GloboLakes

Global Observatory of Lake Responses to Environmental Change

Global Observatory of Lake Responses to Environmental Change

Andrew Tyler

University of Stirling

Scottish Freshwater Group Meeting April 2013

GloboLakes

The Consortium

Global Observatory of Lake Responses to Environmental Change

NATURAL
ENVIRONMENT
RESEARCH COUNCIL

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- **Claire Miller**, **Marion Scott**
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Rationale

Global Observatory of Lake Responses to Environmental Change

- >300 million lakes globally
- Providing essential ecosystem goods & services
- Fundamental to global food security
- Global concerns over future water security (Unsustainable use; MEA 2005)
- Important in global biogeochemical cycling (Bastviken et al. 2011, *Science*)
- Yet:
  - Hard to monitor
  - Existing Monitoring
    - Very small proportion (<0.00003 %)
    - Inconsistently

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Rationale

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- Lakes are ‘sentinels’ of environmental change
- These can trigger internal interactions & direct responses leading to:
  - loss of habitat
  - eutrophication
  - fish kills
  - loss of species (highest proportion of species threatened with extinction; MEA 2005)
  - altered communities & shifts to less desirable species

Lake Chad, Africa

Kankaria Lake, India

Dianchi Lake, China

Nutrient enrichment

Land use change & deforestation

Water abstraction

Climate change

Invasion of non-native species

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Rationale

Global Observatory of Lake Responses to Environmental Change

Timeliness:

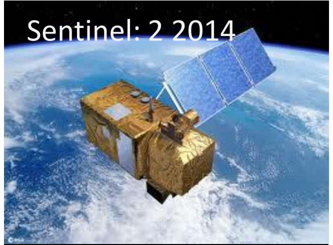
- Increasing robustness of algorithms and ensemble approaches
- Capability for processing huge data volumes in near real time
- MERIS: spectral and temporal resolution (until April 2012)
- GMES: ESA planned launches – superior capabilities (2014)

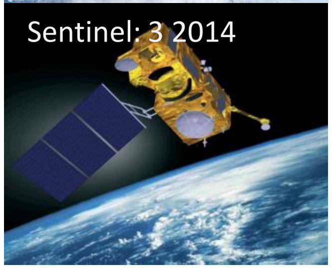
Opportunity:

Access to nearly 20 years of data on 1000 lakes of different types across the globe will give a *paradigm shift* in our ability to ask fundamental ecological questions in relation to the status and change in the condition of the world's lakes


SeaWifs: 1997-2010


MERIS: 2003-2012


Sentinel: 2 2014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Questions

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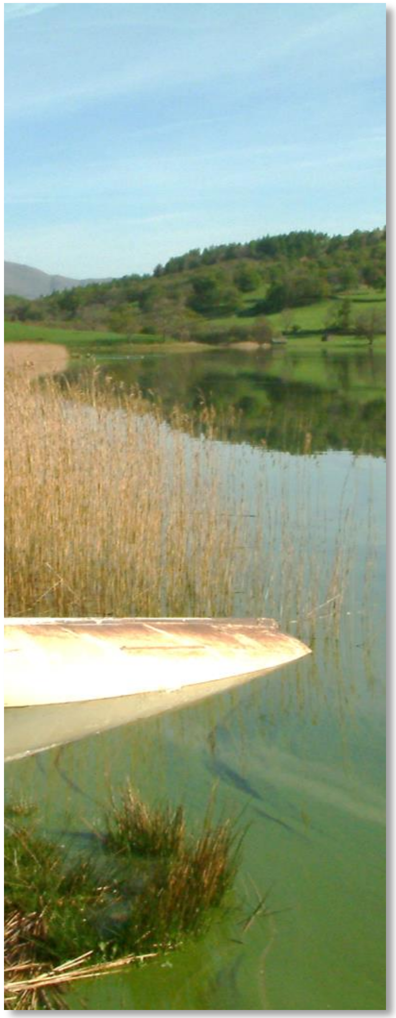
What controls the differential sensitivity of lakes to environmental perturbation?



Some pressing questions:

- What is the present state & evidence for long-term change for the 1000 lakes?

Condition

- To what extent are patterns temporally coherent & what are the causes?
- Is there evidence for phenological change & what are the causes?

Change

- What factors control cyanobacterial blooms?
- What factors control the concentration of coloured DOC?

Controls

- How sensitive are different lake types to varying environmental perturbation?

Resilience

- Can we forecast the future response of phytoplankton composition & abundance, & risk of cyanobacterial blooms, for lakes in different landscapes?

Forecasting

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Aims and Objectives

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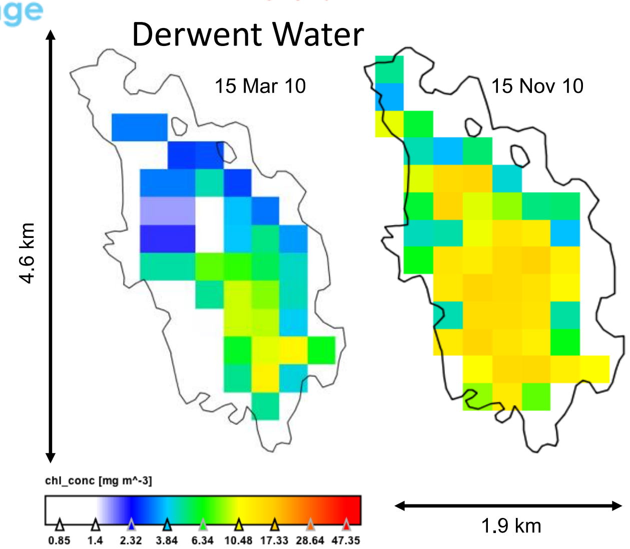
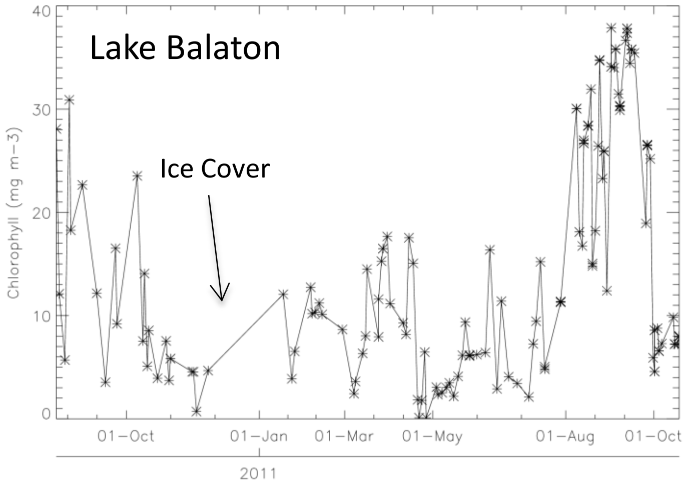
Investigate the state of lakes & their response to environmental change drivers:

- Near real time processing satellite based observatory
- Processing archived data for up to 20-year time series
- Including: (i) LSWT; (ii) TSM; (iii) CDOM; (iv) Chl a;
  (v) PC
- Detect spatial & temporal trends & attribute causes of change for 1000 lakes worldwide (1/3 of inland water, 2/3 of all inland water > 1km^2)
- Forecast lake sensitivity to environmental change
- Apply findings into lake management
- Two Tied PhDs: (i) Primary Productivity;
  (ii) Atmospheric Correction





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Foundations

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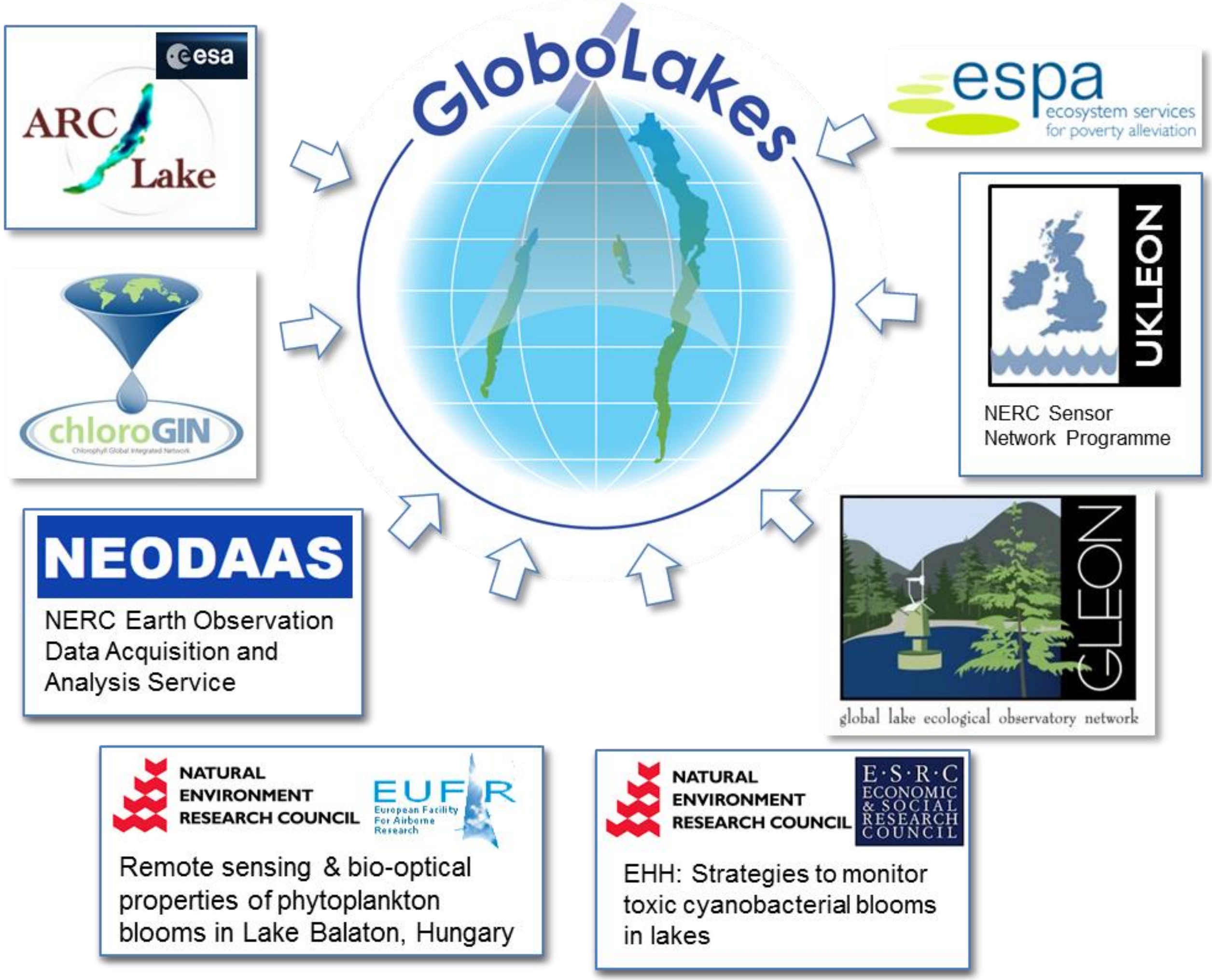

NERC Sensor Network Programme

global lake ecological observatory network

NERC Earth Observation Data Acquisition and Analysis Service

Remote sensing & bio-optical properties of phytoplankton blooms in Lake Balaton, Hungary

EHH: Strategies to monitor toxic cyanobacterial blooms in lakes

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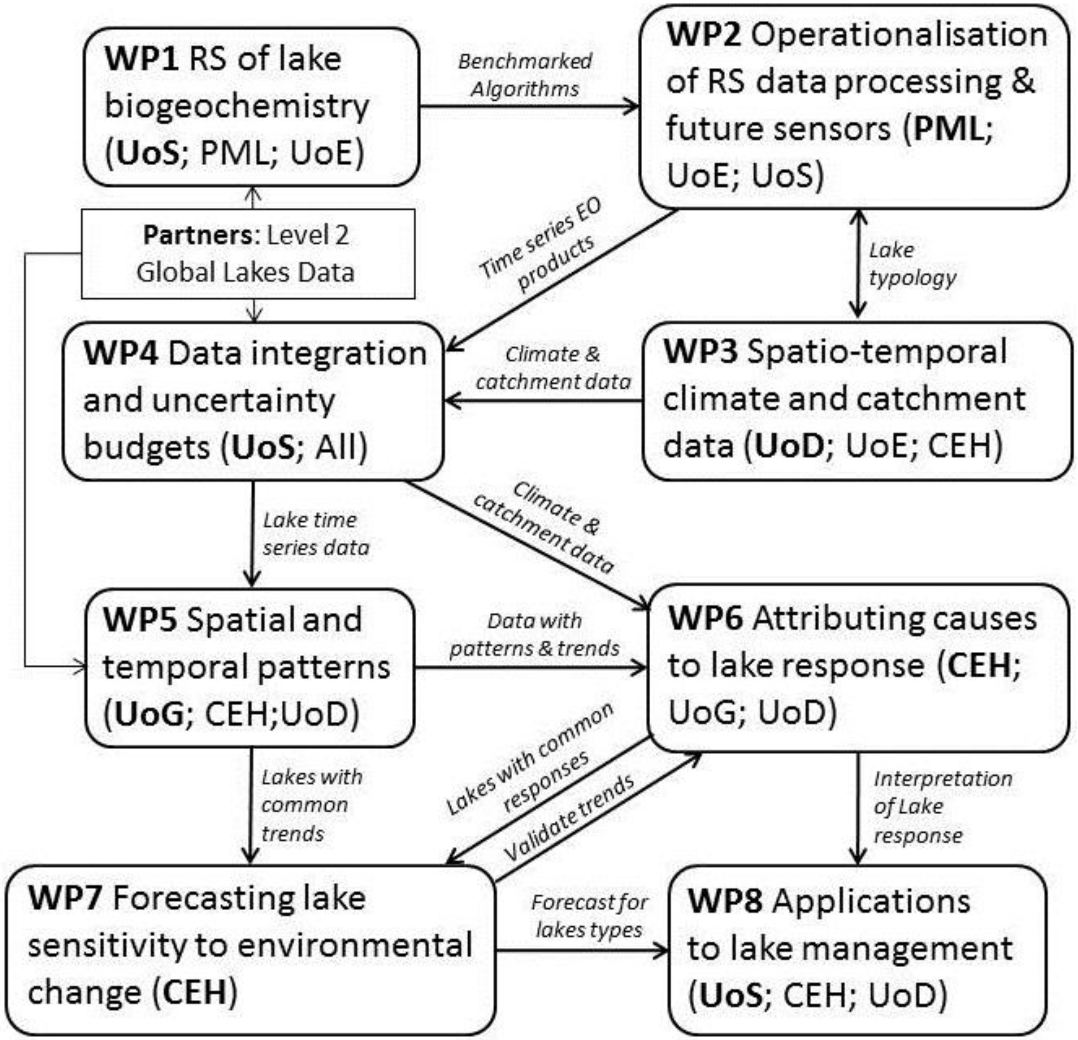

WP1 RS of lake biogeochemistry (**UoS**; PML; UoE)

WP2 Operationalisation of RS data processing & future sensors (**PML**; UoE; UoS)

Partners: Level 2 Global Lakes Data

WP3 Spatio-temporal climate and catchment data (**UoD**; UoE; CEH)

WP4 Data integration and uncertainty budgets (**UoS**; All)

WP5 Spatial and temporal patterns (**UoG**; CEH;UoD)

WP6 Attributing causes to lake response (**CEH**; UoG; UoD)

WP7 Forecasting lake sensitivity to environmental change (**CEH**)

WP8 Applications to lake management (**UoS**; CEH; UoD)

Work package Structure

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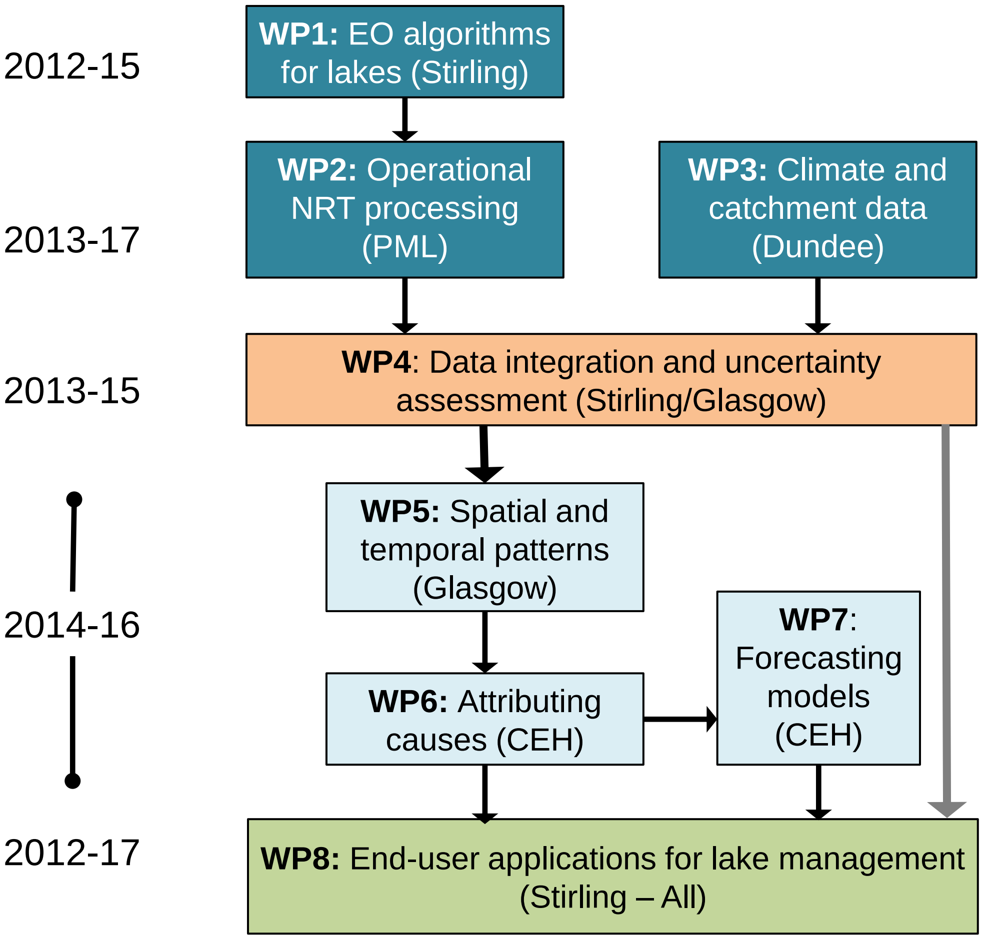

2012-15

WP1: EO algorithms for lakes (Stirling)

2013-17

WP2: Operational NRT processing (PML)

WP3: Climate and catchment data (Dundee)

2013-15

WP4: Data integration and uncertainty assessment (Stirling/Glasgow)

2014-16

WP5: Spatial and temporal patterns (Glasgow)

WP6: Attributing causes (CEH)

WP7: Forecasting models (CEH)

2012-17

WP8: End-user applications for lake management (Stirling – All)

EO model development and processing

Quality assurance

Data analysis and interpretation

End-user engagement

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Lake Data

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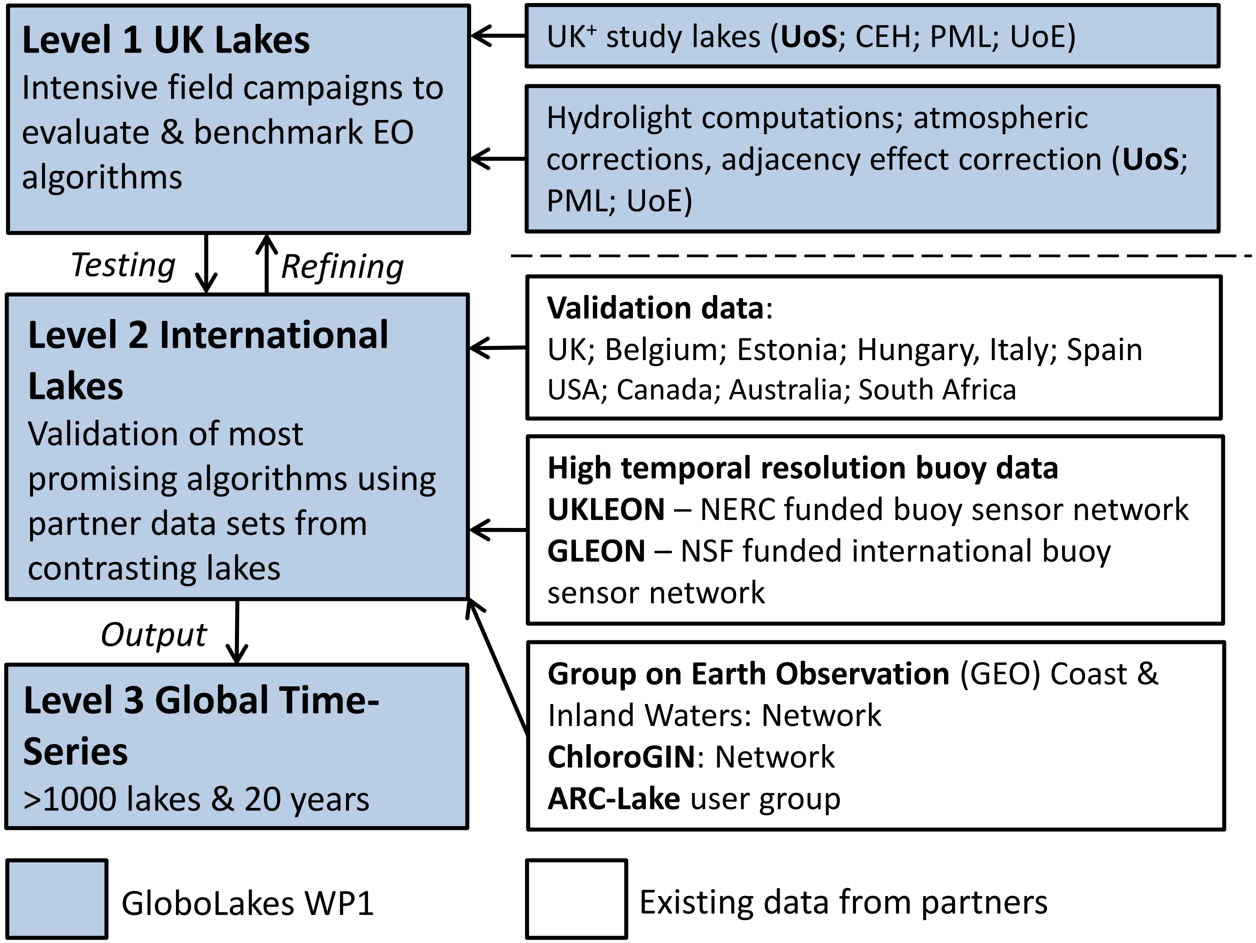

Level 1 UK Lakes
Intensive field campaigns to evaluate & benchmark EO algorithms

UK^{+} study lakes (**UoS**; CEH; PML; UoE)

Hydrolight computations; atmospheric corrections, adjacency effect correction (**UoS**; PML; UoE)

Testing

Refining

Level 2 International Lakes
Validation of most promising algorithms using partner data sets from contrasting lakes

Validation data:
UK; Belgium; Estonia; Hungary, Italy; Spain
USA; Canada; Australia; South Africa

High temporal resolution buoy data
UKLEON – NERC funded buoy sensor network
GLEON – NSF funded international buoy sensor network

Group on Earth Observation (GEO) Coast & Inland Waters: Network
ChloroGIN: Network
ARC-Lake user group

Output

Level 3 Global Time-Series
>1000 lakes & 20 years

■ GloboLakes WP1

□ Existing data from partners

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GloboLakes will validate algorithms using data from a hierarchical populations of lakes

Level 1. UK^{+} lakes (~5-10 lakes)
Intensive field campaigns to test and benchmark algorithms

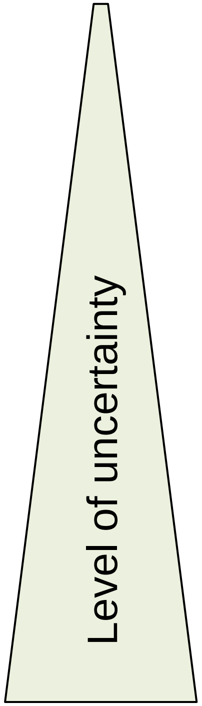
Well understood, with excellent temporal sampling

Level 2. International lakes (~25-50 lakes)
Validation of most promising algorithms against high quality datasets from international lakes

In-situ data available, but less intensively studied and monitored

Level 3. Global lakes (>1000)
Operational processing for global population distributed across all climatic zones

Unknown characteristics, validation data very limited or absent



Case Study: ARC-Lake data

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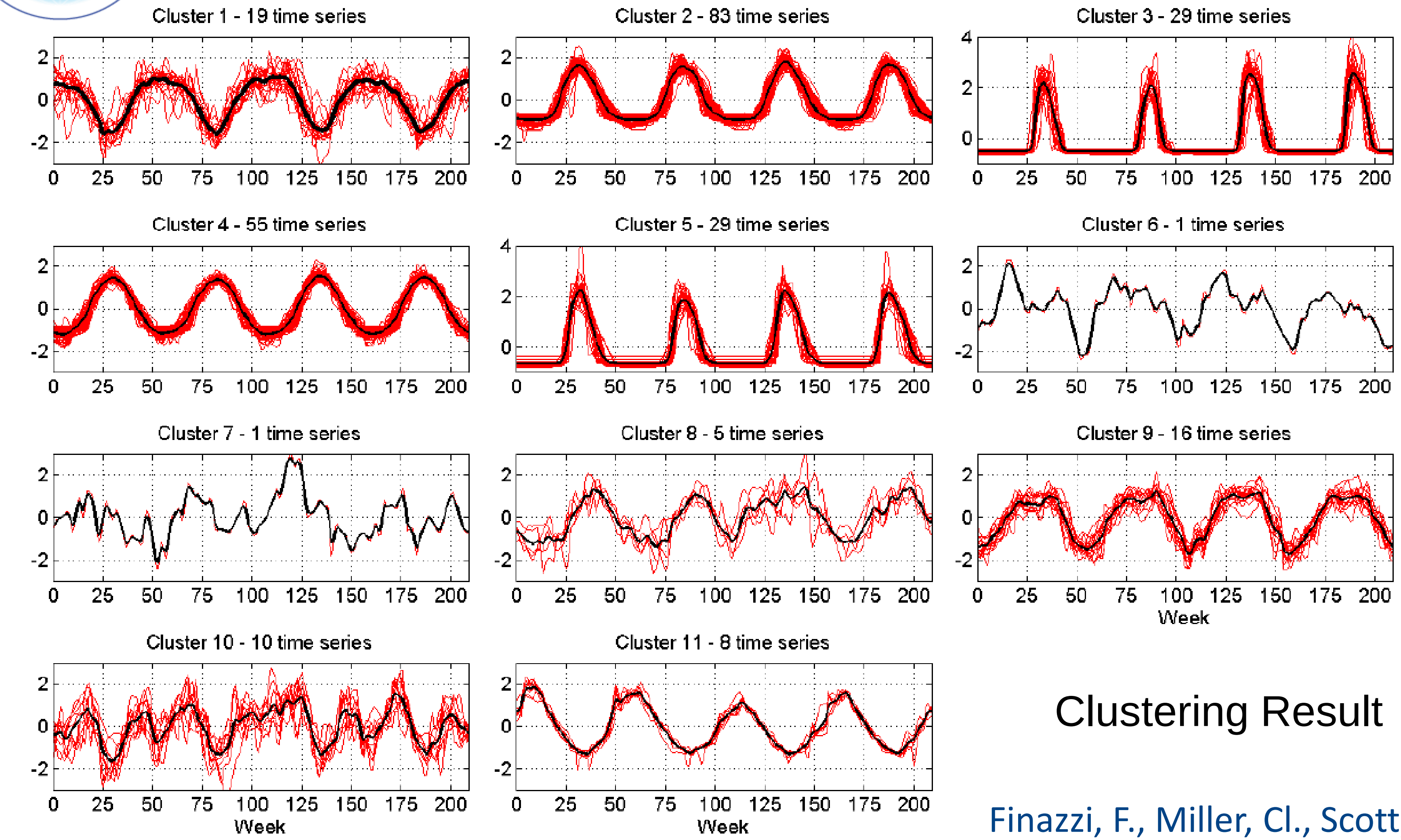

Clustering Result

Finazzi, F., Miller, Cl., Scott, M.

Case Study: ARC-Lake data

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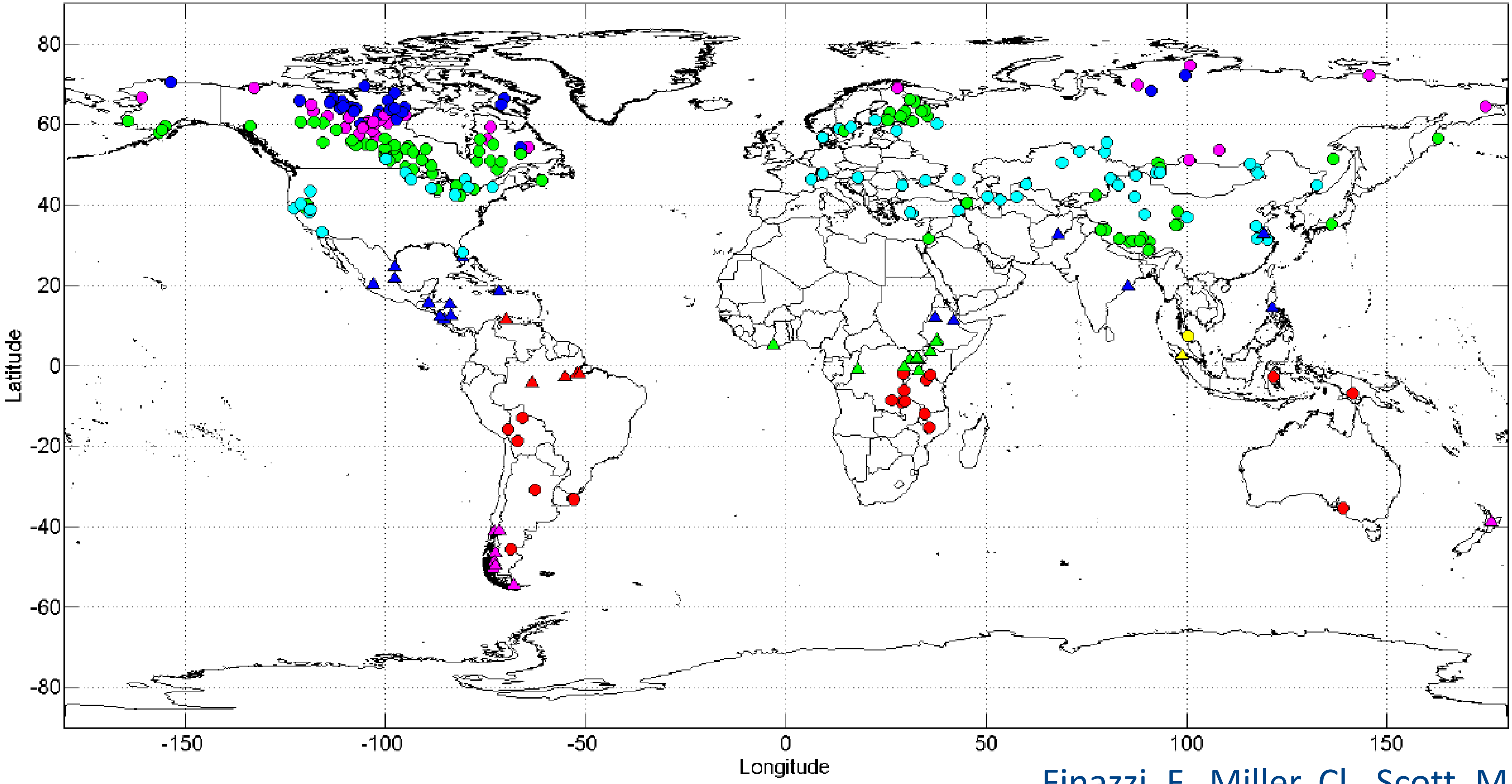
Clustering Result – Global map

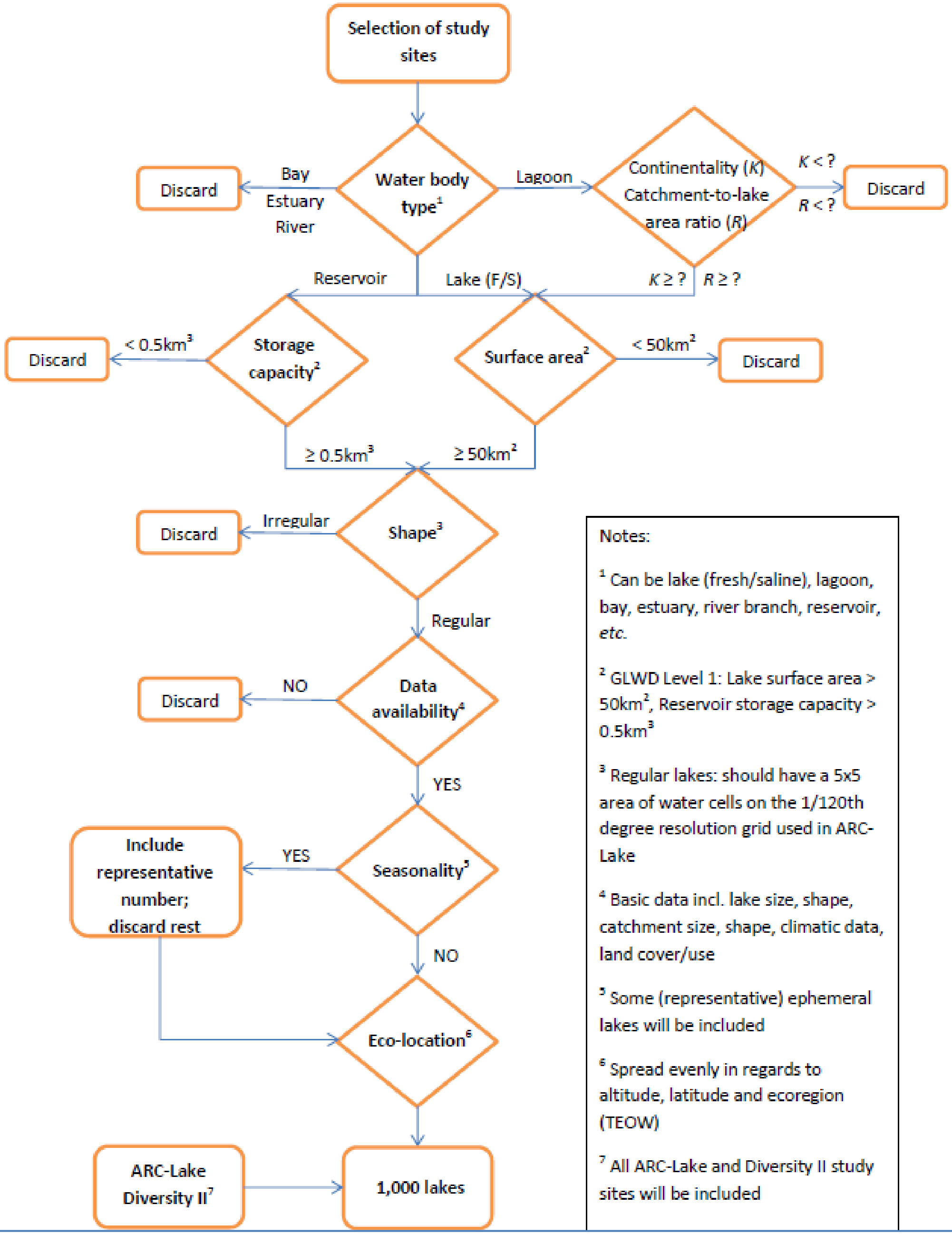


Finazzi, F., Miller, Cl., Scott, M.

Lake Selection

Lake Landscape Context (Sorrano *et al*. (2009)

- incorporate a wide range of catchment-to-lake-surface-area ratios
- span a wide range of water quality parameters and ecological characteristics, e.g. pH, alkalinity, eutrophication status and mixing regime.
- Include lakes of special scientific interest
- Ideally a pool from which lakes selected using a randomised, probability-based approach (Stevens 1994).



Notes:

[1] Can be lake (fresh/saline), lagoon, bay, estuary, river branch, reservoir, *etc.*

[2] GLWD Level 1: Lake surface area > 50km^2, Reservoir storage capacity > 0.5km^3

[3] Regular lakes: should have a 5x5 area of water cells on the 1/120th degree resolution grid used in ARC-Lake

[4] Basic data incl. lake size, shape, catchment size, shape, climatic data, land cover/use

[5] Some (representative) ephemeral lakes will be included

[6] Spread evenly in regards to altitude, latitude and ecoregion (TEOW)

[7] All ARC-Lake and Diversity II study sites will be included

Drivers of change

- Spatial database of drivers of catchment change, including:
    - climate
    - land cover
    - catchment morphology
    - productivity
    - development
    - lake hydromorphology etc.
- Trends in catchment change derived from global datasets (30 years of change)
- Run-off modelled for each catchment using a lumped GIS-based model

Lake and catchment data sets

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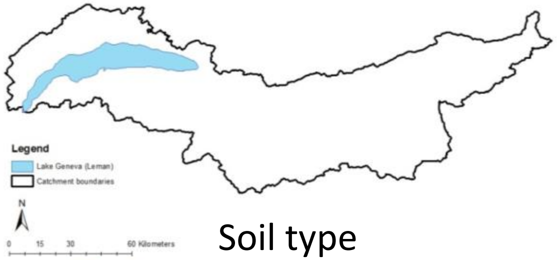
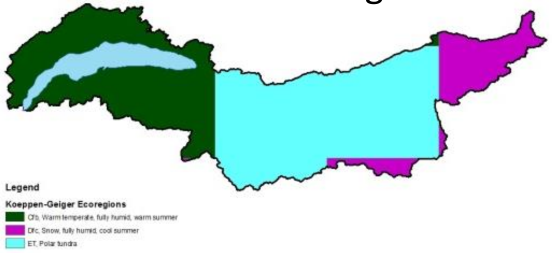


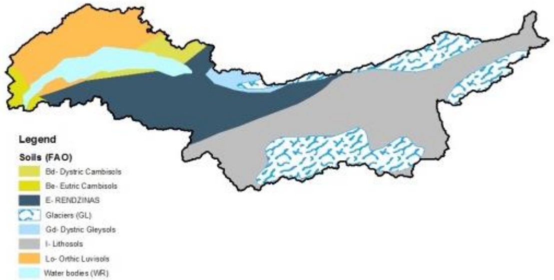
Road network

River network & Dams

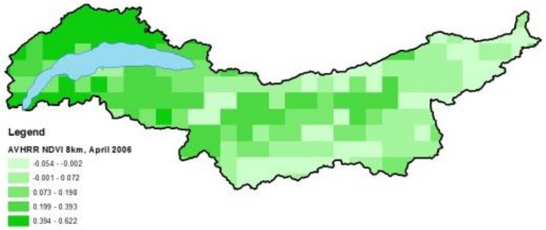
Climatic ecoregions



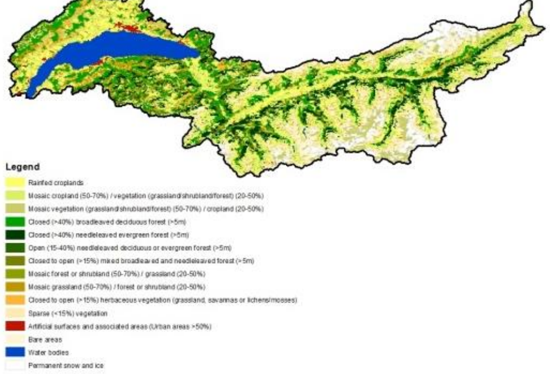
Soil type



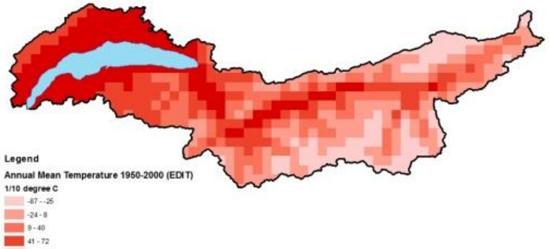
NDVI



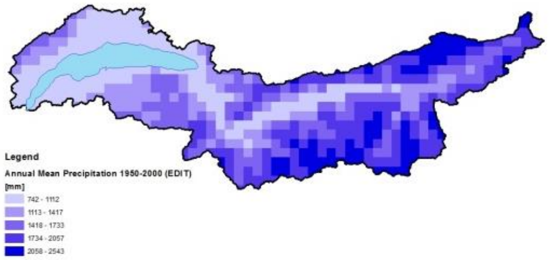
Land cover



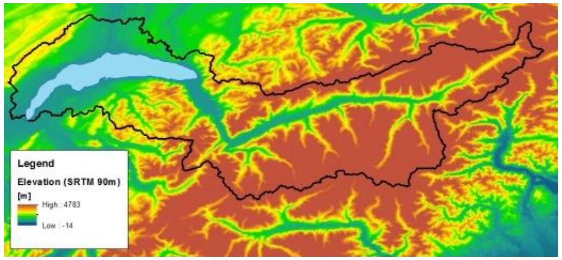
Annual mean temperature



Annual mean precipitation



Elevation



Engagement

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Success of GloboLakes will rely on contributions from across the EO and end-user communities

- More than 20 scientific partners from over 15 nations
    - CSIRO, Australia; CSIR, South Africa; VITO, Belgium
    - Environment Canada; Estonian Marine Institute;
    - EC Joint Research Centre; CNR-IREA, Italy;
    - INTA, Spain; CUNY, USA; Creighton, USA
    - South Florida, USA; Institute of Limnology, Nanjing…
- Engagement with end-users including UK environmental regulators (EA, SEPA, NIEA)
- Engagement with UK National Centre for Earth Observation (NCEO), European Environment Agency, ESA and GEO

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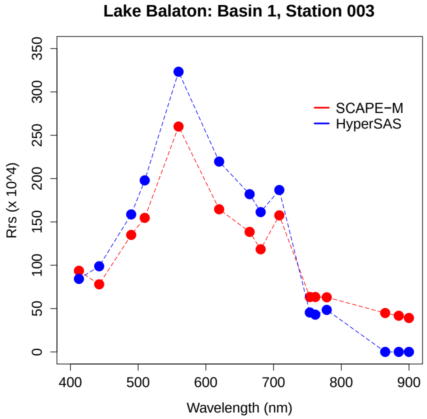
LIMNADES

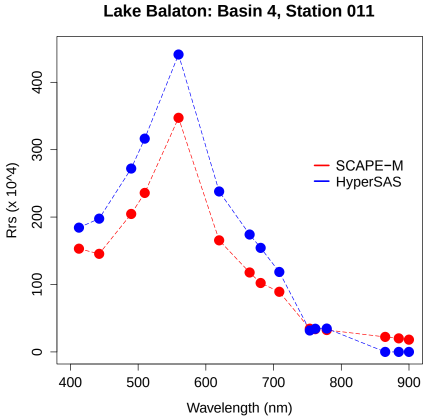
Lake Bio-optical Measurements and Matchup Data for Remote Sensing

- Centralised database of lake bio-optical measurements of worldwide lakes

- LIMNADES will provide a repository for:
  (1) inherent and apparent optical property datasets and associated water constituent measurements
  (2) in situ water constituent measurements for satellite validation

- Long-term vision





LIMNADES

Lake Bio-optical Measurements and Matchup Data for Remote Sensing

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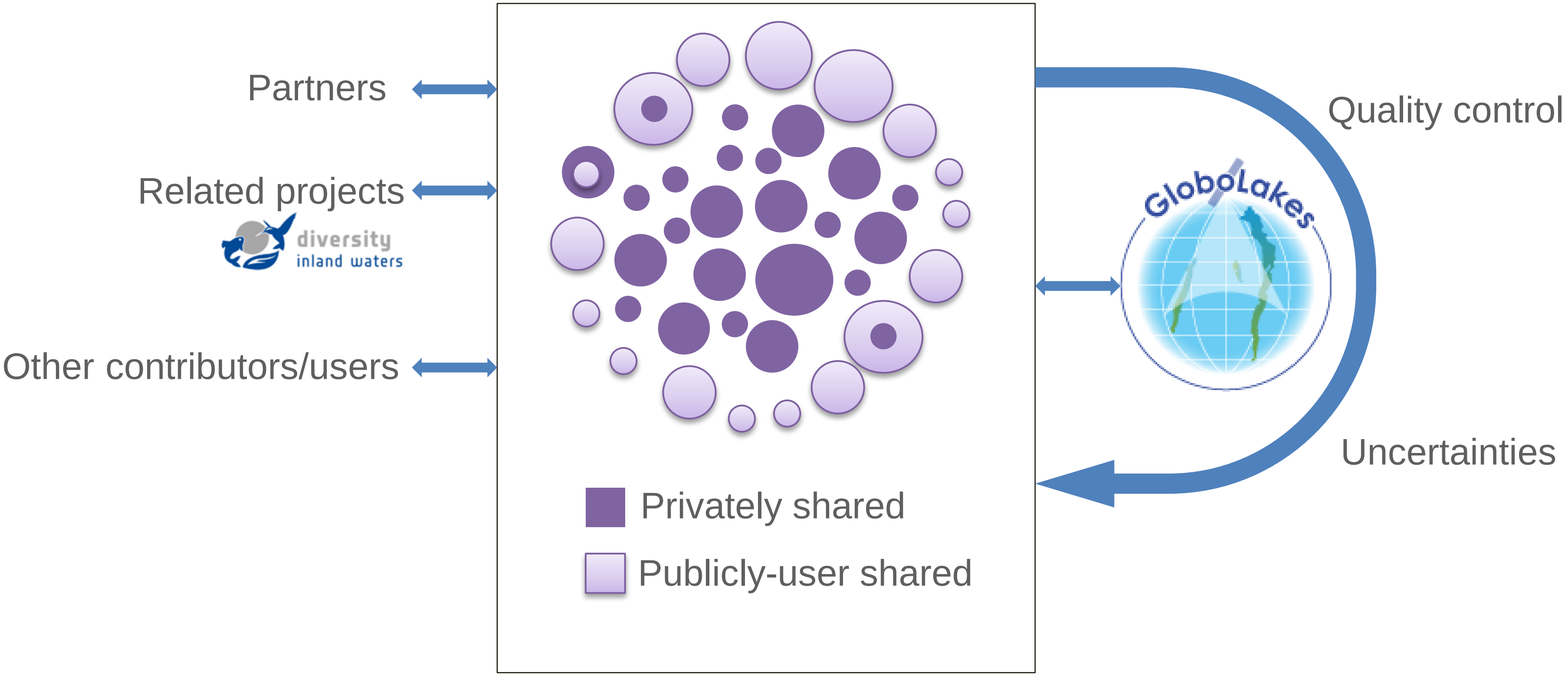

Partners

Related projects

diversity inland waters

Other contributors/users

Quality control

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Uncertainties

■ Privately shared

□ Publicly-user shared

DATA ACCESS & POLICY:

http://www.globolakes.ac.uk/limnades/data_access_policy.html

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Linkages and Developments

Global Observatory of Lake Responses to Environmental Change

- Brockmann Associates
- Lake Algal Bloom Pilot Project
- KTAMOP: Ecological Status and Function of Lakes (Hungarian Academy of Sciences)
  - *HICO (Hypespectral Imager of the Coastal Ocean)*
- Appointed as a validation team for ESA Sentinel 3
- INFORM: Improved monitoring and forecasting of ecological status of European Inland waters by combining Future earth ObseRvation data and Models (FP7 project pending)
- CYANOCOST: Training and networking for EO
- NETLAKE: COST Action for in-situ sensors

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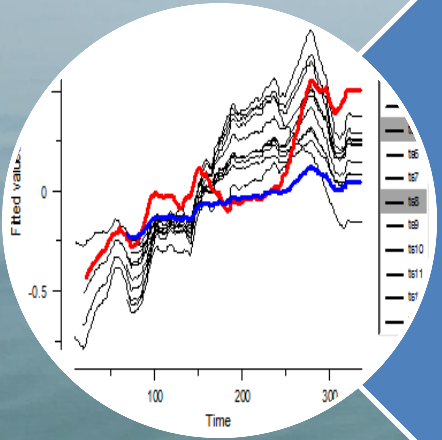
We all recognise:

- *Long-term data sets provide some of the most powerful tools that we have to describe ecosystem function, variation & resilience to environmental change*
- *For Lakes – a critical interface with society – Earth Observation provides a powerful approach to monitor lakes globally*



GloboLakes will deliver:

- *Long-term data sets across the globe*
- *Consistent measures of physical & biological condition*
- *Data enabling hypotheses on processes that operate over large scales & long time frames to be tested*
- *Data for the effective and sustainable management of these dynamic environments*

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