730 nm

Wetlabs ECO BB3
Spectral backscattering
3 channels: 470, 532, 650 nm

TriOS RAMSES radiometers
(new for 2014)
Surface and sky radiances; solar irradiance
Remote sensing reflectance (Rrs(0+))
Tilt and heading sensor



TriOS OSCAR hyperspectral PSICAM
(new for 2014)
Spectral absorption (*a*)
256 channels: 360-750 nm

Sampling protocol

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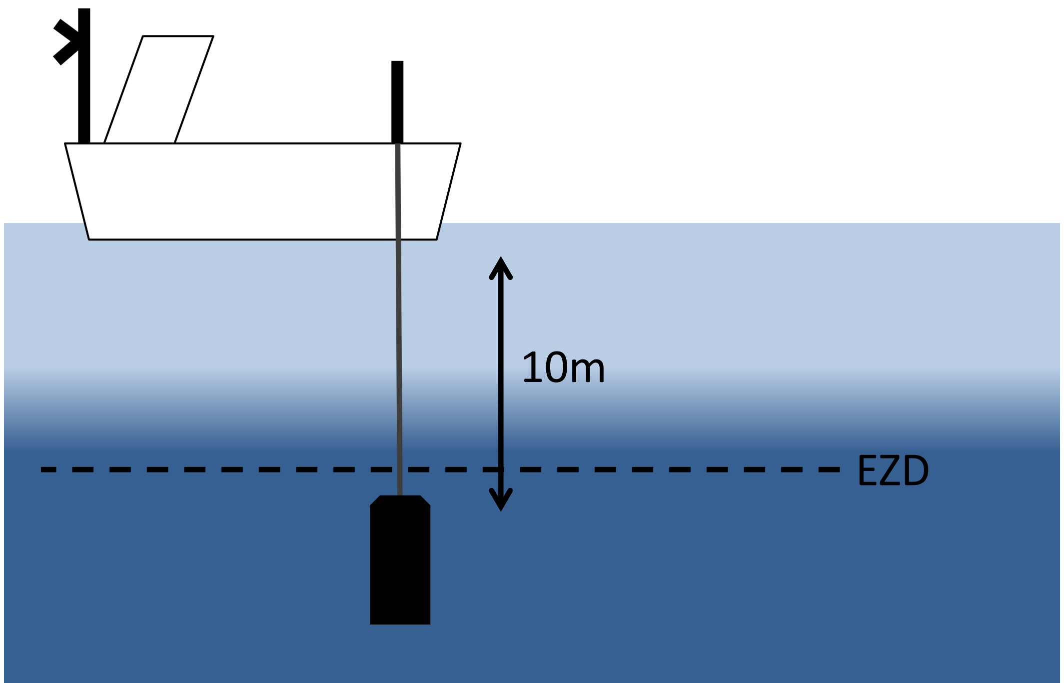
1. Latitude and longitude (per cast & logged with HyperSAS)
2. Water depth, Secchi depth and other field measurements
3. Water-leaving reflectances (continuously logged)
4. In-water optics (minimum 4 casts per station)
5. Water sample collection and onboard filtration (3 replicates ~15 min apart)



Standard protocol (deep waters)
Dummy surface cast
10m up-cast (no filter)
Dummy surface cast (0.2µm filter)
10m up-cast (0.2µm filter)

Selected stations
Size-fractionated IOPs (*a* & *b*)
(20, 2, 1, 0.2 µm filters)

Parameters and protocols

Field parameters	Bio-optical parameters	Laboratory parameters
Secchi disk depth	Remote sensing reflectance (Satlantic HyperSAS)	Chl-*a* (spectrophotometric ISO method)
Water depth	Subsurface irradiance reflectance (Satlantic HyperOCRs)	Size-fractionated Chl-*a* (FP7 INFORM)
Water temperature	Spectral absorption coefficients (Wetlabs AC-S)	HPLC pigments (CSIRO method)
Wind speed	Spectral scattering coefficients (Wetlabs AC-S)	Phycocyanin (adapted from Horváth et al., 2013)
Digital photos (water & sky conditions)	Spectral backscattering coefficients (Wetlabs BB3)	CDOM ($a_{200-800}$ & S_{CDOM})
	Temperature, depth, salinity profiles (Sea-Bird Electronics)	CDOM synchronous fluorescence scans (Universidade de Vigo)
	Spectral Kd(λ) (FP7 INFORM)	TSM, PIM, POM (REVAMP protocol)
		Particulate absorption (NASA Ocean Optics method)
		DOC (Shimadzu TOC-V_{SCN})
		POC (Perkin Elmer CHN analyzer)
		Phytoplankton samples (preserved in Lugol's)
		Flow cytometry (preserved)

Sampling campaigns: summary

May to September 2013

- 5 UK lakes: Loch Leven (4), Loch Lomond (7), Windermere (2), Bassenthwaite (1), & Derwent Water (1)
- 2 Hungarian lakes: Lake Balaton (4) & Kis Balaton (1)
- 82 stations sampled
- 230 water samples processed
- 520 optics casts

		Stations	Samples	Casts	May	June	July	August	September
UK lakes	Lomond	35	93	161					
	Leven	17	51	121					
	Windermere	7	21	37					
	Bassenthwaite	5	15	21					
	Derwent	5	15	22					
Hungarian lakes	Balaton	11	33	150					
	Kis Balaton	2	2	8					
	Total	82	230	520					

UK study lakes

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Loch Lomond. Largest lake on mainland UK (71 km^2). Warm, monomitic and stratifies. Two basins: (1) North is deep (mean ~130 m) and oligotrophic; (2) South is shallow (mean ~ 10 m) and mesotrophic. Phytoplankton flora include diatoms, desmids and green algae, some cyanobacteria in South basin

Loch Leven. The largest shallow lake on mainland UK. Britain. Surface area 13.2 km^2, mean depth of 3.9 m. Polymictic, nonstratifying and eutrophic. Diatoms dominate in spring, cyanobacteria in summer

Windermere. Surface area 14.7 km^2. N basin: oligo; mean (max) depth 25.1 (64) m. S basin: meso; mean (max) depth 16.7 (42) m

Bassenthwaite Lake. Surface area 5.13 km^2; mesotrophic; mean depth 5.3 m; max depth 20m.

Derwent Water. Surface area 5.2 km^2; mesotrophic; mean depth 5.5m; mac depth 22m.

UK study lakes

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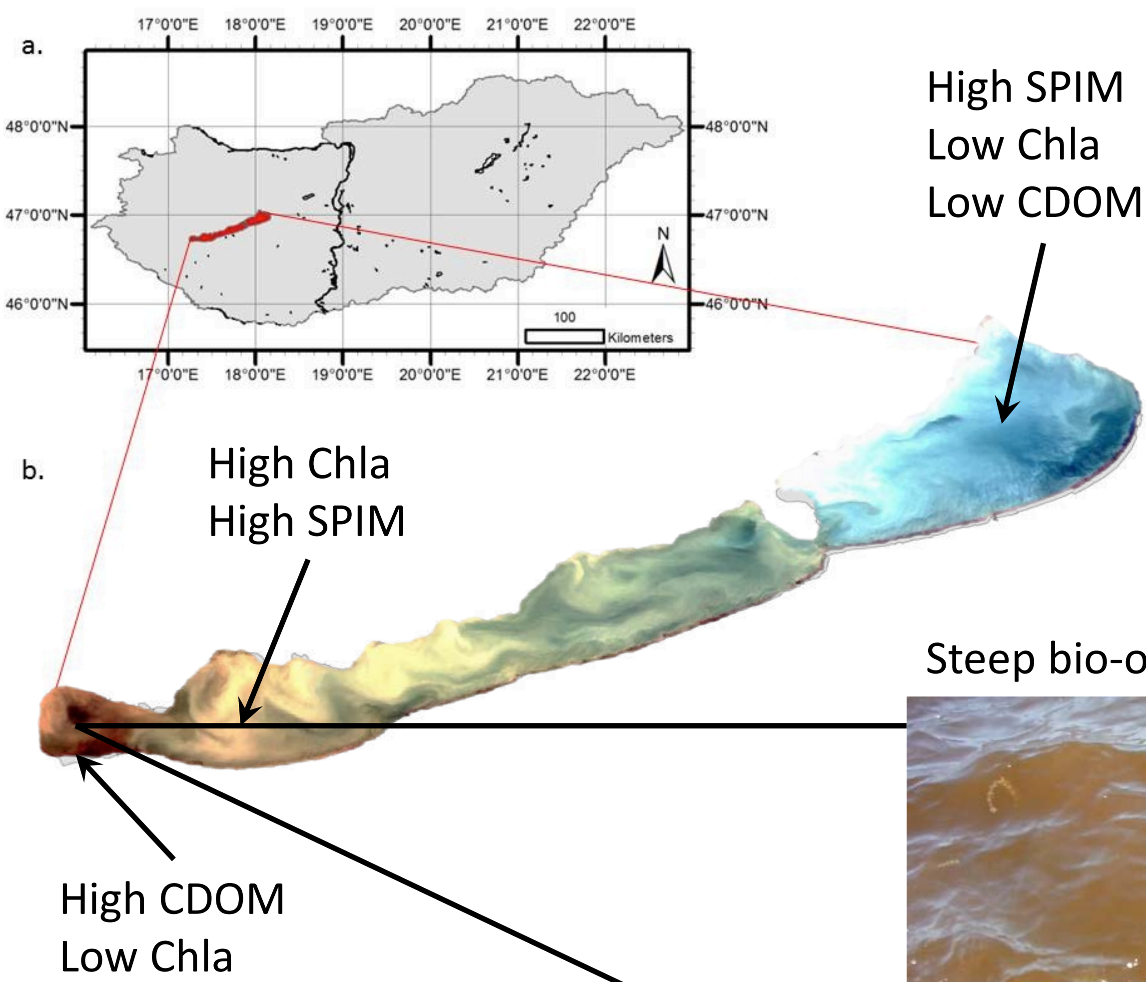
Preliminary biogeochemical data

	TSM (mg/L)			Chla (mg/m^{-3})		
	Min	Max	Mean	Min	Max	Mean
Bassenthwaite	0.827	1.213	0.964	3.996	7.992	6.344
Derwent	0.593	0.753	0.690	5.328	11.988	8.120
Leven	1.193	9.288	4.708	6.105	50.912	28.232
Lomond	0.380	1.396	0.768	0.148	10.212	6.149
Windermere	0.558	2.735	1.031	0.100	11.544	7.048

	PC (mg/m-3)			DOC (mg/L)		
	Min	Max	Mean	Min	Max	Mean
Bassenthwaite	bd	4.303	1.825	2.192	3.502	2.404
Derwent	0.742	7.864	4.091	1.648	1.917	1.750
Leven	1.847	51.426	20.533	2.905	7.032	5.197
Lomond	bd	14.320	6.184	1.394	3.846	2.910
Windermere	0.000	8.642	4.168	1.395	1.767	1.631

Lake Balaton

- 597 km^2 surface area
- 3.3 m mean depth
- Mesotrophic to eutrophic
- High inorganic sediment loads

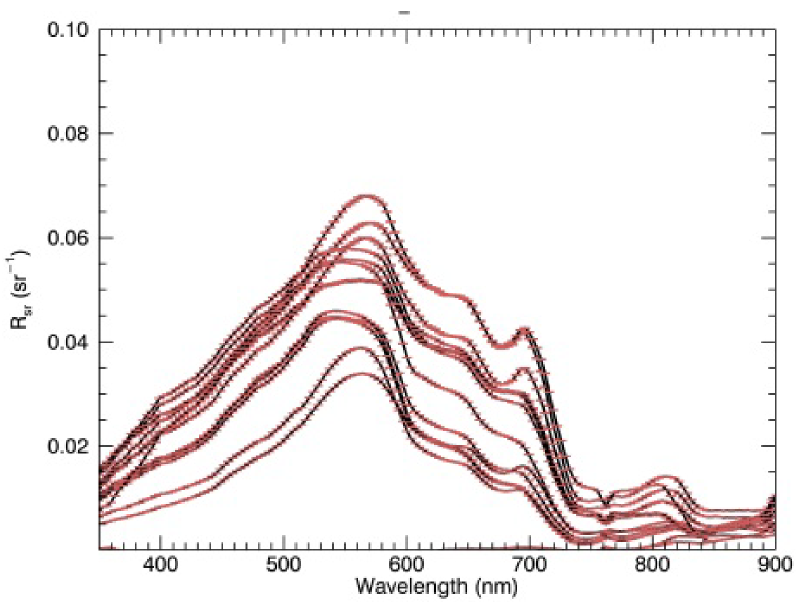


Steep bio-optical gradients

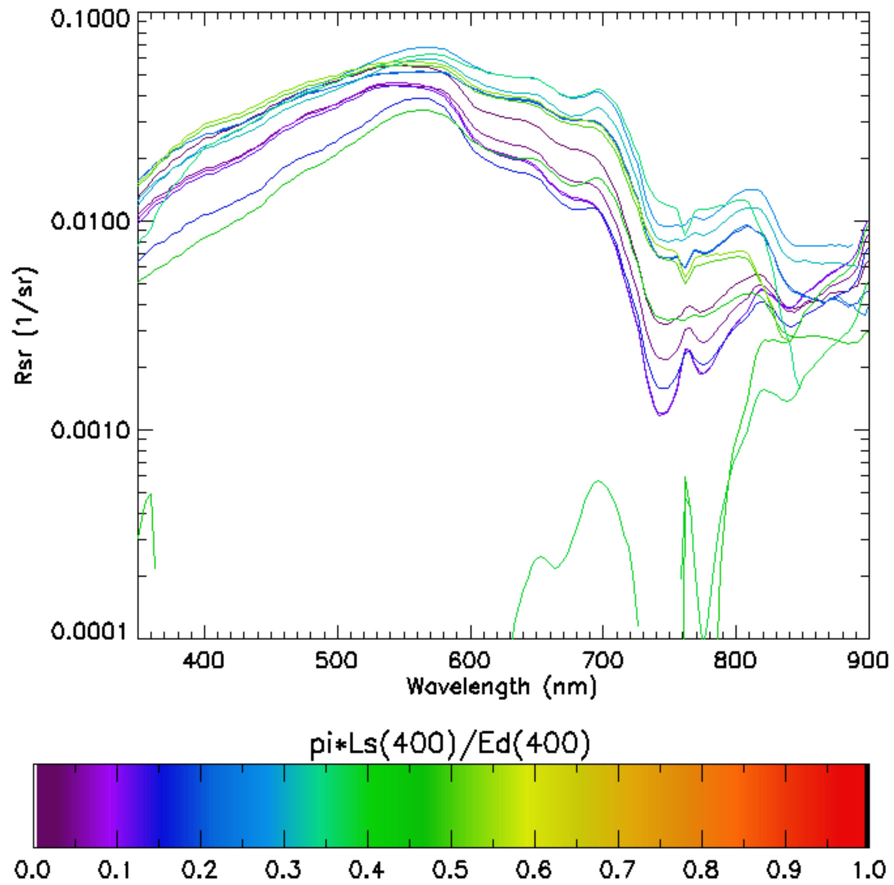
Lake Balaton

Preliminary remote sensing reflectance spectra

Development of processing and quality control (VM – PML)



Above. HyperSAS data processed using similarity spectrum (Ruddick et al. 2006).



Right. Same spectral with QC based on cloud cover after Simis et al. 2013.

LIMNADES

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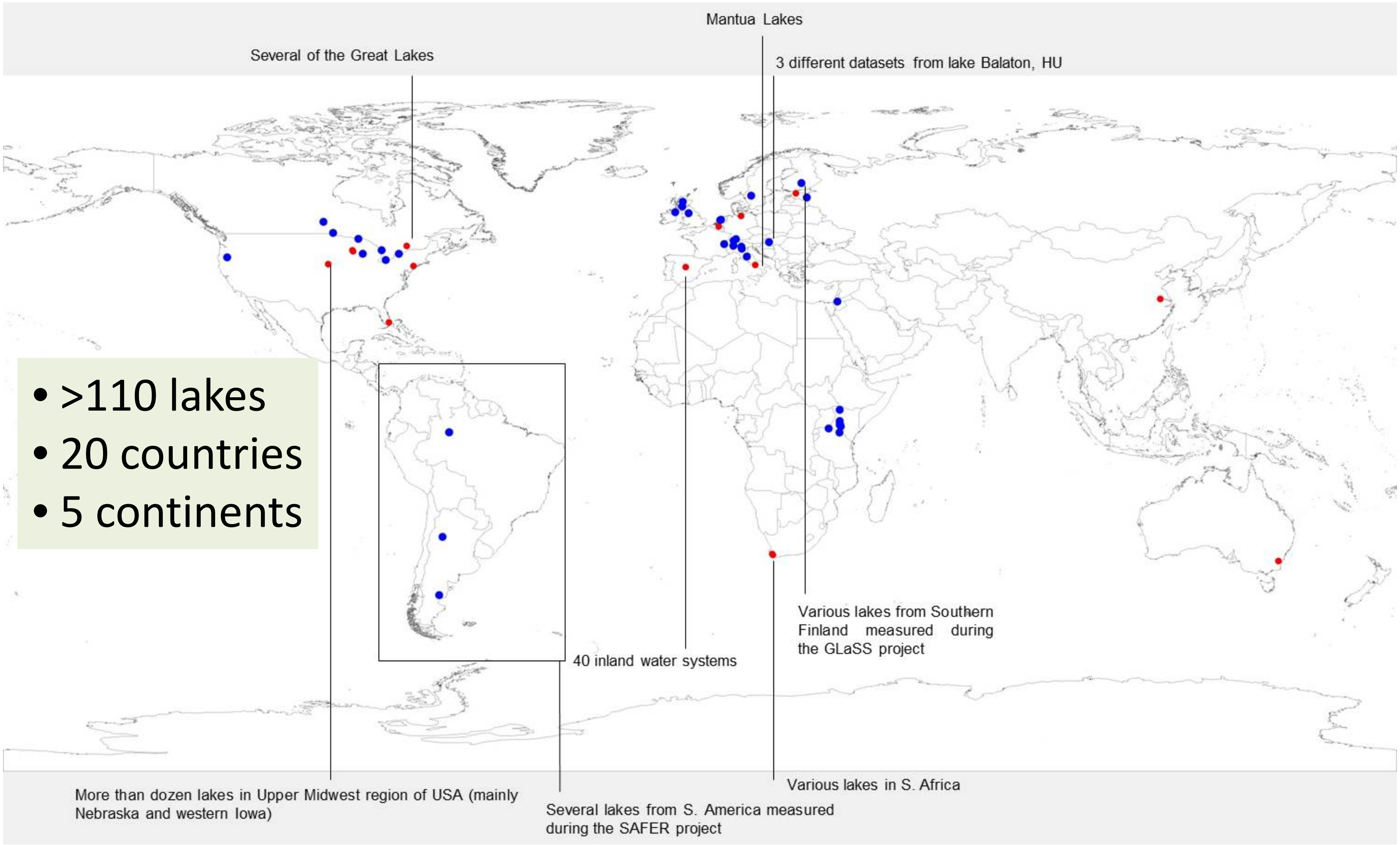

- >110 lakes
- 20 countries
- 5 continents

Algorithm validation - Balaton

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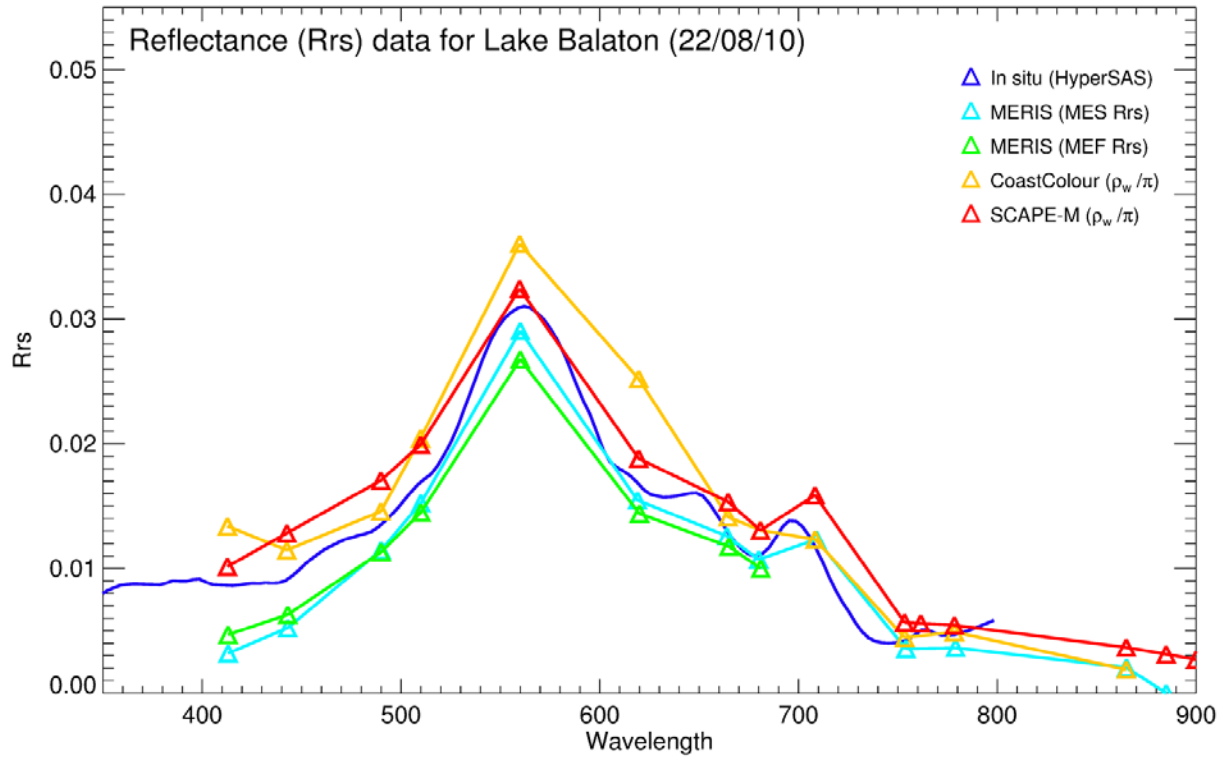
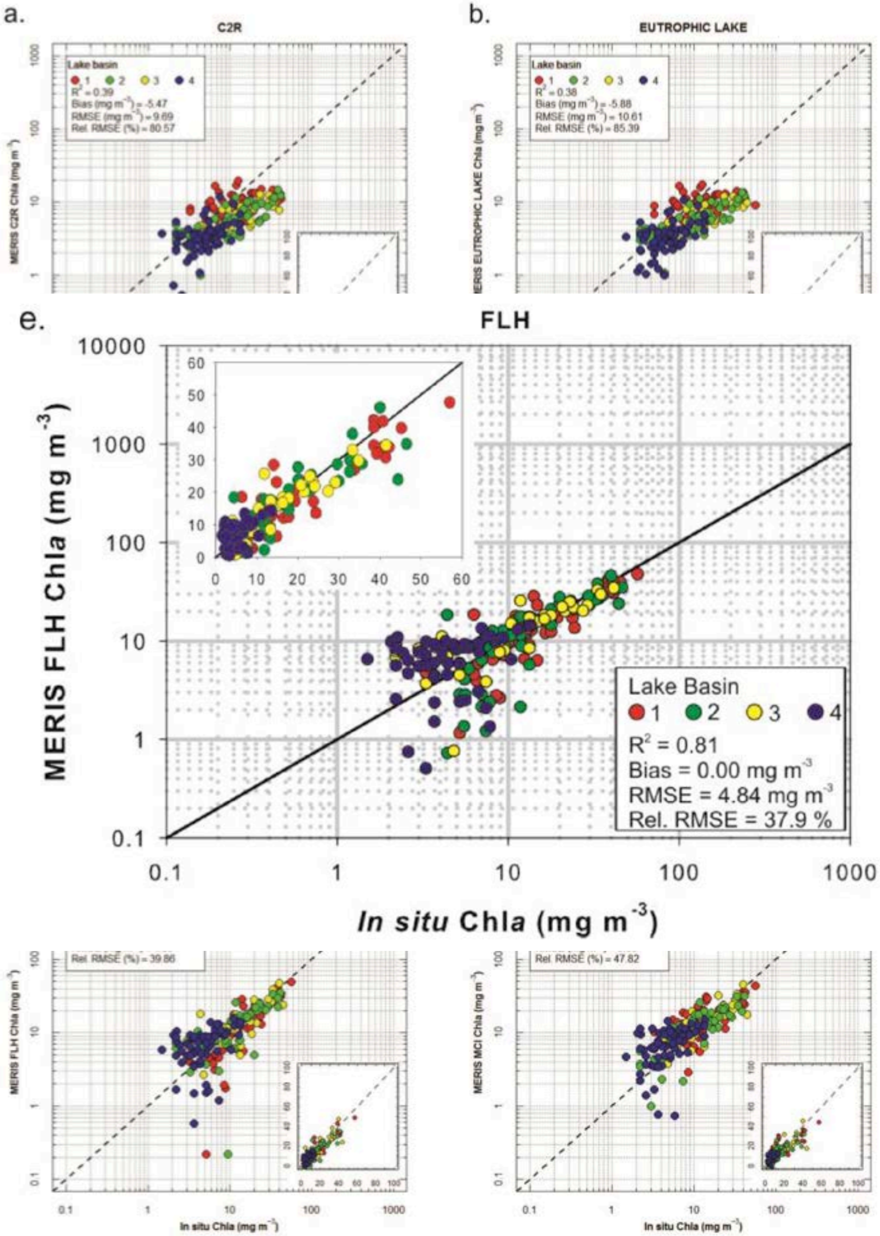


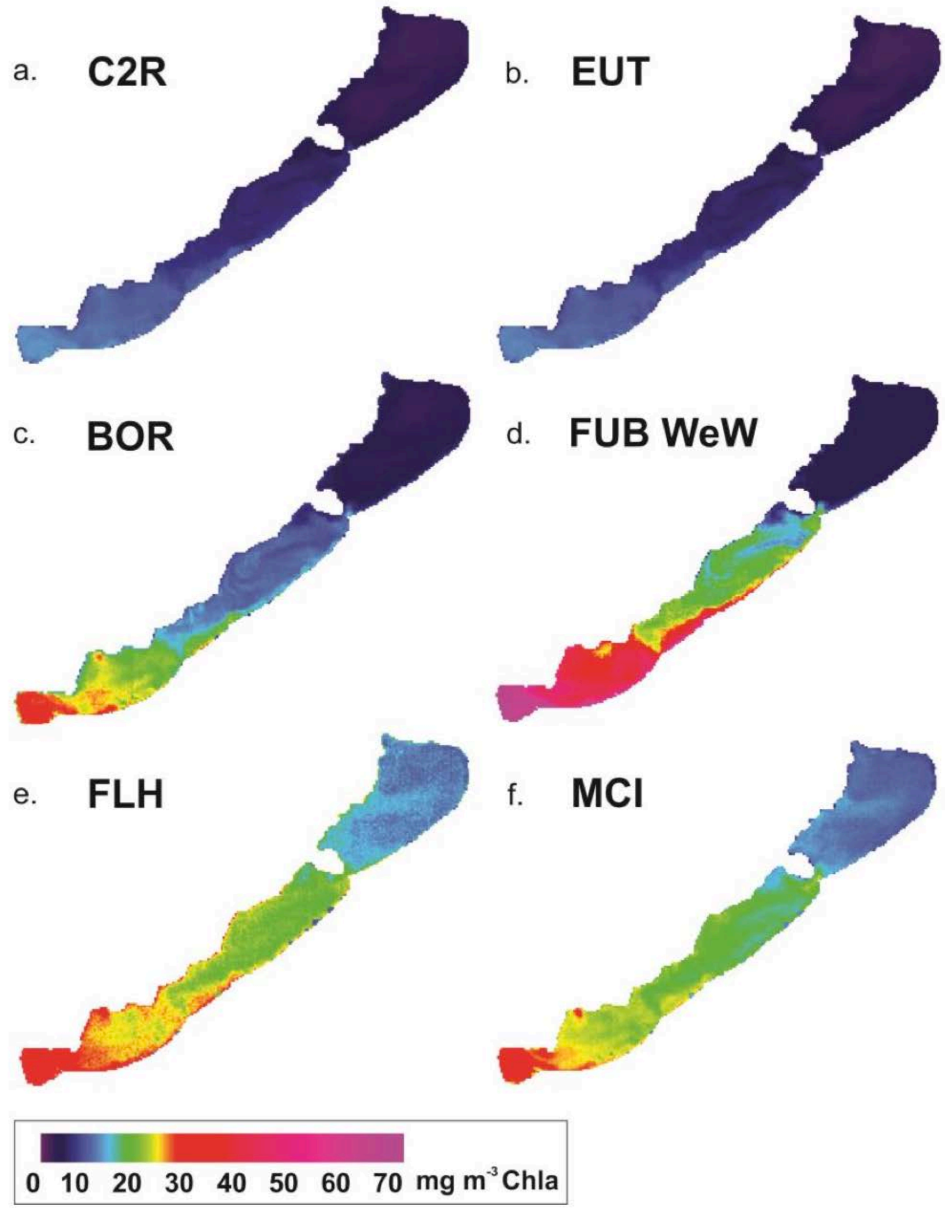
Comparison between a variety of MERIS products and in-situ data for Lake Balaton

Four AC models
- MERIS MES (Standard ESA)
- MERIS MEF (SeaDAS)
- CoastColour
- SCAPE-M

Dataset	r	RMSE	Bias	CP RMSE	S	I
MERIS MES	0.8295	0.1795	0.0869	0.1571	0.9300	0.1636
MERIS MEF	0.8897	0.2371	0.0994	0.2152	1.4016	-0.328
CoastColour	0.5142	0.5372	0.5114	0.1643	0.1906	1.5179
SCAPE-M	0.8320	0.1886	-0.123	0.1430	0.6913	0.2122

Algorithm validation - Balaton





Algorithm validation – Lough Neagh

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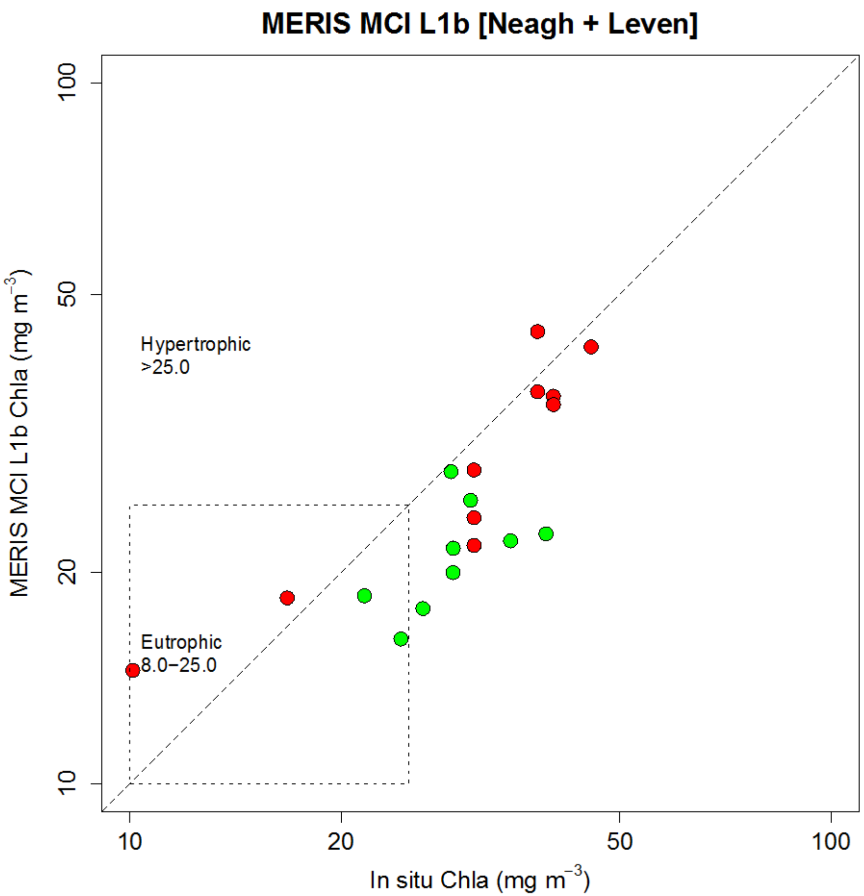
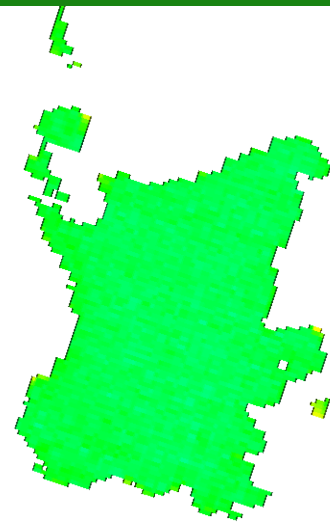


n = 26 RMSE = 4.69 mg m^{-3}

R^2 = 0.81 Rel.RMSE = 16.0%



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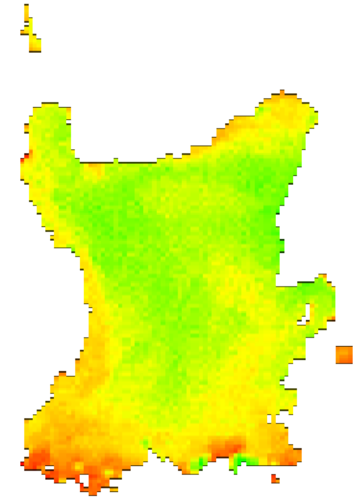

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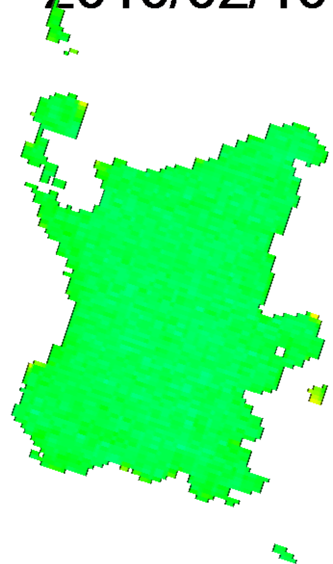

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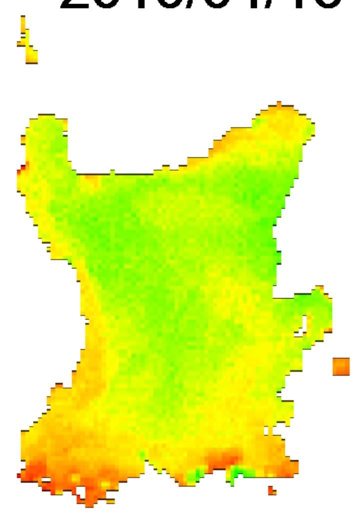

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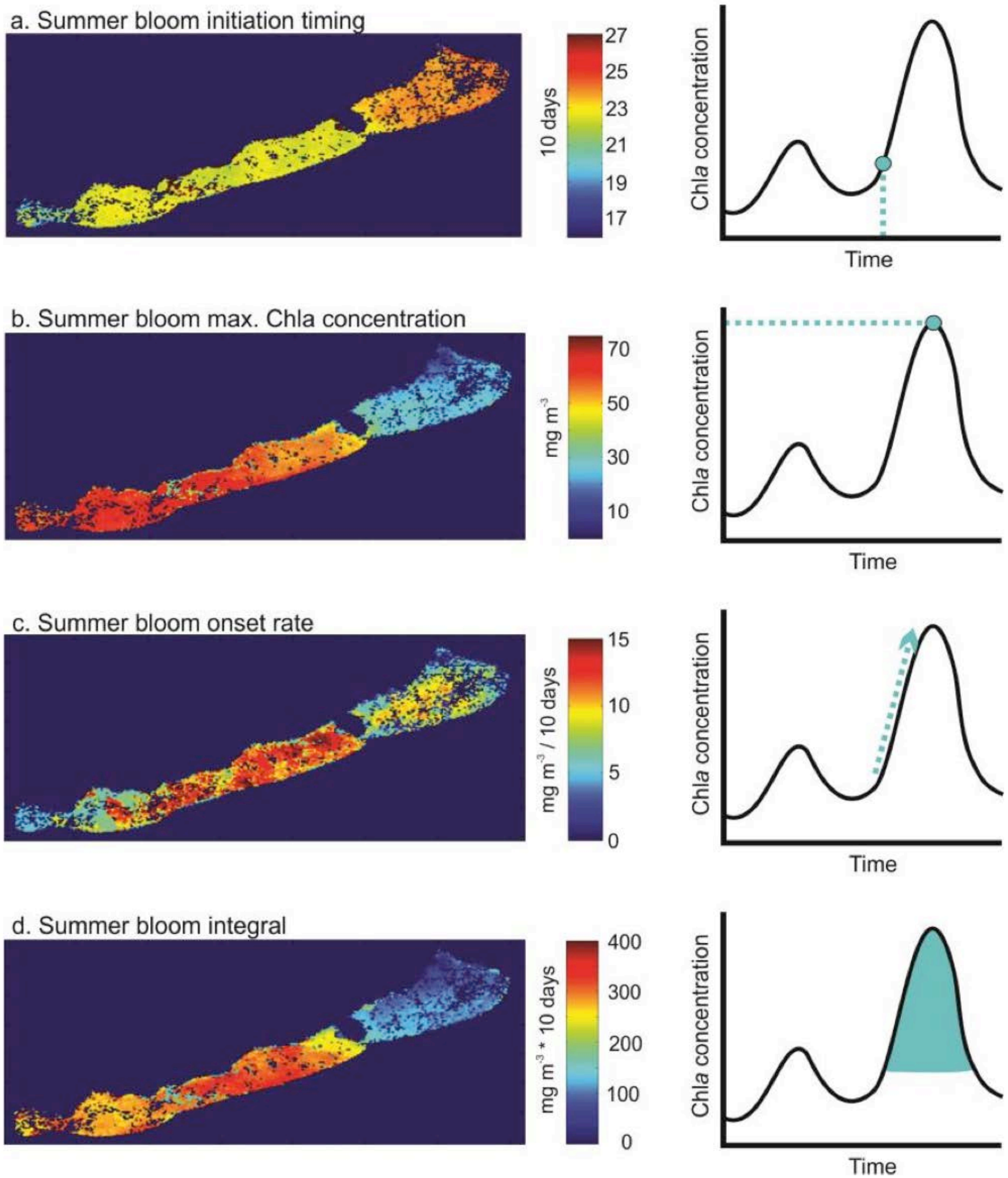
Phytoplankton phenology - Balaton



- Phenology modelled using TIMESAT software
- Input product: 10-day CoastColour Chla composites product from ESA Diversity II

Proposed work plan for 2014

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Sampling campaigns

Sentinel-2 launch late 2014?
Sentinel-3 launch 2015?

Funded

Late April	Loch Ness
Mid June	Cumbrian lakes
Early July	Lough Neagh, Lough Erne
Early August	**Lake Balaton**
Opportunistic	Loch Leven
Opportunistic	Loch Lomond
TBC	Lake Geneva (Spring/Summer)
TBC	**INFORM "Development campaign" (May onwards)**
Summer	**NERC ARSF (Leven, Lomond, Lough Neagh/Windermere)**

Subject to funding

Lake Vänern (INCIS-3IVE)	mid/late summer
Amazonian lakes (freshEarth)	autumn/winter
Lake Taihu (freshEarth)	autumn/winter

Proposed work plan for 2014

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Algorithm development, testing and validation

First outputs due late 2014

- Implement existing Diversity II processing chain on PML system and process global MERIS archive at full resolution (300m)
- Test existing and additional algorithms using simulated, *in situ* and satellite reflectances (with uncertainty propagation studies)
    - Diversity II models
    - aLMI (Brando)
    - NIR-red 2-/3-/4- band models
    - New MPH algorithm (Matthews)
    - New NN (with Vigo)
    - PC models (Simis, Hunter, Li etc)
    - ….?
- Develop and test water optical type classification scheme (*a priori*) and/or ensemble model (blending?) (*a posteriori*)

Other developments

New projects

- FP7 INFORM (Jan 2014 to Jan 2018; includes USTIR, PML)
- EartH2Observe (includes CEH, PML)

ESA Sentinel-3 Validation Team Ocean Colour (S3VT-OC)

- GloboLakes-S3VT proposal accepted

Funding proposals in review

- **NERC LIMNADES** (database development; web-GIS interface)
- **NERC INCIS-3IVE** (inter-comparison of radiometers; partners Water Insight, Tartu Observatory; University of Stockholm)
- **GII freshEarth** (partners Chinese Academy of Sciences, INPE (Brazil))

Thank you

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