GloboLakes

NATURAL ENVIRONMENT RESEARCH COUNCIL

Global Observatory of Lake Responses to Environmental Change

WP1: Remote sensing models for lakes

GloboLakes Scientific Workshop
University of Stirling, 10-12 December 2012

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UNIVERSITY OF STIRLING | PML Plymouth Marine Laboratory | CEH Centre for Ecology & Hydrology NATURAL ENVIRONMENT RESEARCH COUNCIL | University of Glasgow | The University of Edinburgh | University of Dundee

The Ambition

Satellite-based observatory with near real-time data processing for more than 1000 large lakes

- Our global population of lakes will span all climatic zones with water bodies observable from space
- Incorporating data from multiple sensors (SeaWiFS, MODIS, MERIS, Sentinel-3) to produce a near-continuous 20-year time series spanning 1997-2017
- GloboLakes core NRT products will include chlorophyll, TSM, CDOM, phycocyanin and LSWT - plus primary production and phenology
- Sentinel-2 processing for selected smaller lakes of high ecological or socioeconomic importance
- Data used to study lake responses to environmental change and freely distributed externally via web portal and ftp (WP2)

GloboLakes WPs

Schedule

2012-15

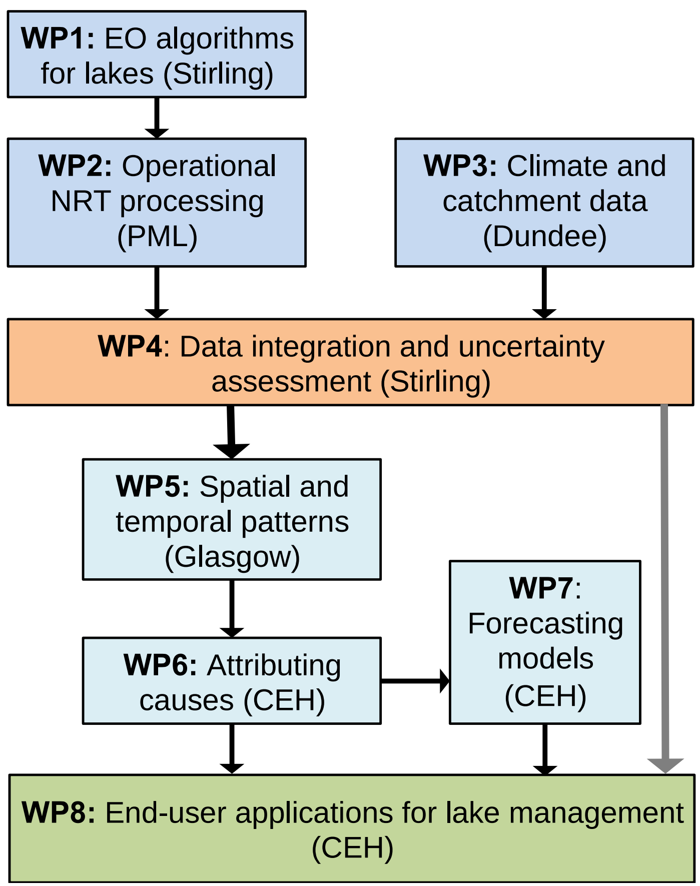
2013-17

2013-15

2014-16

2012-17

Work plan



Activity

EO model development and processing

Quality assurance

Data analysis and interpretation

End-user engagement

WP1: The Challenge

How do we routinely observe a global population of lakes with acceptable levels of uncertainty?

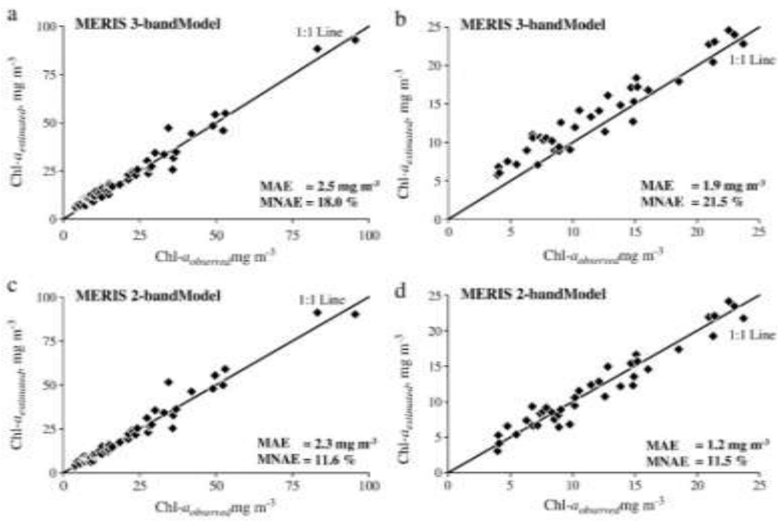
- Currently there is no operational system for satellite monitoring of lakes with global coverage
  - Optical properties of lakes and their overlying atmospheres are complex and diverse and this constrains the applicability of biogeochemical algorithms in space and time
  - Observations over smaller lakes can be greatly affected by land adjacency and bottom effects in clear shallow waters
  - Global LSWT algorithms need to be adapted to smaller lakes and finer resolution data (see Chris Merchant's keynote)

State of the Science

Many algorithms of varying architecture have been proposed for the estimation of biogeochemical properties

Empirical models

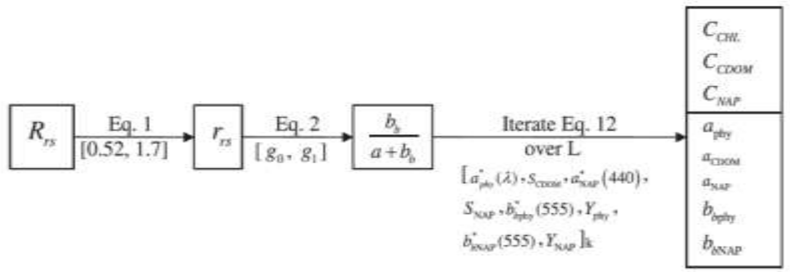
- Simpler to design, develop and parameterise
- Local optimisation provides high accuracies
- But often limited ability to generalise across space and time
- Very reliant on extensive *in-situ* data for calibration

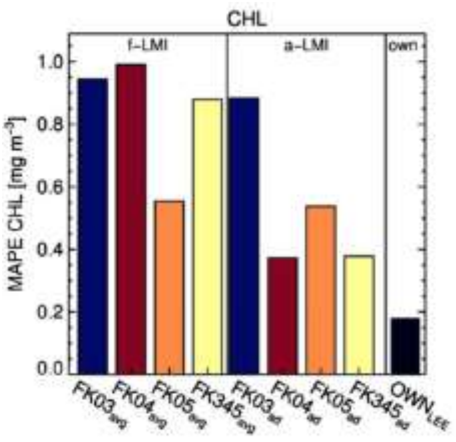


Gurlin, D, Gitelson, AA, Moses, WJ (2011) Remote estimation of Chl-a concentration in turbid productive waters. Return to a simple two-band NIR-red model? Remote Sensing of Environment 115: 3479-3490.

STATE OF THE SCIENCE

Many algorithms of varying architecture have been proposed for the estimation of biogeochemical properties





Brando, VE, Dekker, AG, Park, YJ, Schroeder, T (2012) Adaptive semi analytical inversion of ocean color radiometry in optically complex waters Applied Optics, 51: 2808-2833.

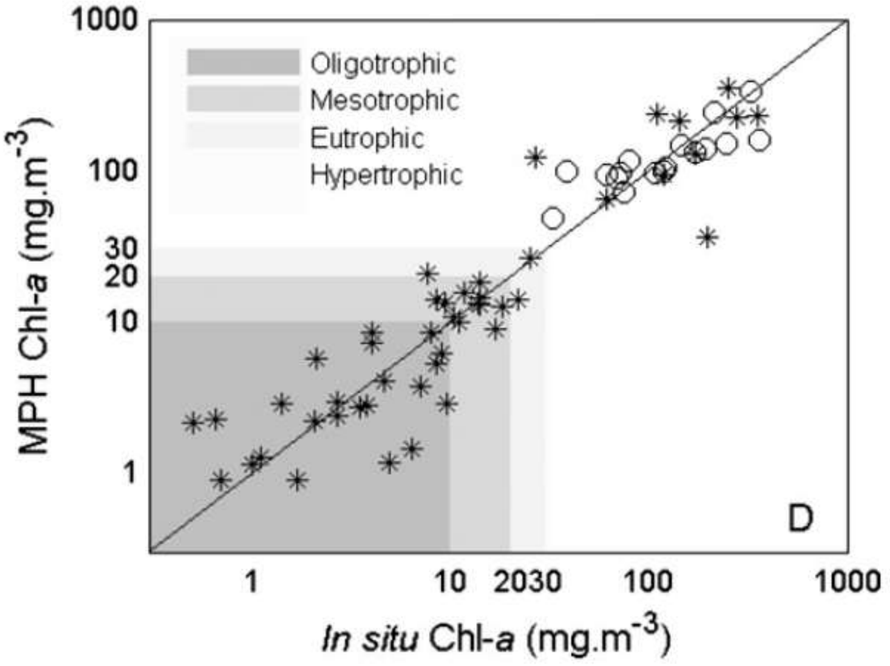
Analytical models

- Have greater potential for generalisation
- Simultaneous estimation of IOPs and in-water constituents
- Stronger physical basis allows for better error budgeting
- Parameterisation can be complex and needs knowledge of IOPs

WP1 Approach

Adaptive model with dynamic selection of in-water models based upon lake type and bio-optical properties

Example

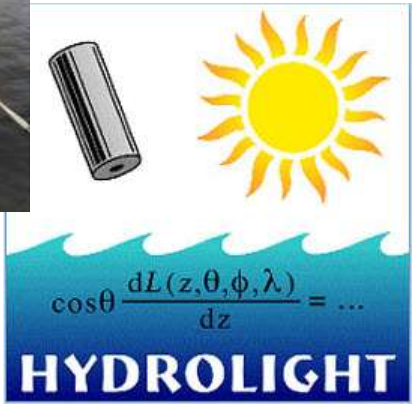


Matthews, MW, Bernard, S, Robertson, L (2012) An algorithm for detecting trophic status (chlorophyll-a), cyanobacterial dominance, surface scums and floating vegetation in inland and coastal waters. Remote Sensing of Environment 124: 637-652

WP1 Approach

Research cruises on UK lakes to support algorithm testing using modelled, *in-situ* and satellite data

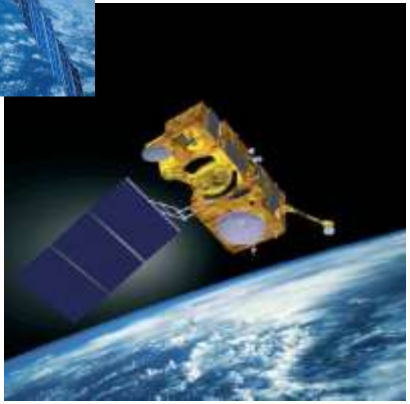
- Sources and magnitude of variability in bio-optical properties for range of lake types
- Radiative transfer modelling in Hydrolight to generate synthetic databases for initial algorithm testing
- Sensitivity analysis and construction of error budgets



WP1 APPROACH

Inter-comparison of existing atmospheric correction and in-water algorithms

- Selection of algorithms for operationalisation based upon further validation using satellite data
- Initially MERIS archive, but later Sentinel-3 OLCI
- Internal or external algorithm inter-comparison exercise
- *In-situ* data from research cruises, long-term monitoring programmes and instrumented buoys (UKLEON)



STUDY LAKES

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

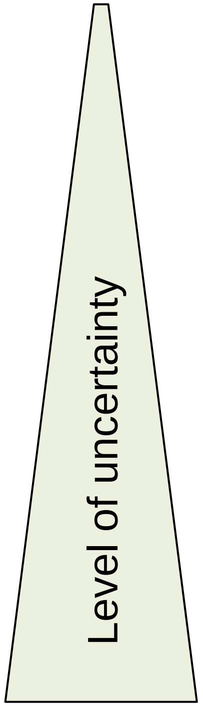
Well understood, with excellent temporal sampling

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



UK Lakes

Lakes of contrasting type from deep, stratifying and oligotrophic to shallow, well mixed and eutrophic systems

Loch Ness. Deep, oligotrophic and stratifies during summer. Surface area 56 km^2, mean depth 132 m. Phytoplankton flora dominated by diatoms and desmids.

Derwent Water. Shallow, mesotrophic, with weak stratification. Surface area 5.35 km^2, mean depth 5.5 m. Phytoplankton flora dominated by diatoms, small flagellates and green algae.

Lough Neagh. Shallow, eutrophic and well mixed. Surface area 383 km^2, mean depth 8.9 m. Summer blooms of filamentous cyanobacteria common.

International Validation

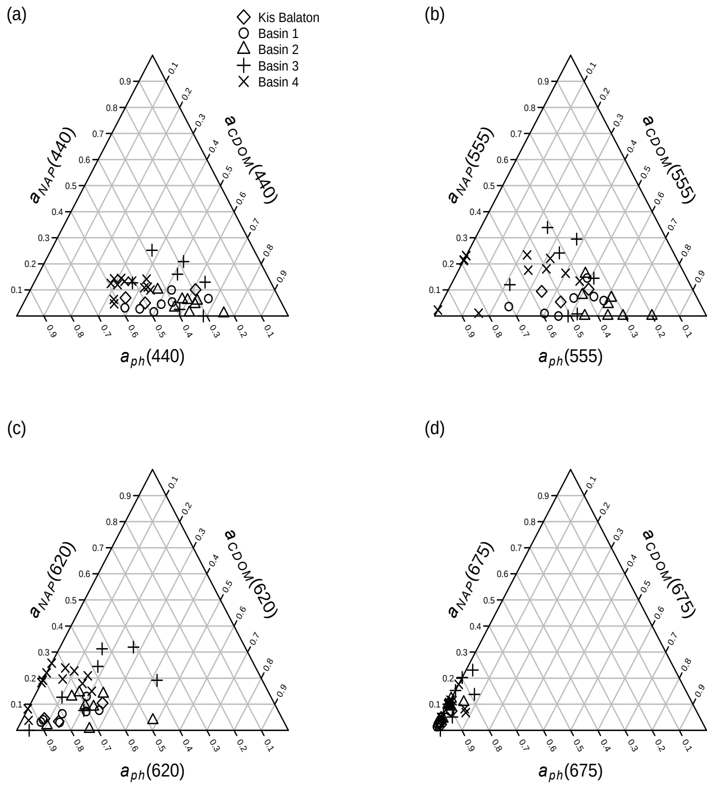
Comprehensive validation of algorithms will require international cooperation

- Must encompass full range of lake types and conditions
- More than 20 project partners covering North and South America; Australia; Africa; China; Southern, Eastern and Central Europe
- Access to *in-situ* data for validation through GLEON and WISER projects

Progress: Lake Optics

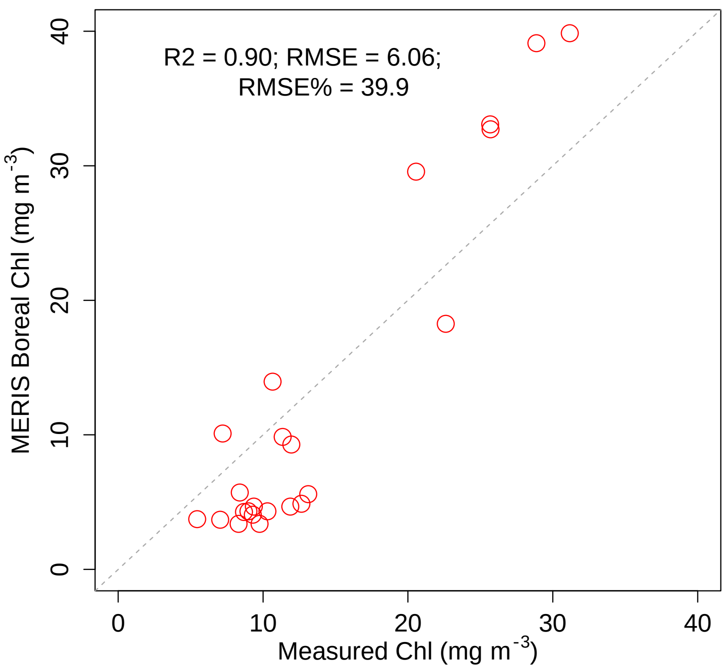
Variation in mass- and material-specific light absorption and scattering across different lake types

- Optics cruises undertaken on Lake Balaton, Loch Leven, Loch Lomond and Windermere…
- Construction of absorption and scattering budgets
- Spatial and seasonal change in specific inherent optical properties

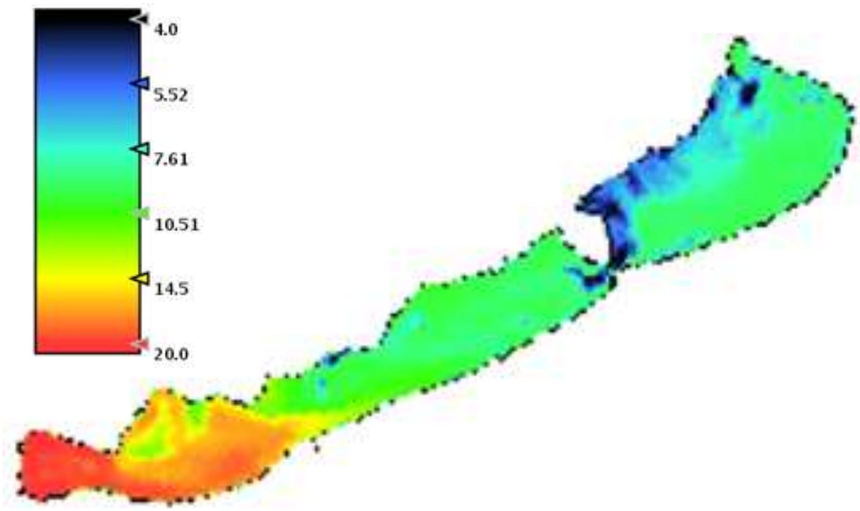


PROGRESS: ALGORITHMS

Validation of MERIS Chla algorithms over Lake Balaton



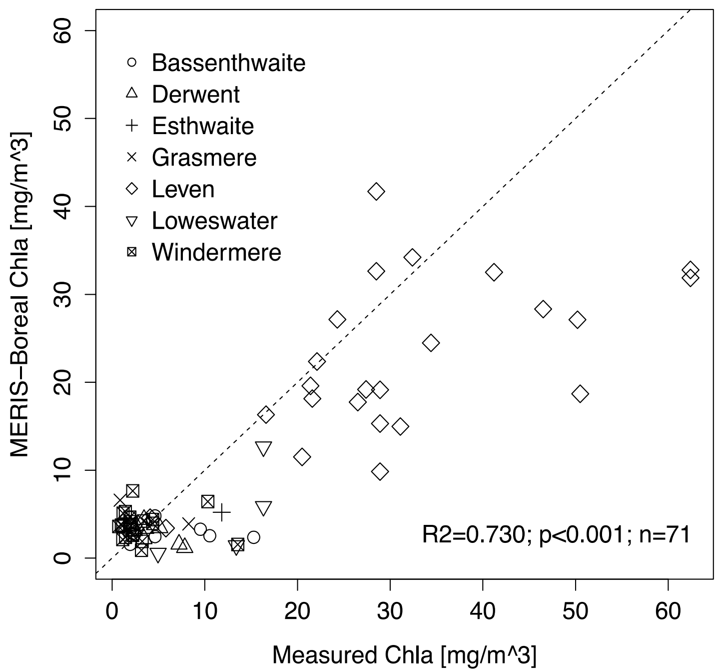
Chla values retrieved from MERIS FR data over Lake Balaton in Aug 2010 using Boreal Lakes processor (same day match ups)



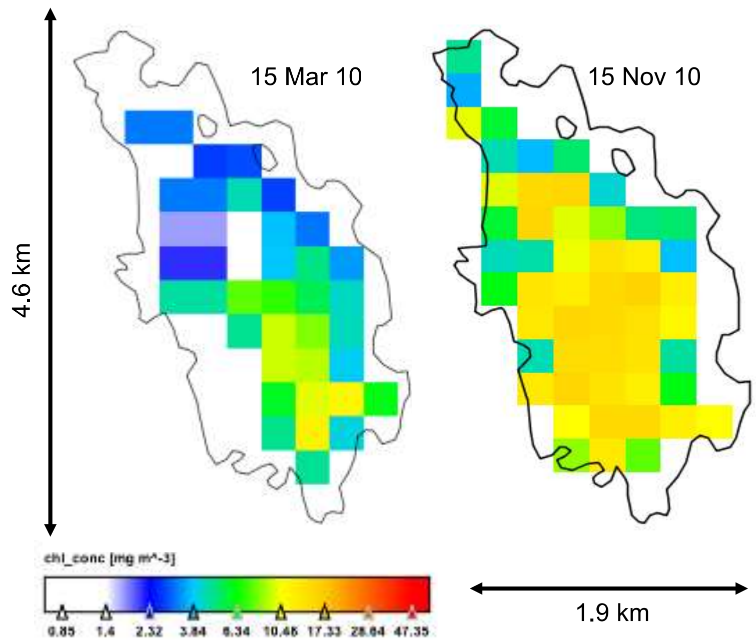
Chla mapped in Lake Balaton using MERIS FR data on 22 Aug 2010

Progress: Algorithms

Validation of MERIS Chla algorithms over UK lakes



Chla concentrations in UK lakes retrieved from MERIS FR data using Boreal Lakes



Chla concentrations in Derwent Water, UK retrieved from MERIS FR data using the Boreal Lakes processor

SUMMARY

WP1: Biogeochemical and lake surface water temperature algorithms for lakes

- WP1 will undertake comprehensive testing of available of atmospheric correction and in-water algorithms
- This will be supported by extensive studies on the source and magnitude of variability in lake bio-optical properties
- Hierarchal approach to validation using modelled, *in-situ* and satellite data for well-studied UK and international lakes
- Construction of globally adaptive ensemble processor primarily for MERIS and Sentinel 3 OLCI
- Estimation of product uncertainties for global population to be built from Level-1 and Level-2 lakes

Thank you

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