climate change initiative

LAKES

Updates from the Lakes ECV

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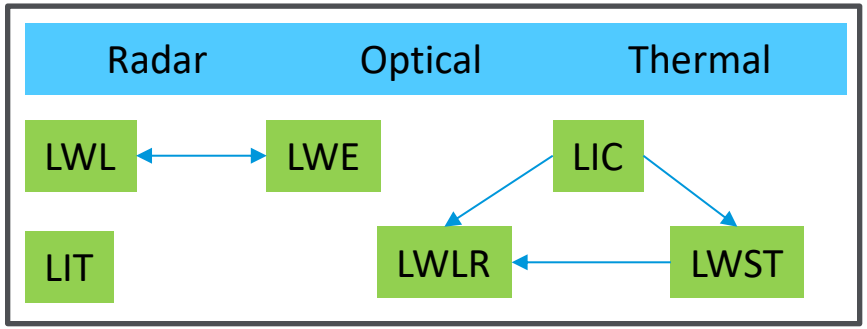
Climate Research Group lead: Claudia Giardino (CNR)
Thematic leads: LWST - Chris Merchant (U Reading), LIC/LIT - Claude Duguay (H2O Geomatics),
LWE - Pierre Thibaut (CLS), LWL – Jean-Francois Cretaux, LWLR – Stefan Simis
Project & System Managers: Bruno Coulon, Beatriz Calmettes (CLS)

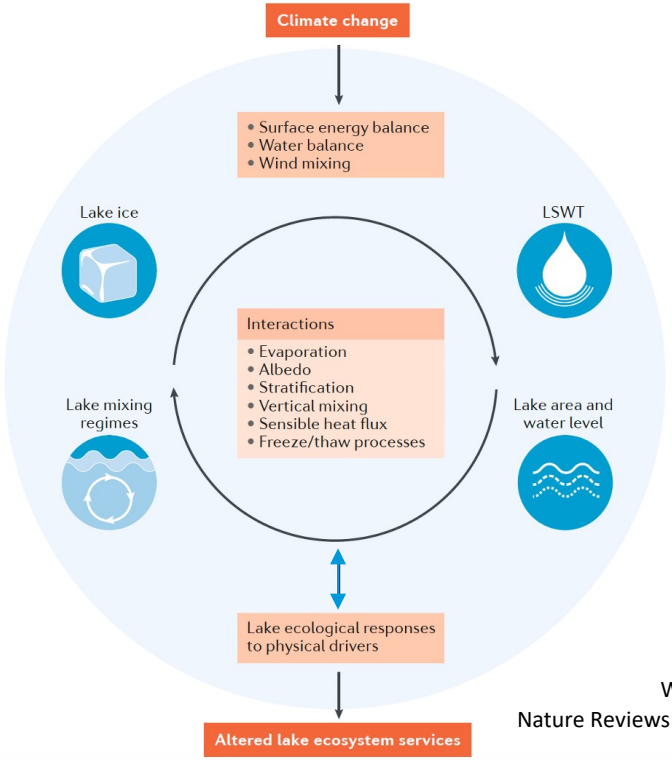
lakes cci

Overview

The Lakes ECV includes **six thematic variables**

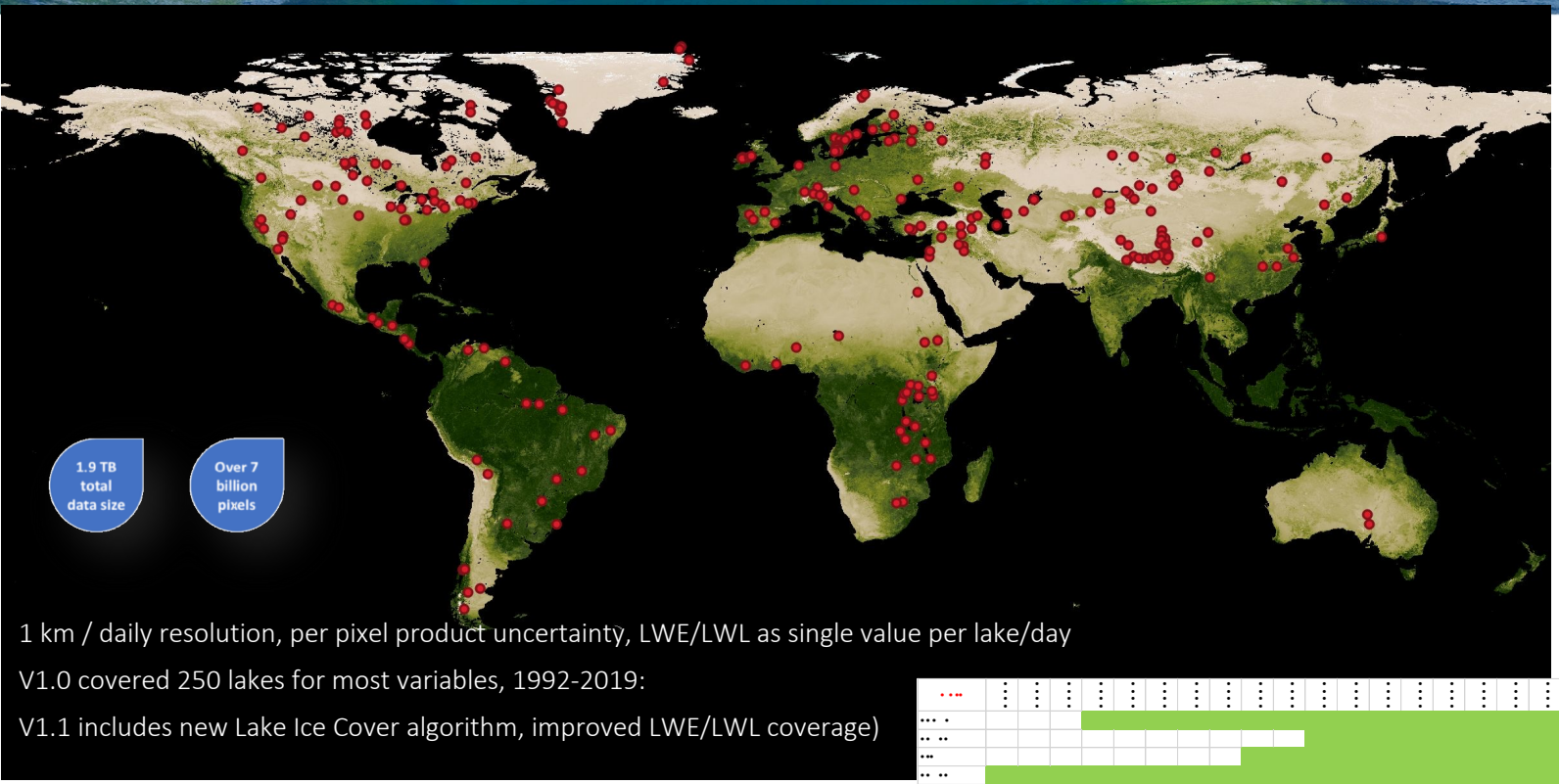
- **L**ake **W**ater **E**xtent & **L**ake **W**ater **L**evel (coupled)
- **L**ake **I**ce **C**over
- **L**ake **S**urface **W**ater **T**emperature
- **L**ake **W**ater-**L**eaving **R**eflectance
- **L**ake **I**ce **T**hickness (developed in 2021)





Woolway *et al.* 2020
Nature Reviews Earth Environment

Spatio-temporal coverage, CRDP v1.0, 1.1



1 km / daily resolution, per pixel product uncertainty, LWE/LWL as single value per lake/day

V1.0 covered 250 lakes for most variables, 1992-2019:

V1.1 includes new Lake Ice Cover algorithm, improved LWE/LWL coverage)

CLS

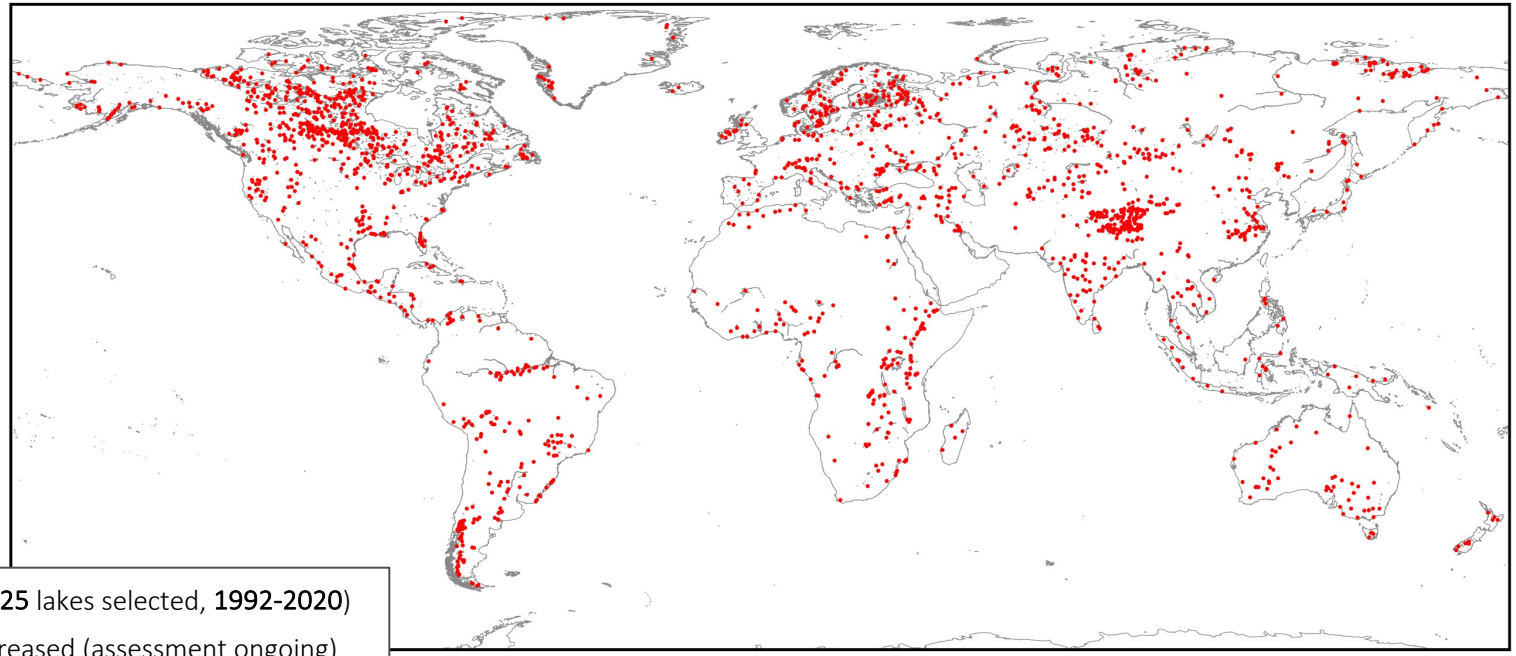
LEGOS

H2O Geomatics

PML Plymouth Marine Laboratory

University of Reading

Spatio-temporal coverage, CRDP v2.0



V2.0 in preparation now (**2025** lakes selected, **1992-2020**)

- LWL/LWE coverage increased (assessment ongoing)
- LWLR 2013-2015 added (largest lakes)

Climate Research Group - Use cases

University of Reading

UNIVERSITY of STIRLING

National Research Council of Italy

Brockmann Consult

Brockmann Geomatics Sweden AB

GeoEcoMar

Thermodynamics in Lakes of Greenland

Understanding mixing water regime

Temperature & biogoechemistry for **large lakes**

LWLR-colour, LSWT over a climatic gradient

Long-term integrative analysis (LTER sites)

Integrating in situ and satellite LWLR, LSWT, LWL data records

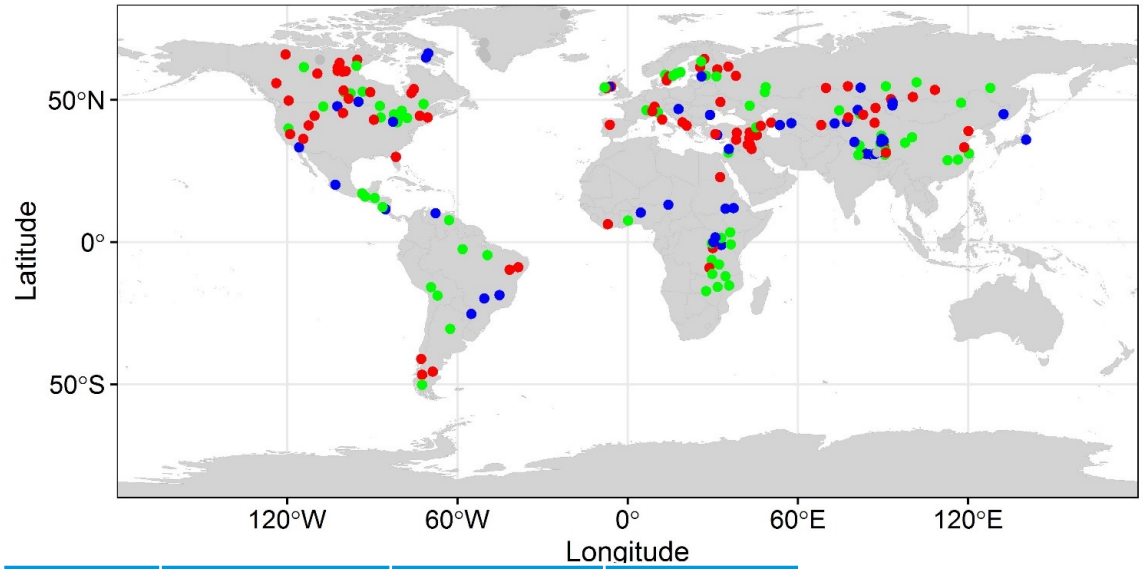
Brownification of lakes in the boreal region

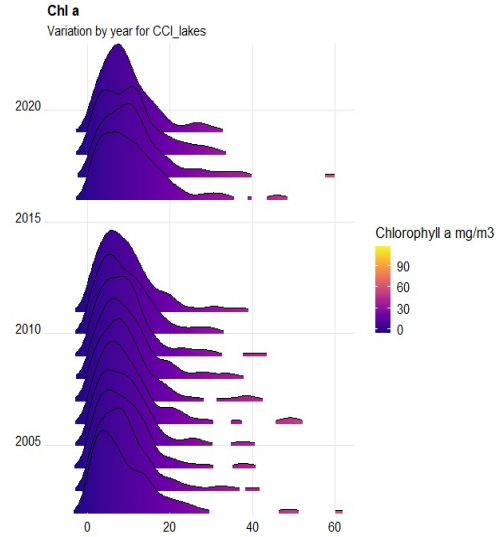
LWLR, LWL, LIC on/off

Understanding a complex **river-lake-lagoon** system

LWLR-biogeochemical products, LSWT in Danube river-lake-lagoon

Global scale trends in CRDPv1.0





Trend	Chla	Turbidity	LSWT
Increase	80 lakes	56 lakes	49 lakes
Decrease	43 lakes	63 lakes	17 lakes
No change	73 lakes	77 lakes	136 lakes

Increase of Chla & turbidity mainly happens in the Northern Hemisphere

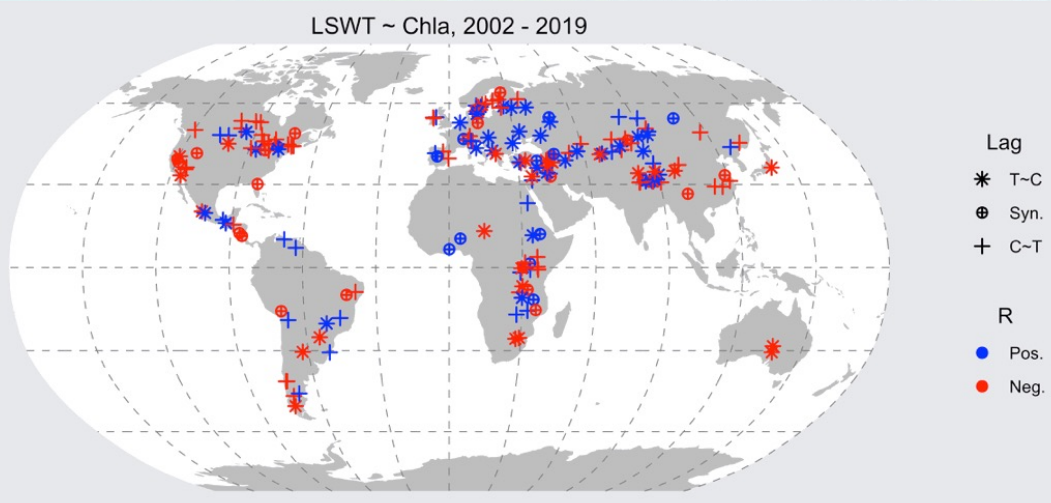
Chl-a & turbidity are relatively stable in African and South American lakes

Global scale trends in CRDPv1.0

Lake Temperature-driven changes in **Lake Colour** products (chlorophyll-a, turbidity) for large lakes.

Ongoing analysis reveals some clustered responses: northern vs southern hemisphere, N-America, continental Europe, East Asia

Attribution? CC, land use impacts on terrestrial runoff and productivity far from uniform, explore links with other ECVs?



Lag

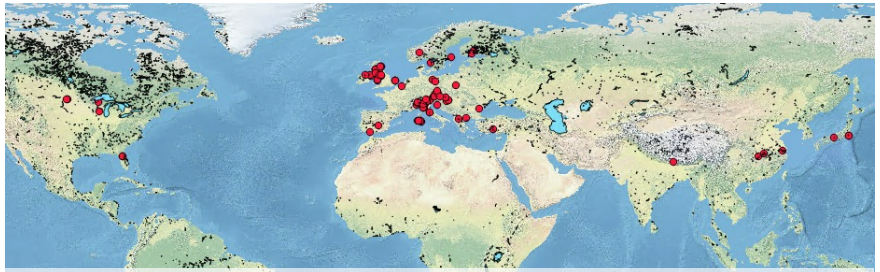
- Chla/turb changes follow LSWT changes
- Chla/turb-LSWT changes are synchronous
- LSWT changes follow Chla/turb changes

59% of lakes show **negative** relationship between LSWT and Chl-a & Turbidity
64% of lakes show **positive** relationship between LSWT and Chl-a & Turbidity

R

- **Pos.:** positive relationship between Chla/turb and LSWT
- **Neg.:** negative relationship between Chla/turb and LSWT

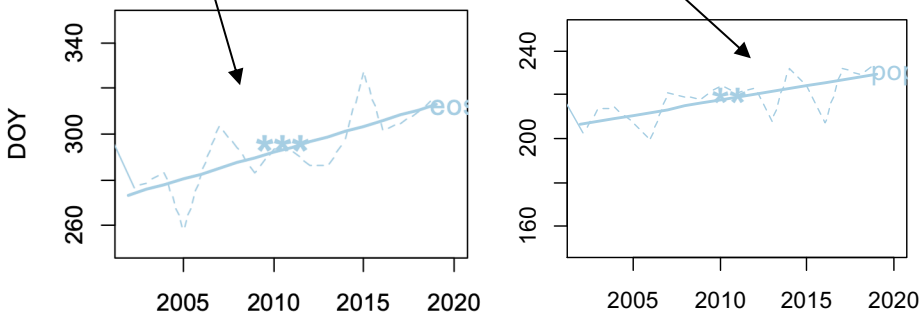
Region-scale change



Phytoplankton phenology in LTER* lakes

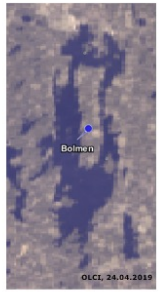
* Long-term ecological research network

Plots of day of year (DOY) against **position of peak** (pop) and **end of season** (eos).
Lake Trasimeno, Italy)

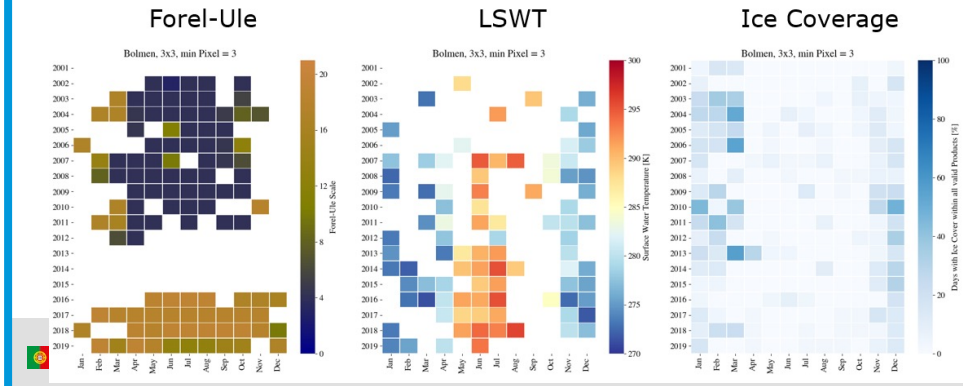


Water colour (FU-Scale) to identify brownification trends in Scandinavian lakes (chelation, snow melt).

Small lakes revealed sensor-dependent adjacency effects not seen in product validation. Corrections developed for v2.



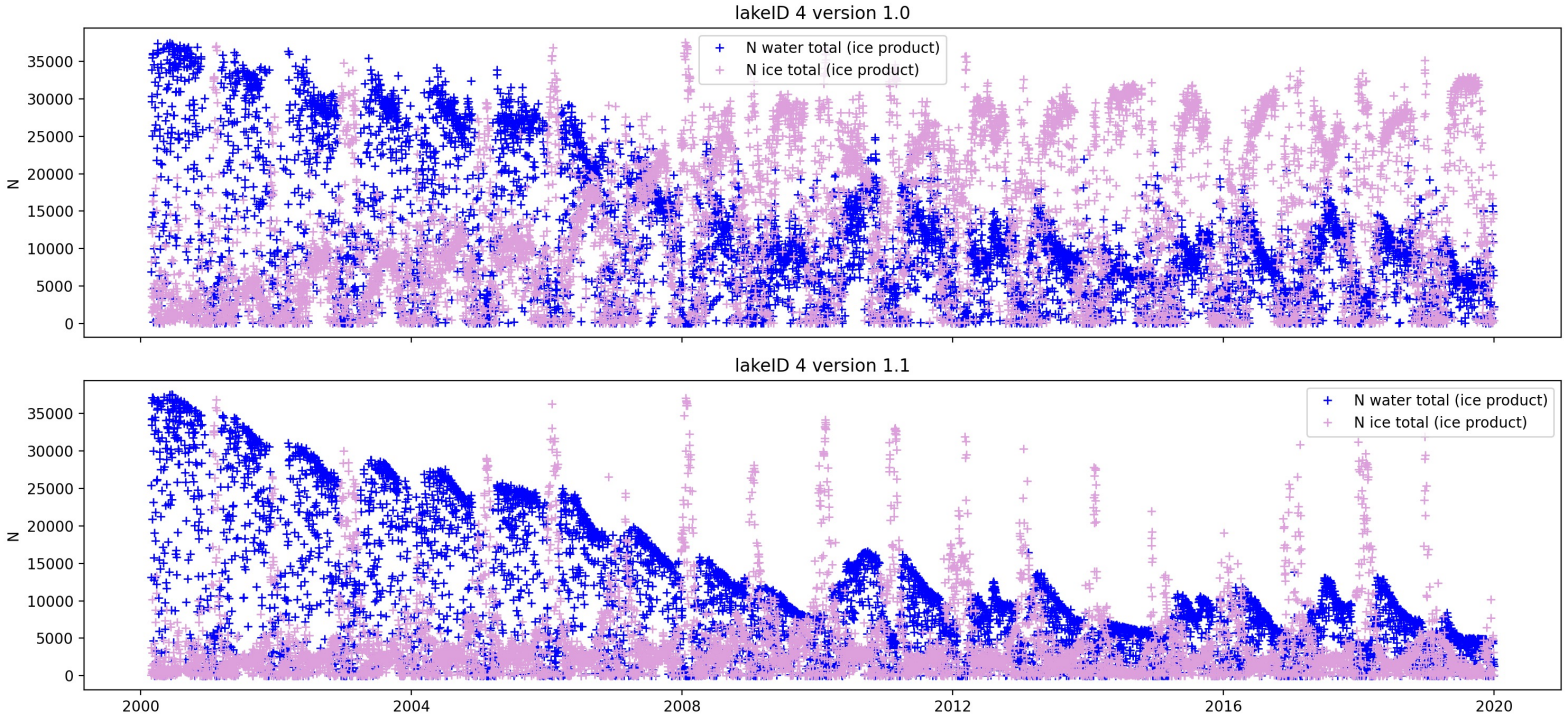
Lake Bolmen (Sweden)



New methodologies: Lake Ice Cover v1.1

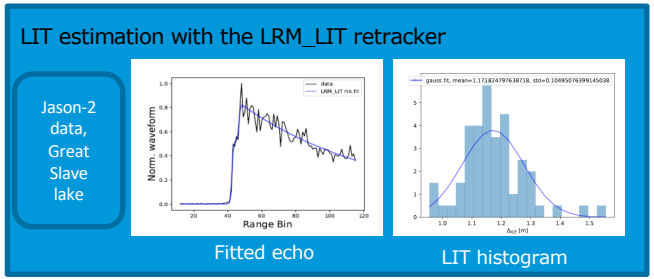
Aral Sea
2000-2020

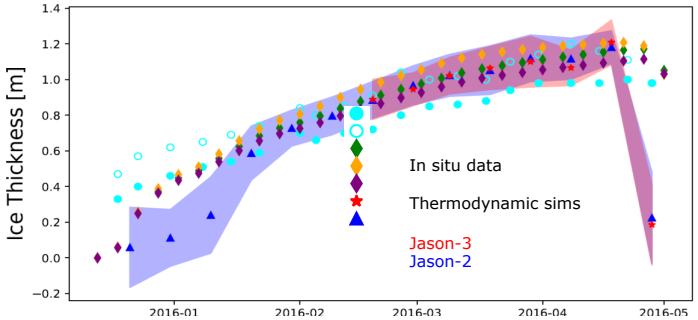
Number of pixels in product as
+ Water
+ Ice

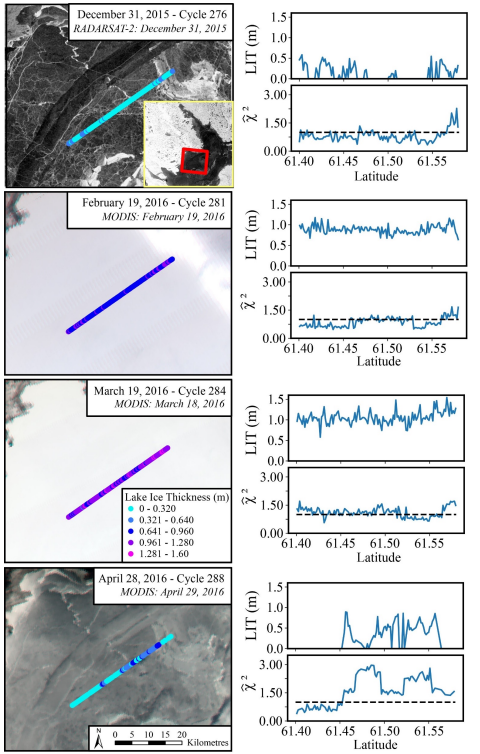


New methodologies: Lake Ice Thickness

- **New retracker** (LRM_LIT) based on the **physical modelling** of the radar waveforms that, over iced covered lakes, show a specific signature related to the double backscattering of the radar wave due to the ice (Mangilli et al. in prep)





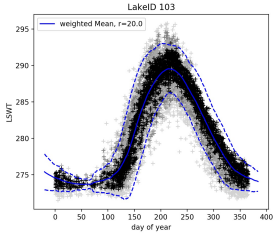


- **Validated** on simulations, consistent estimates from Jason-2/3 over Gr Slave Lake (2013-16)
- **Accuracy ~10cm** for each data cycle (10 days): **significant improvement** with respect to previous analysis
- **LIT radar altimetry estimates** are **compatible with LIT thermodynamic simulations** and **in situ data** and are **consistent with MODIS images** (see figure on the right)
- **Captures seasonal transitions** and the **inter-seasonal LIT variation**

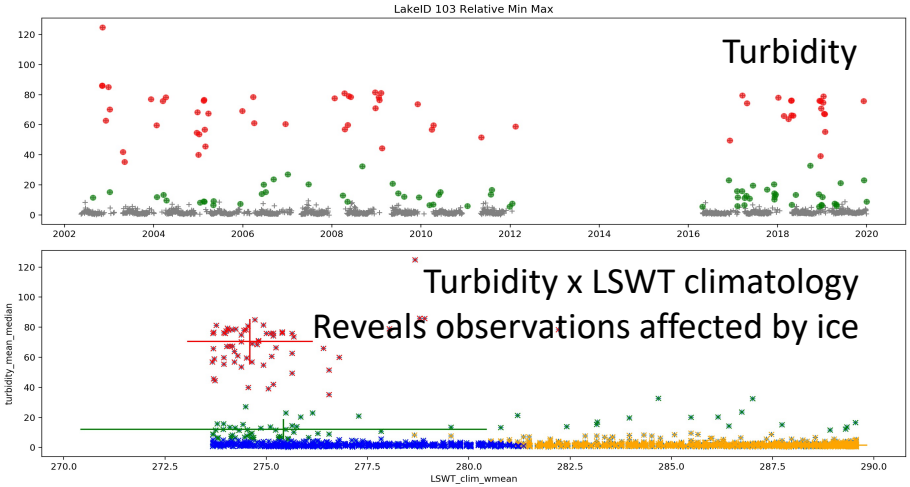
Mangilli, Thibaut, Duguay & Murfitt, TGRS 2021 in prep

New methodologies: cross-ECV quality control

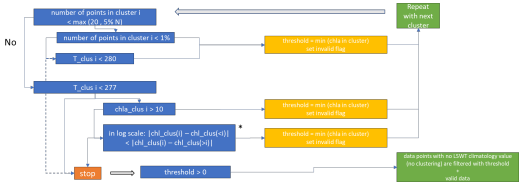
Lake colour product uncertainties (~50%) exceed GCOS targets, can benefit from cross-ECV quality control.



Temperature climatologies



multi-annual clustering



Repeated for each water body

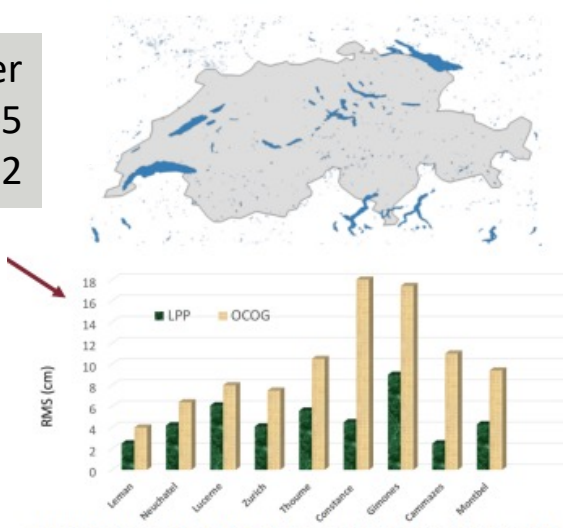
Brockmann Consult

University of Stirling

PML Plymouth Marine Laboratory

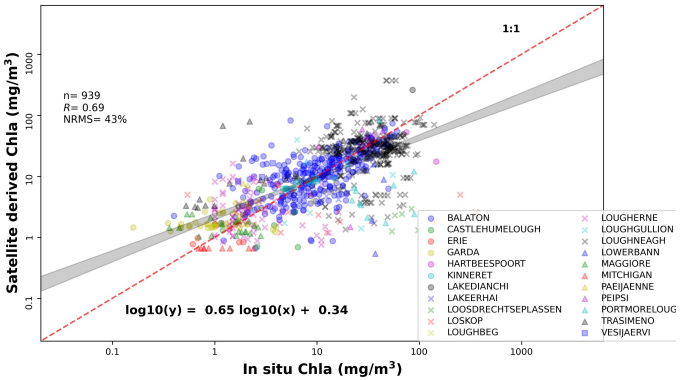
New methodologies: LWL, LSWT, LWLR

Reprocessing of SAR altimetry (incl. peakiness, view angle, and backscatter analysis) improves accuracy of **Lake Water Level** retrieval by factor 2-5 (currently 5-50cm). Implementation -> 2022



Validation of LPP data processing compared to OCOG (V1) with IS data in Switzerland

Lake Surface Water Temperature products upgraded to include MODIS and ERA5



Lake Colour blended-algorithm chlorophyll-a product from Aqua/MODIS fills the current 2012-2016 data gap. Large lakes in CRDPv2. Full release after global validation.

Summary & outlook

- Clear benefits from combining multi-disciplinary tECVs for data quality control and use cases, but tECVs are in varying stages of development which presents a harmonization challenge.

- Strategies identified to improve consistencies between thematic variables.
  - Interdependencies suggest timing of tECV production and CRDP release can be improved

- Current project phase ends Feb. 2022
- New methodologies for LIT and LWL ready to be implemented from 2022

- High user interest, downloads

http://cci.esa.int/lakes