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Listen to the ocean

Mapping lakes, catchments, and land use impacts on water quality: the GloboLakes 1000

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GloboLakes

Lakes are “sentinels of change”

Lakes respond rapidly to change

Lake ecosystems are well defined and ‘everywhere’

Responses are quantifiable: *direct* indicators e.g. water level, temperature, ice cover; *indirect* (catchment) indicators e.g. dissolved organic carbon, plankton composition

> Lakes are usually studied in local or regional context

Limnol. Oceanogr., 54(6, part 2), 2009, 2349–2358
© 2009, by the American Society of Limnology and Oceanography, Inc.

Lakes as sentinels and integrators for the effects of climate change on watersheds, airsheds, and landscapes

D. W. Schindler*

Limnol. Oceanogr., 54(6, part 2), 2009, 2283–2297
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Lakes as sentinels of climate change

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GloboLakes

Responses of individual lakes or populations of lakes vary in time and space

What controls the differential sensitivity of lakes to environmental change?

Aims:

Develop robust **algorithms** for lake remote sensing of biogeochemical parameters, primary production and lake surface water temperature at regional to global scales.

Operationalization of these algorithms in a satellite-based Global Lake Observatory.

Compilation of integrated spatio-temporal information on **ecosystem condition and function** for global network of lakes and their catchments.

Models forecasting the trajectory of lake responses, including **impacts** on ecosystem services, to climate and land use change on lakes across different climate zones.

An assessment of the **sensitivity and coherence** of lake response to environmental change at a **global scale.**

Implementation

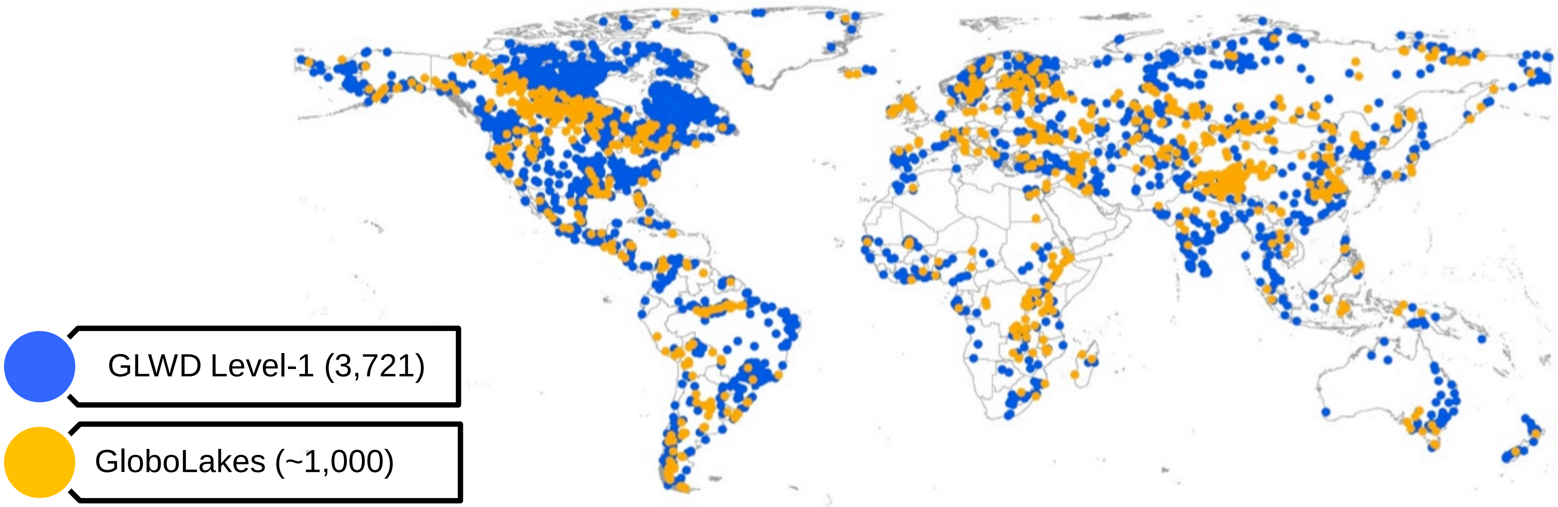
Observatory with archived and near real-time data for >1000 lakes globally

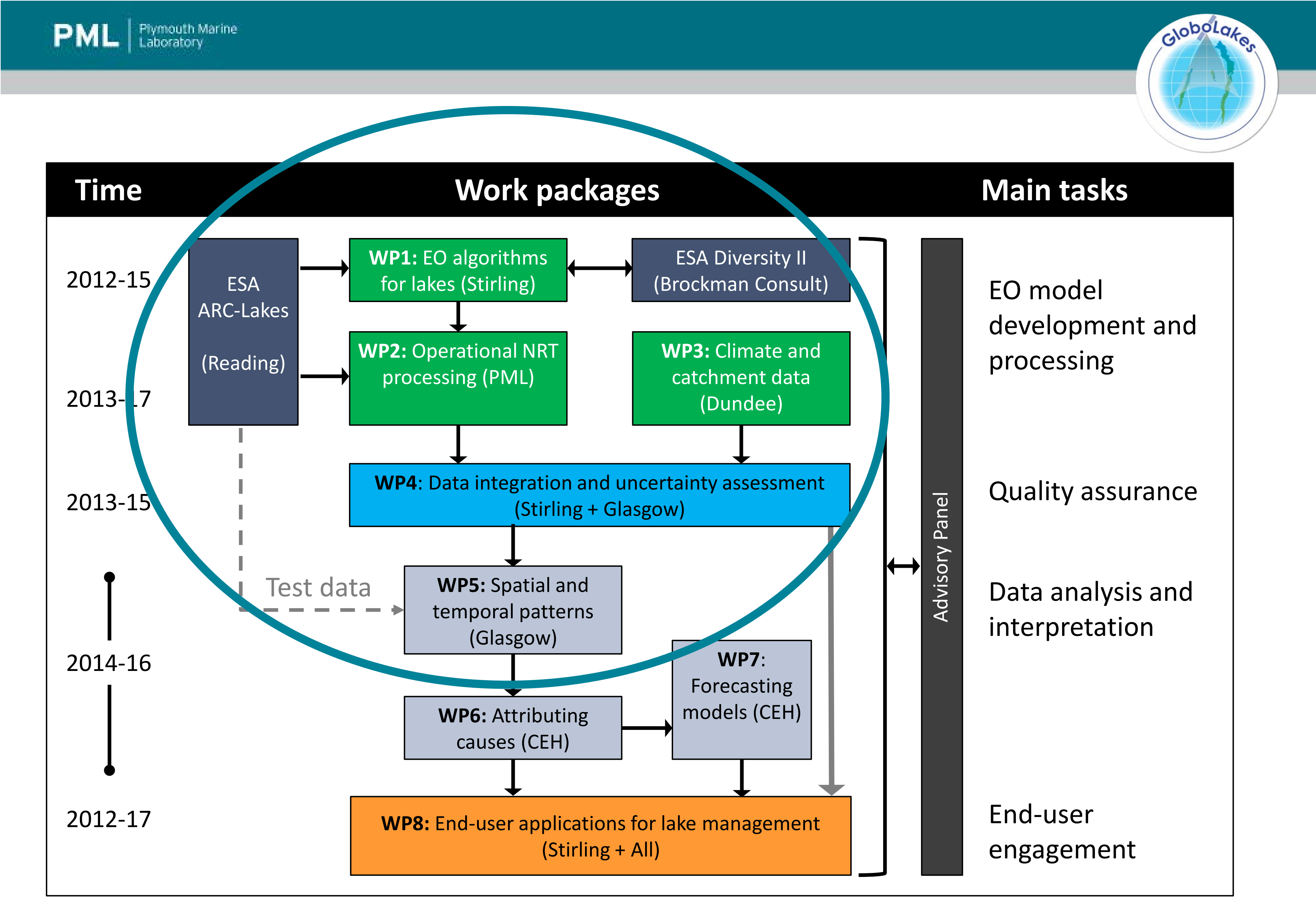
Global population of lakes selected from all climatic zones

Data from SeaWiFS, MODIS, **MERIS**, **(A)ATSR + Sentinel-3 OLCI** & **SLSTR**

Core time-series products: Chlorophyll-*a*, Suspended Matter, Chromophoric Dissolved Organic Matter, Phycocyanin, Lake Surface Water Temperature

Open Data

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GloboLakes
Time
Work packages
Main tasks
2012-15
2013-17
2013-15
2014-16
2012-17
ESA ARC-Lakes (Reading)
WP1: EO algorithms for lakes (Stirling)
ESA Diversity II (Brockman Consult)
WP2: Operational NRT processing (PML)
WP3: Climate and catchment data (Dundee)
WP4: Data integration and uncertainty assessment (Stirling + Glasgow)
Test data
WP5: Spatial and temporal patterns (Glasgow)
WP6: Attributing causes (CEH)
WP7: Forecasting models (CEH)
WP8: End-user applications for lake management (Stirling + All)
Advisory Panel
EO model development and processing
Quality assurance
Data analysis and interpretation
End-user engagement

WP1: Algorithm development and validation

Extensive research campaigns on UK and European lakes

- 200 stations on 10 lakes
- S2/S3 validation 2015 onwards

LIMNADES

- Community-owned
- Approximately 1200 lakes (12 countries)
- > 1700 stations (>120 lakes) with *in situ* hyperspectral Reflectance
- > 650 stations with *in situ* measurements of inherent optical properties
- Database and website in beta during May 2015

LIMNADES

Lake bio-optical Measurements and matchup Data for Remote Sensing

WP2: EO data production

CaLimnos

Developed at Brockmann Consult for ESA Diversity II

Continued development in GloboLakes

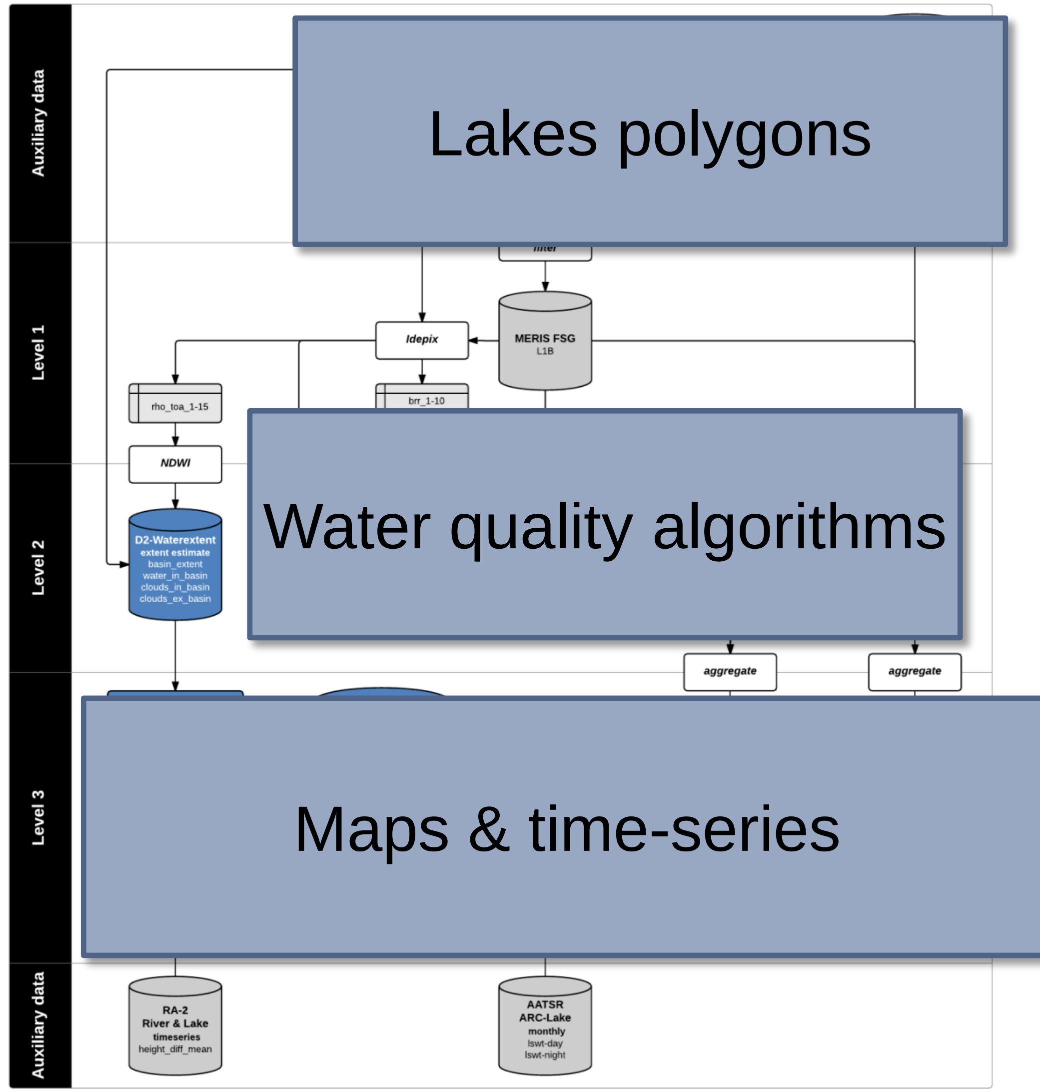
Data production schedule

Autumn 2015
1000 bgc + 300 LSWT

Spring 2016
1000 bgc + 1000 LSWT

Spring 2017
with S3 NRT production

[More on Div-II in next talk]

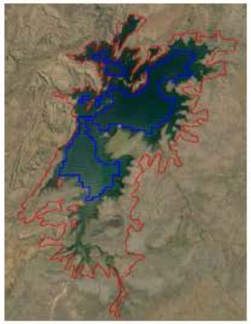


WP3: Site selection

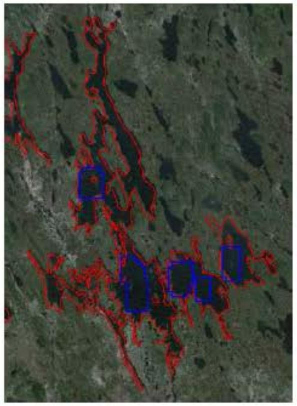
GLWD Level-1 (3,721 water bodies) → Water body type → R/S water mask → Water-mask-to-lake-area → No. of daytime R/S observations per year → 960 lakes & reservoirs

Regular shoreline – Larger area detected by R/S ⟷ Irregular shoreline – Smaller area detected by R/S

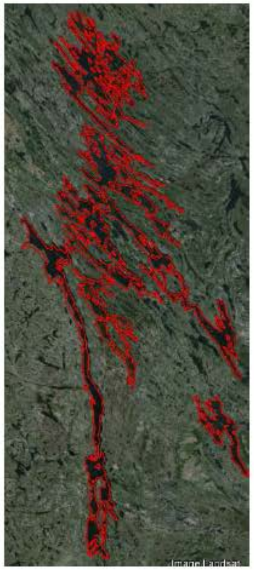
GLWD ID 907, D_L = 1.03



GLWD ID 98, D_L = 3.8



GLWD ID 345, D_L = 7.9



GLWD ID 115, D_L = 17

R/S mask (detectable area)

GLWD Level-1 lake shoreline

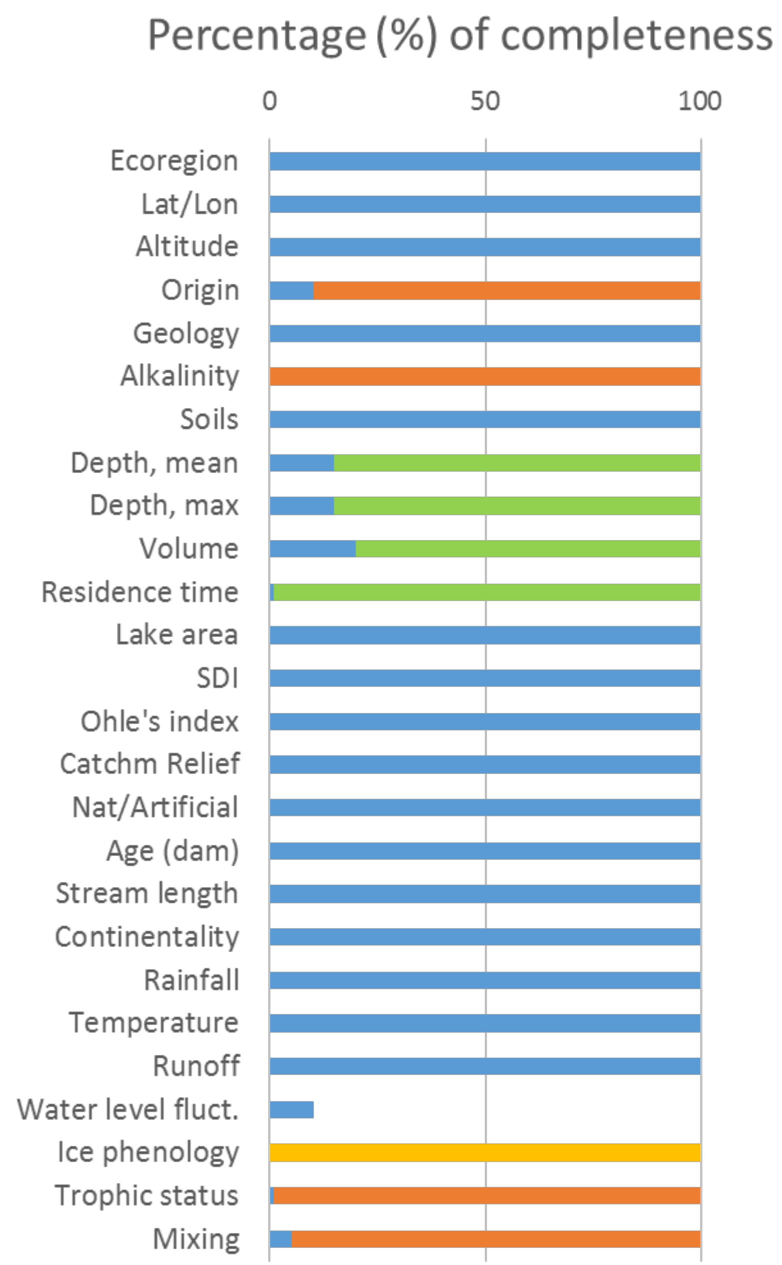
Water mask developed by ARC Lake

Global lake typology – Lake attributes

Inferred, *where published information unavailable*

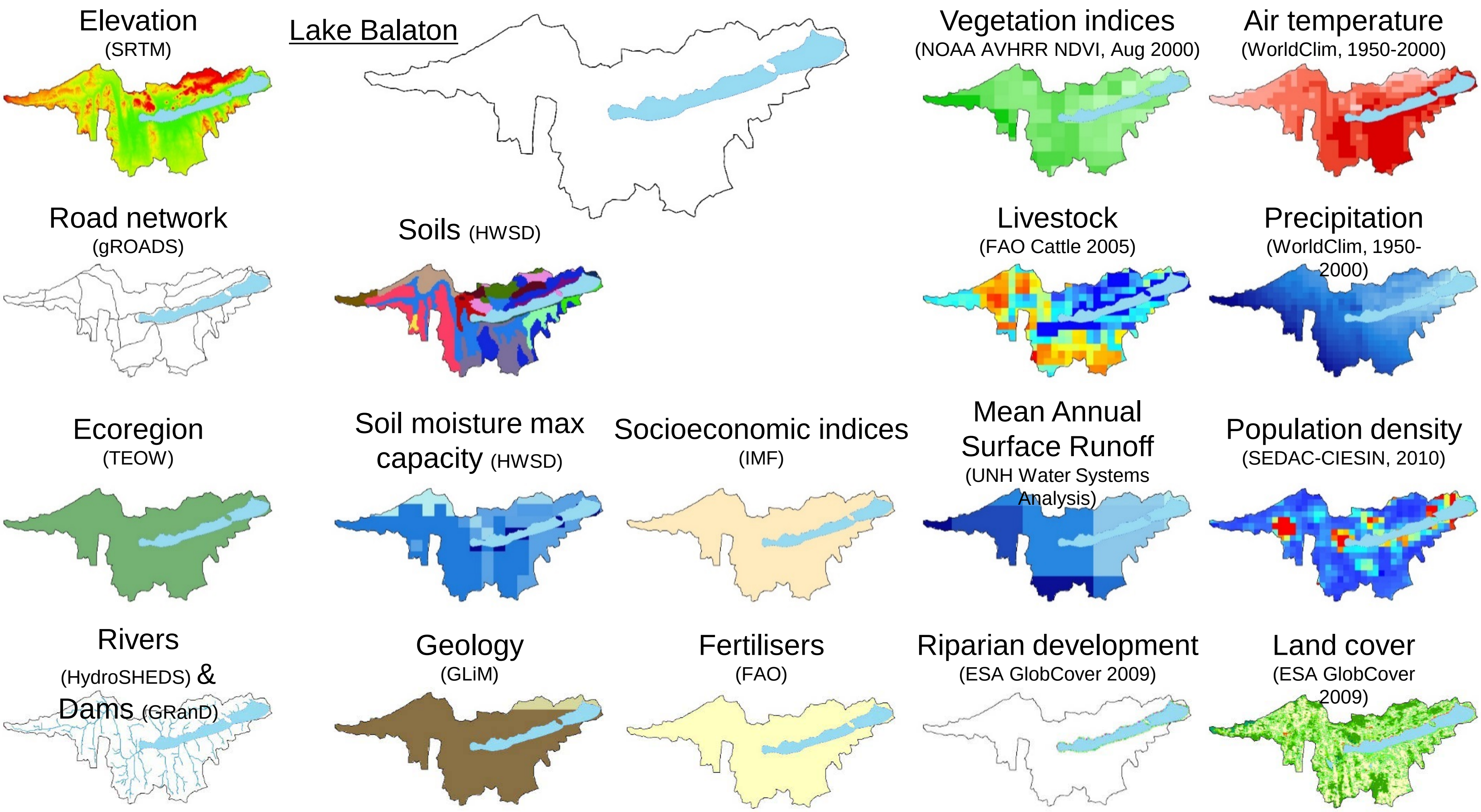
Modelled, *where published information unavailable*

Derived from Arc-Lake, other EO sources?

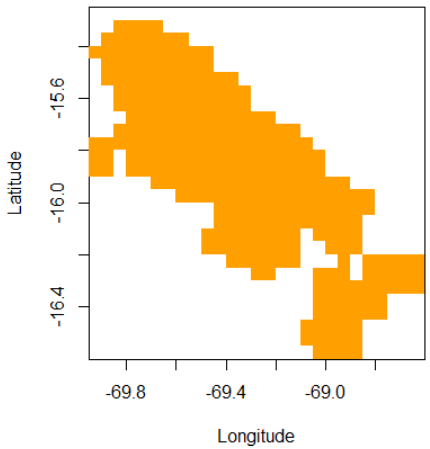


Politi, MacCallum, Cutler, Merchant & Rowan, *submitted*, Selection of large sentinel lakes and reservoirs around the world for a climate study using remote sensing and the Global Lakes and Wetlands Database, *Limnology & Oceanography*

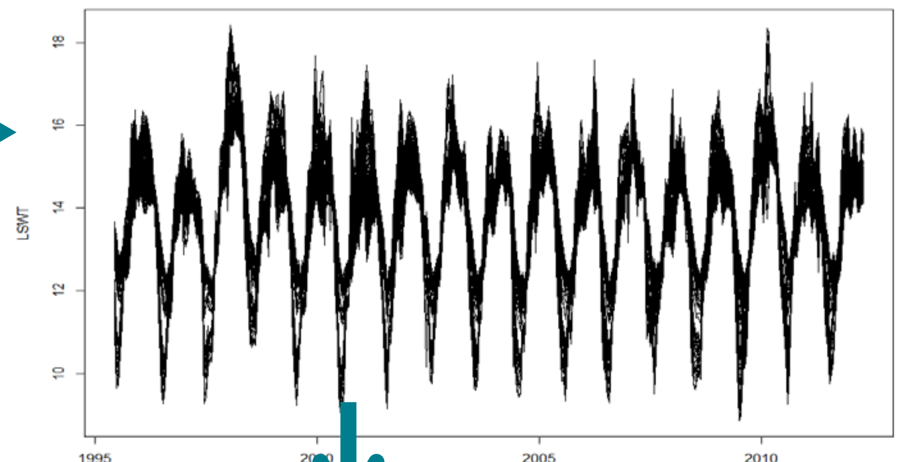
WP3: Catchment drivers



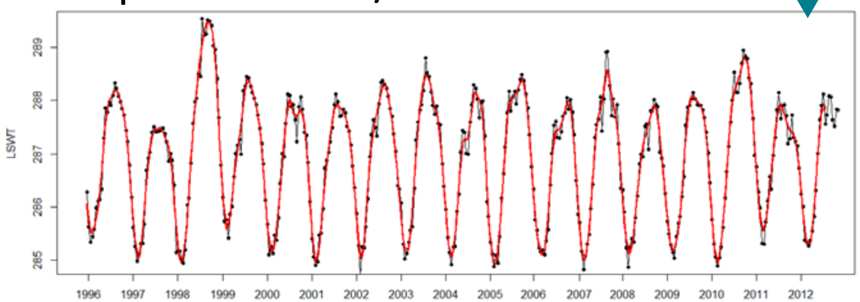
WP5 Spatial and temporal patterns



Per-pixel time-series

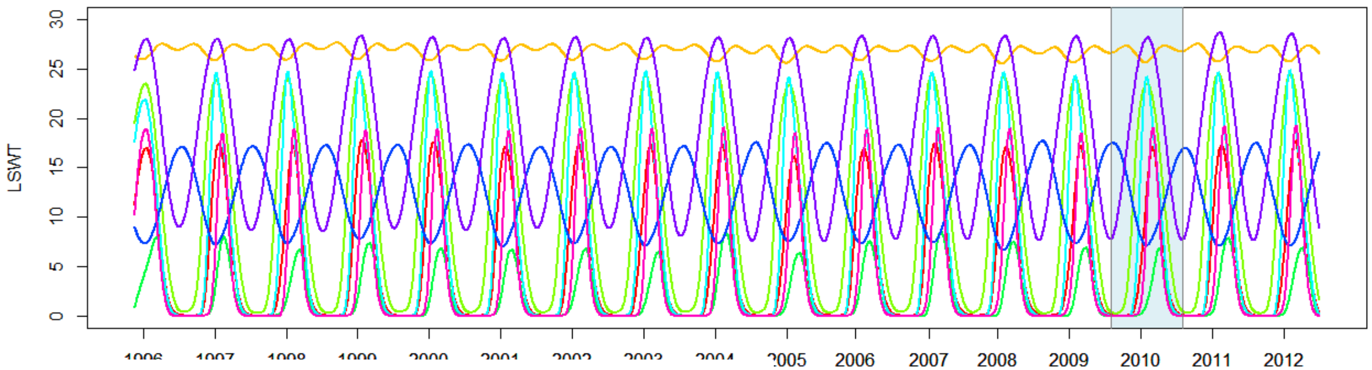


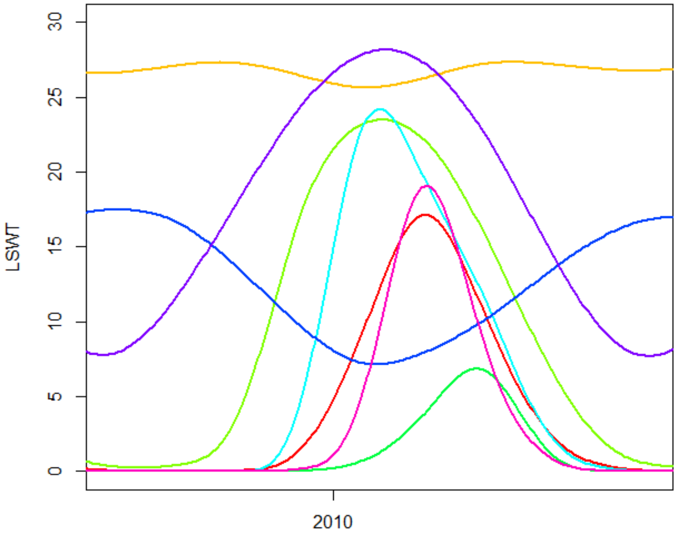
b-spline smooth/fit

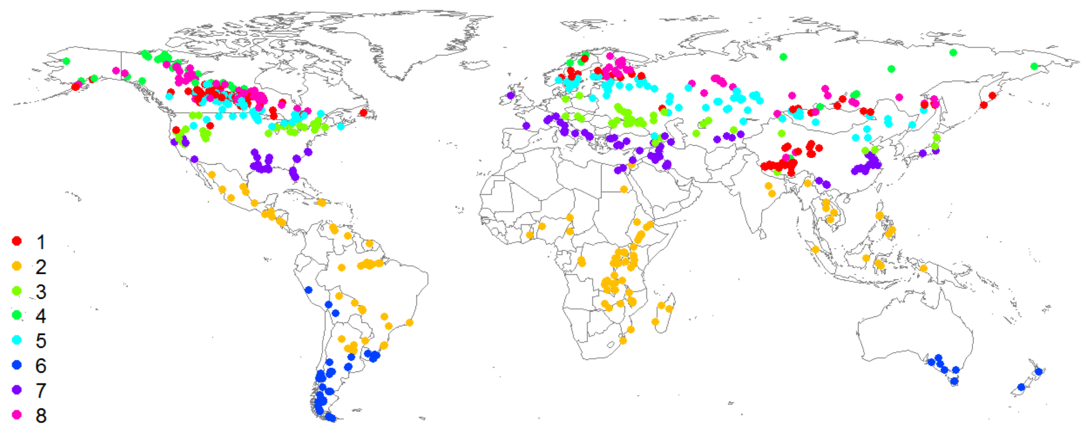


Model based clustering applied to the b-spline coefficients which define the smooth curves.

WP5 Spatial and temporal patterns: temperature coherence: 8 global lake clusters







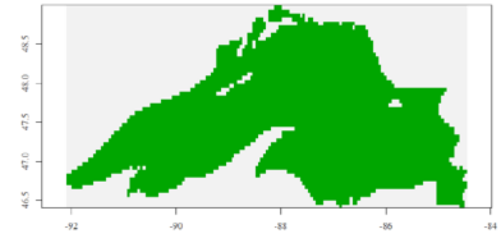
WP5 Spatial and temporal patterns: within-lake coherence

Seasonal patterns in lake basins/areas

Functional Principal Component Analysis

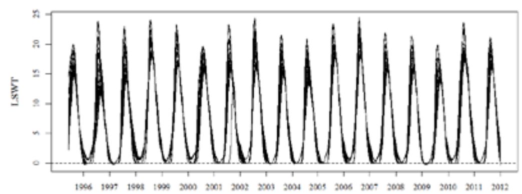
- Identify dominant modes of variation
- Cluster basis functions

For lakes > 30 pixels

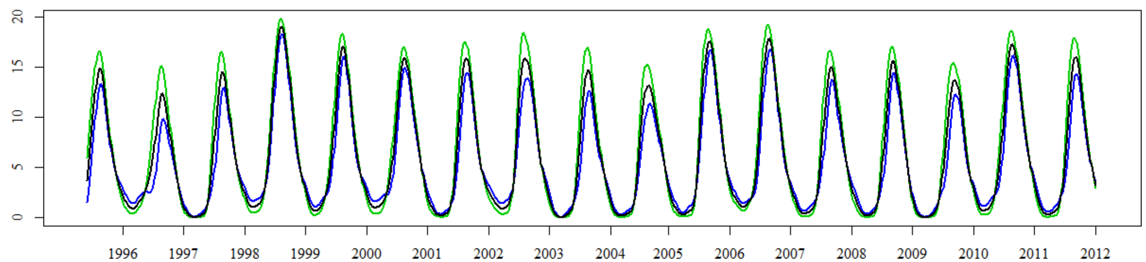


Lake Superior

4096 pixels

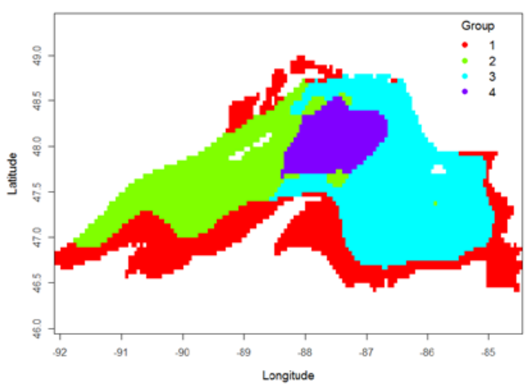


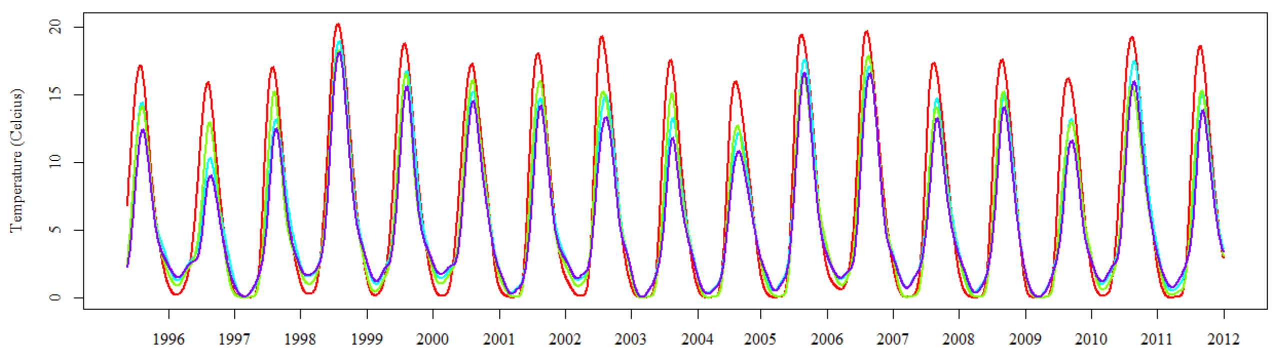
4096 smoothed time-series



PC 1: 77%
PC 2: 9%

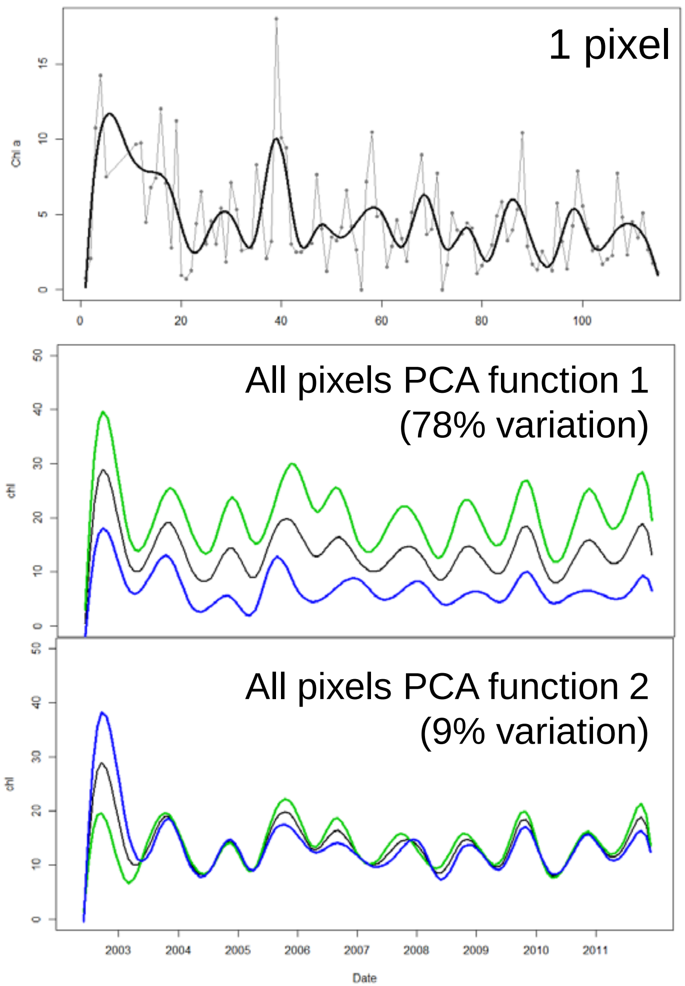
4 clusters with different temperature responses

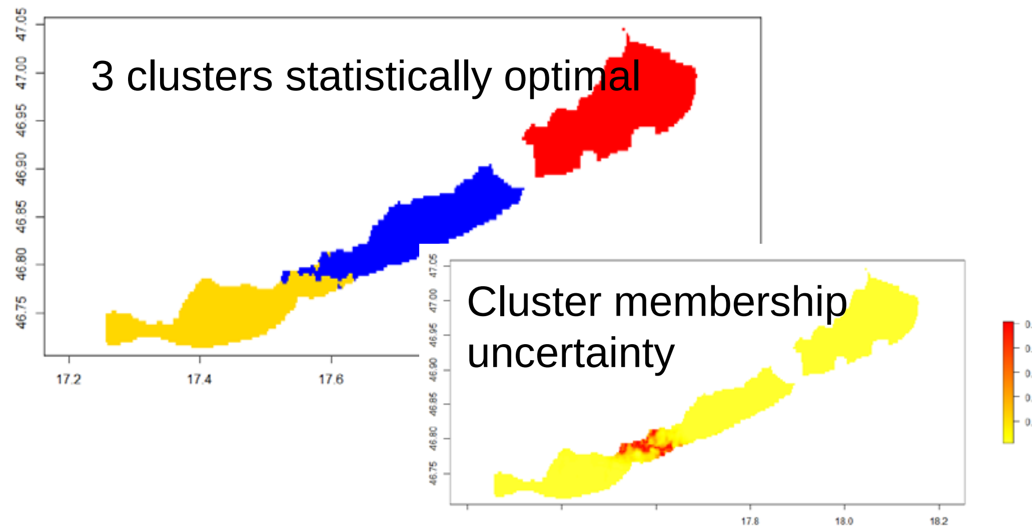


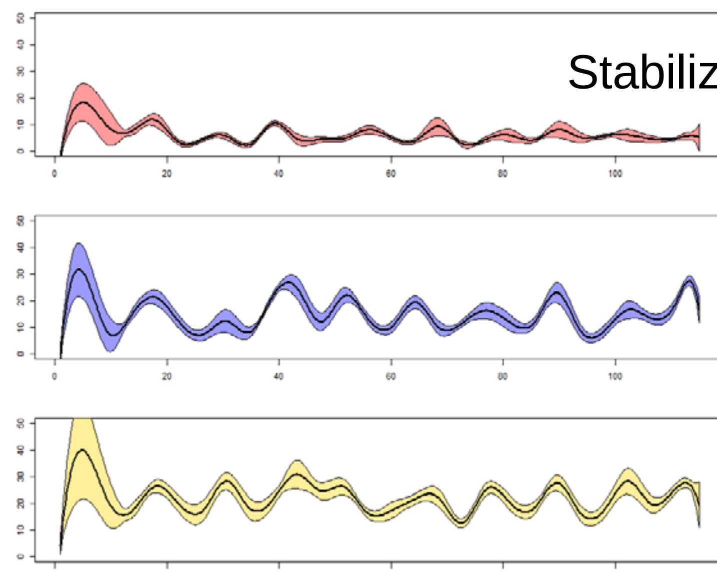


WP5 Chlorophyll-a data-driven clustering

Lake Balaton: 115 months,
6000 pixels from ESA Diversity-II







#1 question

Are you going to include more lakes?
Will you include my lake?

Yes

Strong focus on process automation

& looking for synergies at MWBS15

to move from 0.001 % of all lakes to an even higher number

Catchment extraction from DEMs

868 from SRTM (<60°, 90 m) took 1 yr on 15PCs (150 yrs without subsetting)

Lake polygons to extract EO data

Various databases now exist – how reliable are they, experiences, new initiatives?
Moving from static maximum lake extent (e.g. 300-m CCI land mask) to dynamic
Towards 20-30m footprint sensors -> higher requirements for global db

In other words – we are happy to be your end-user

GloboLakes summary

Long-term internally consistent datasets provide some of the most powerful tools that we have to describe ecosystem function, variation and resilience to environmental change

Earth-observing satellites provide a powerful approach to monitor the status of lakes globally

GloboLakes will provide:

- Long-term (10-20 years) and consistent lake physical, biogeochemical and catchment data for 1000 lakes globally
- Data to enable hypotheses on processes that operate over large scales and decadal time frames to be tested and to underpin effective and sustainable lake management
- Development of EO-based **Essential Climate Variables** (ECVs) for lakes to feed into Global Climate Observing System (GCOS)

Acknowledgements

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