climate change initiative

→ LAKES

Introduction to Lakes CCI

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lakes cci

CLS COLLECTE LOCALISATION SATELLITES · LEGOS · Brockmann Consult · University of Stirling · H2O Geomatics · Sertit ICUBE · TRE Sensing the Planet · PML Plymouth Marine Laboratory · University of Reading · GeoEcoMar · norut Northern Research Institute · National Research Council of Italy

ESA Climate Change Initiative

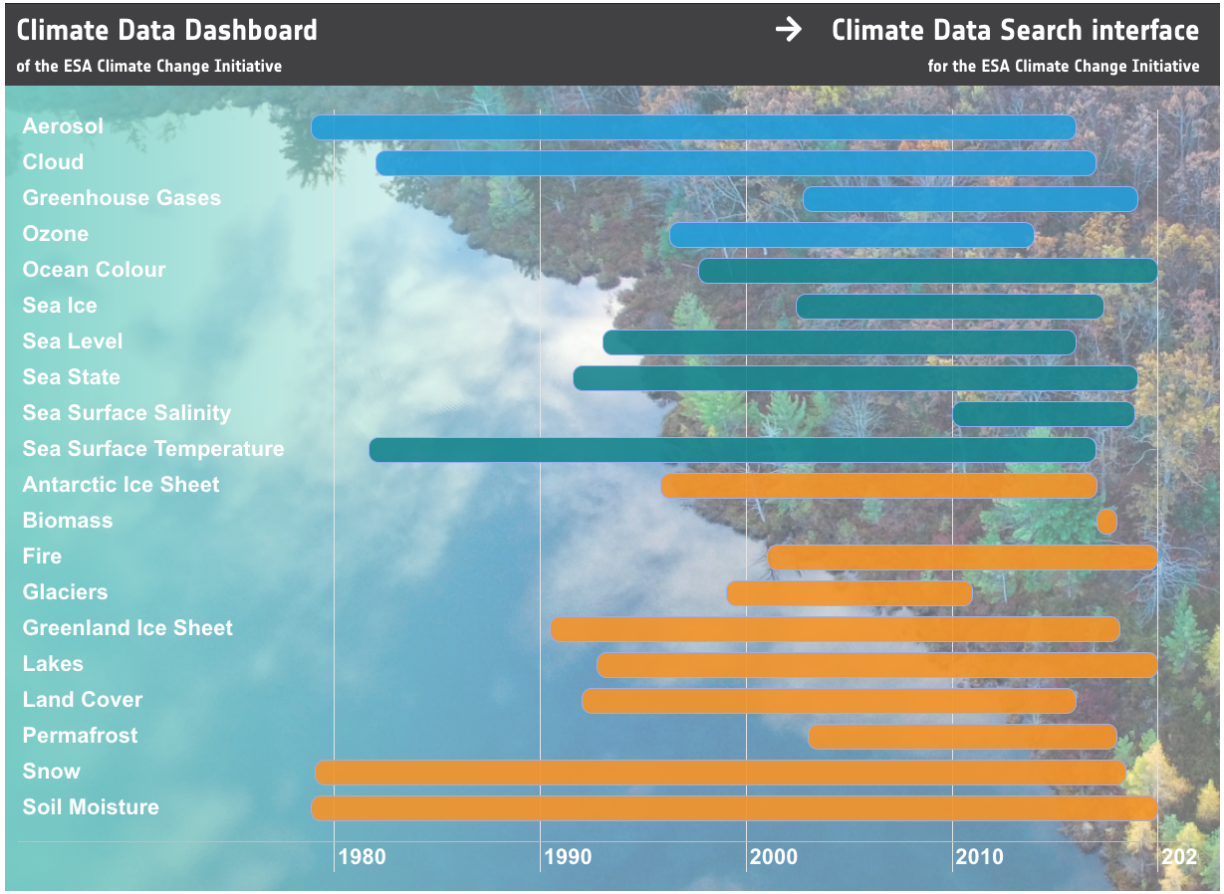
Addresses creation of **climate records** based on EO

Programme covers >20 essential climate variables

Feeds many Copernicus services

Data available freely

https://climate.esa.int/en/odp



Lakes CCI

Objective: consistent, longest attainable time-series for the largest possible number of lakes of "essential climate variables"

30+ instruments considered, combining many technologies:

Lake Water Extent & Level	ERS2, T/P, Envisat, GFO, Jason-x, Cryosat-2, Icesat-1/2, Saral/AltiKa, S3A/B, Jason-CS, SRAL A/B, SWOT
Lake Ice Cover	AVHRR, MODIS A/T, VIIRS, OLCI A/B, C-SAR A/B
Lake Surface Water Temperature	ATSR2, AATSR, Metop-A/B AVHRR, SLSTR A/B, ATSR-1
Lake Surface Water Reflectance	MERIS, OLCI A/B, MODIS A, VIIRS, SeaWIFS

Consistency: Lake selection, common masks/boundaries, output formats (projection, resolutions), product verification

Limitations: Observations are not synchronous, revisiting times differ, there are continuity issues (no-sensor gaps) and newer satellites offer more capabilities

Lake Water Extent & Level

Lake Ice Cover

Lake Surface Water Temperature

Lake Surface Water Reflectance

Scientific challenges

Obtain lake variables from Earth observation with sufficient confidence to address lake-climate interactions

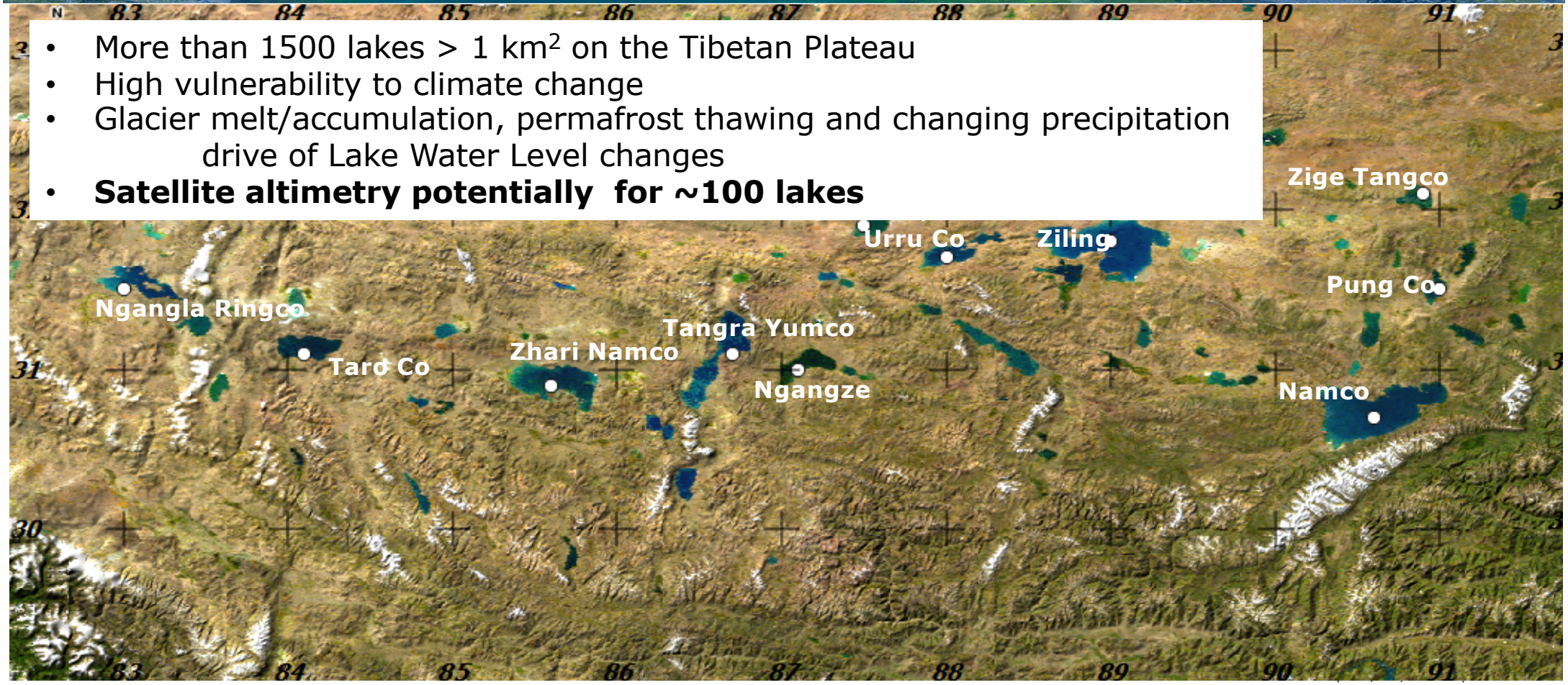
- Water cycle
- Greenhouse gas cycle
- Biophysical processes

Use the data to interpret recent changes and understand the diverse futures of different inland waters

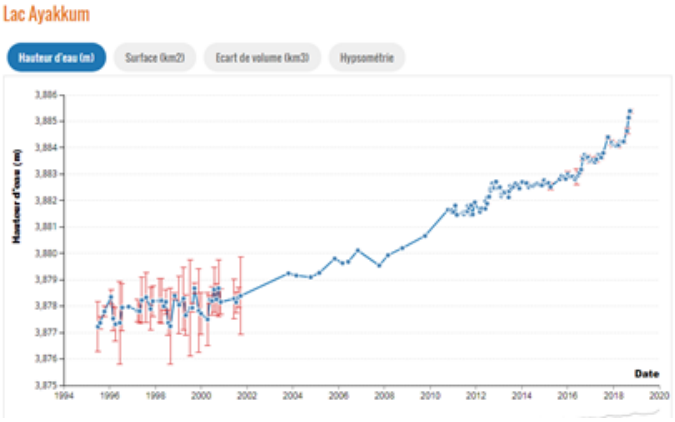
Need for large and long observation dataset to disentangle natural and anthropogenic change

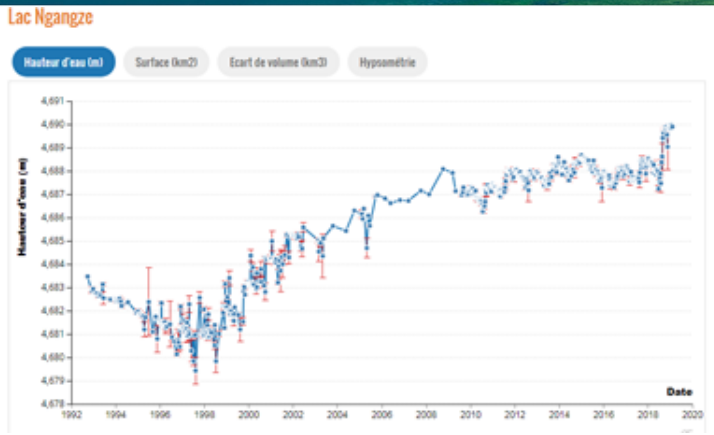
Lakes as sentinels of climate change (Level)

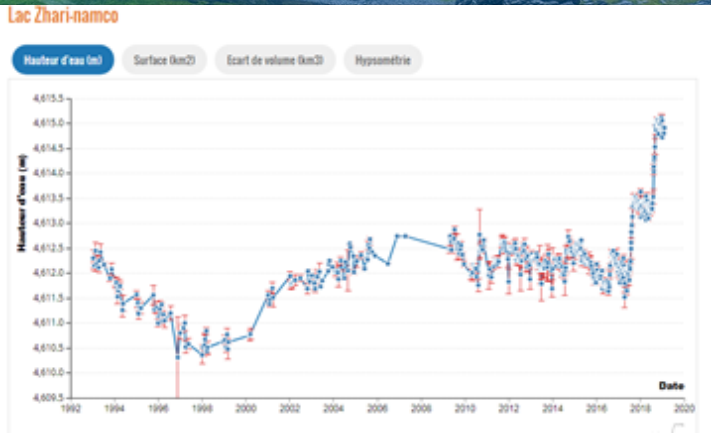
- More than 1500 lakes > 1 km^2 on the Tibetan Plateau
- High vulnerability to climate change
- Glacier melt/accumulation, permafrost thawing and changing precipitation drive of Lake Water Level changes
- **Satellite altimetry potentially for ~100 lakes**

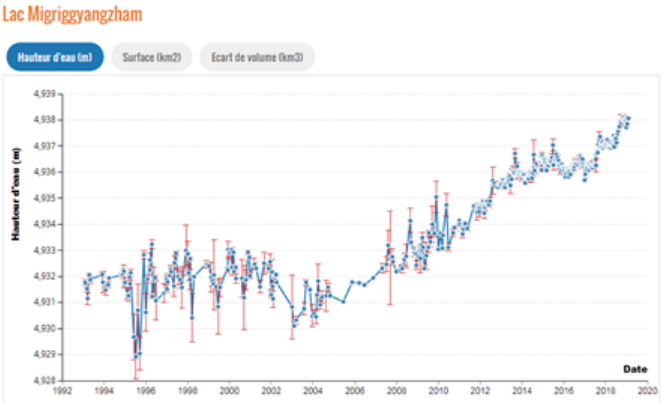


Lakes as sentinels of climate change (Level)









Attributing lake water level variations requires long observation time series.

Commonalities over large areas indicate share drivers (climate variability and change).

Particularities of individual lakes also evident.

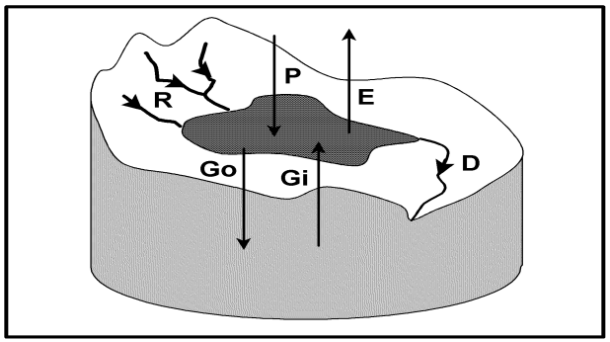
Lakes as sentinels of climate change (Extent)

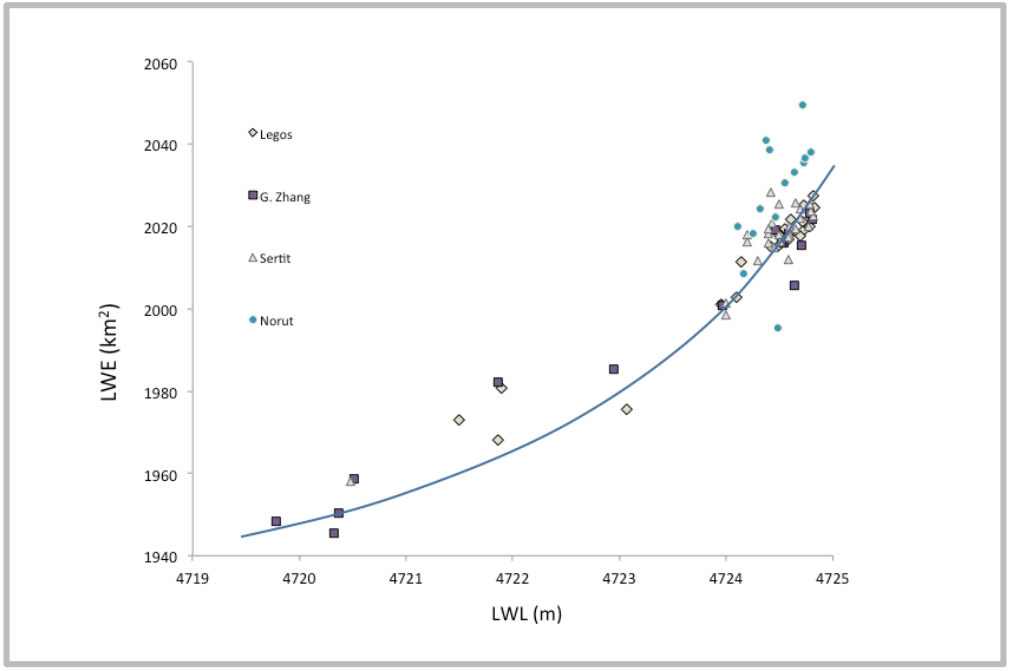
Lakes are buffers in the regional water cycle

Changes in the hydro-meteorological parameters of the catchment will tend towards a new lake equilibrium

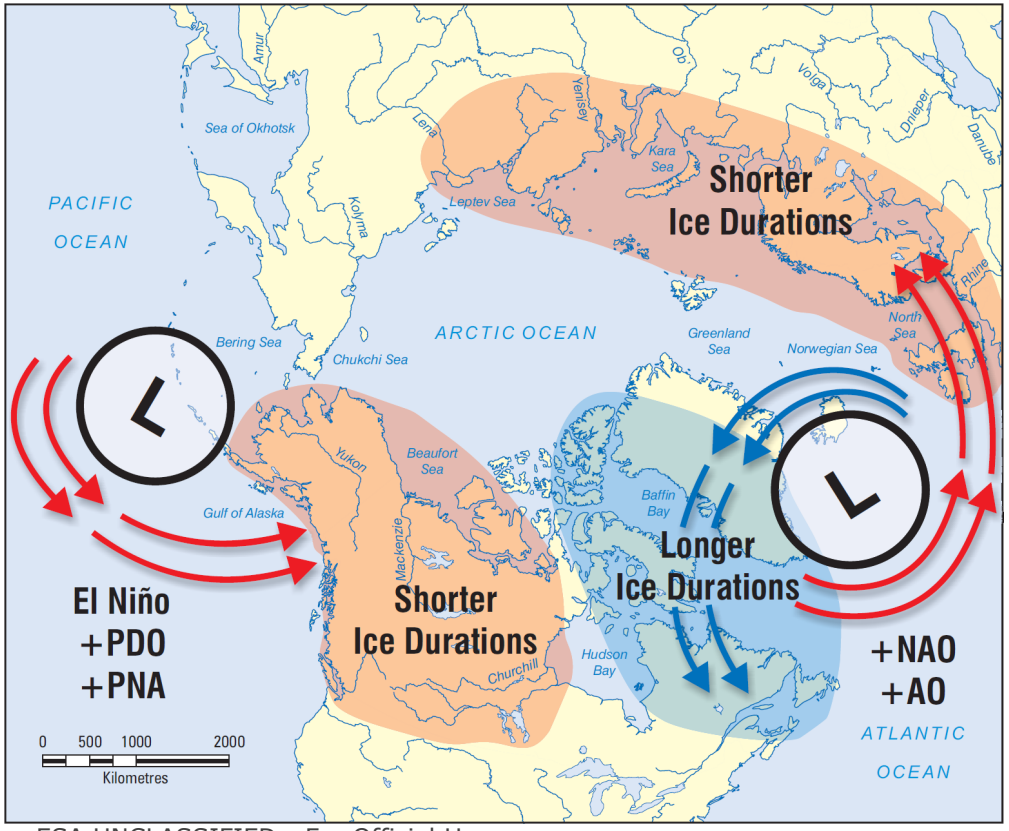
Lake in equilibrium:

Area = Net flow / (Evaporation – Precipitation)





Lakes as sentinels of climate change (Ice cover)



Freeze-up/break-up, (ice duration) are robust indicators of climate variability and change

Ice cover extent/concentration has an important impact on lake-atmosphere interactions

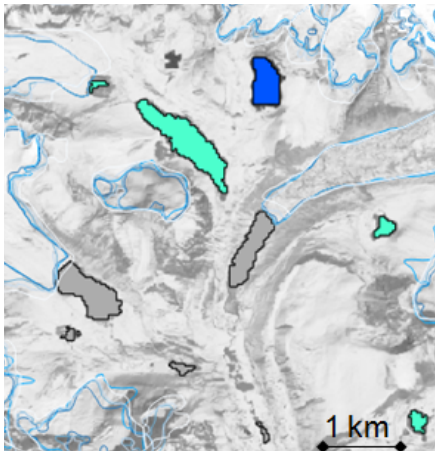
In situ observations of ice freeze/break-up dates have become drastically less common

Ice cover in Lakes_cci using novel combinations of optical, thermal bands and machine learning approaches

Lakes as sentinels of climate change (Colour)

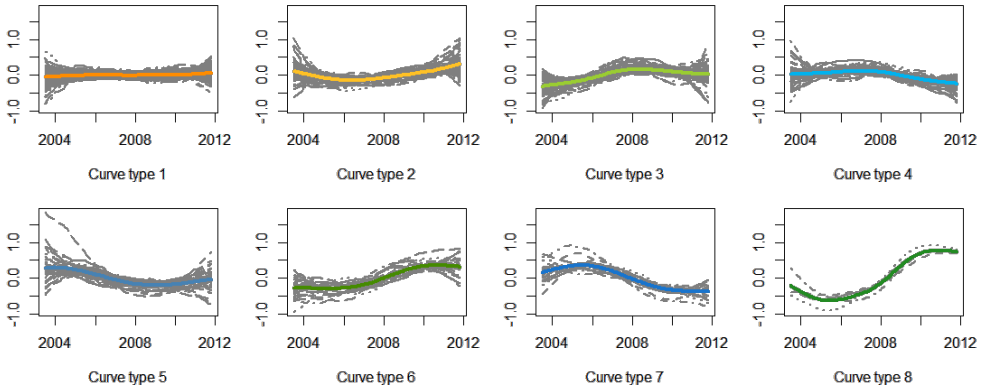
Lake water-leaving reflectance (colour) links the physical, chemical and biological processes

- Heat trapping potential (absorption and scattering of solar irradiance)
- Long term indicators of biogeochemical responses to (changing) physical and hydrological regimes: phytoplankton bloom timing, community shifts, resuspension, terrestrial runoff and glacial melt, eutrophication, brownification. *Long time-series without gaps needed.*



67% increase over 6 years of grey waters in 116 Himalayan lakes (Matta et al. 2014)

Lake biogeochemistry trends (chlorophyll-a)

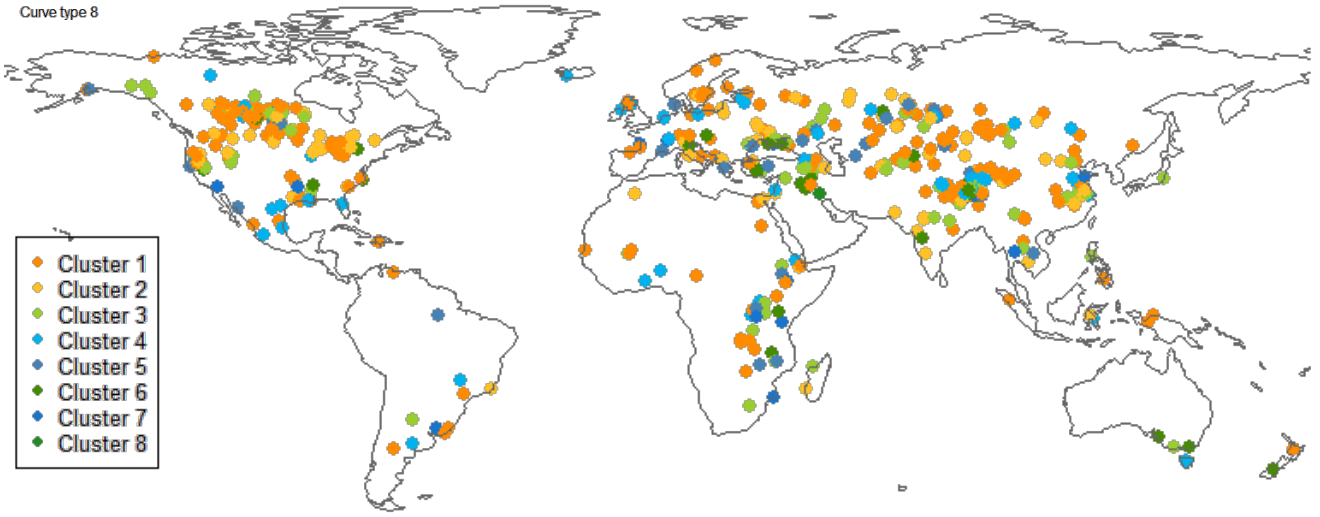


Challenges

- Attribution of change
- *Scarcity of in situ data hampers algorithm development and uncertainty characterization*

little change
generally decreasing
generally increasing

Carvalho et al. *in prep.*
using GloboLakes 10-yr dataset



Apply LSWT to the future of lakes

- Major aspect of lakes function is how the waters mix vertically
- Question: will lake mixing change because of climate change?
- Challenge: EO gives surface, not profile vs. depth

MARCH 19, 2019

Lake 'dead zones' could kill fish and poison drinking water

by University of Reading

Credit: CC0 Public Domain

'Dead zones' could become increasingly common in lakes in future due to climate change, reducing fish numbers and releasing toxic substances into drinking water.

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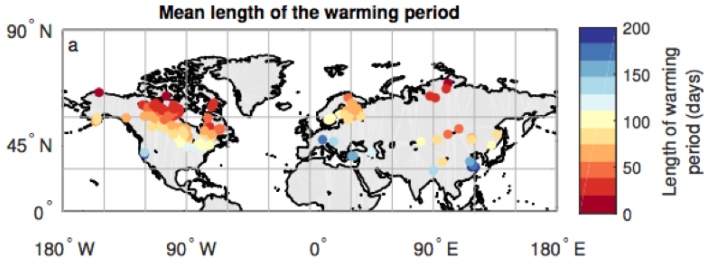
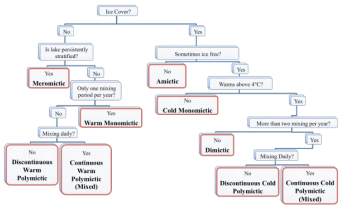
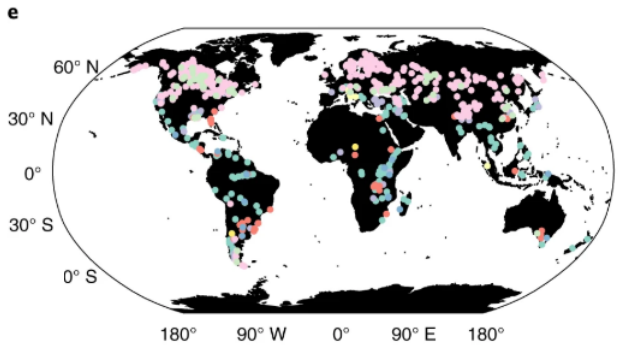
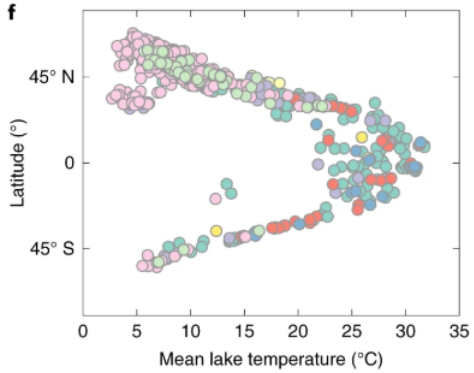
EO data → train model → model the future



FLake Vertical Profile Model
Trained lake-by-lake



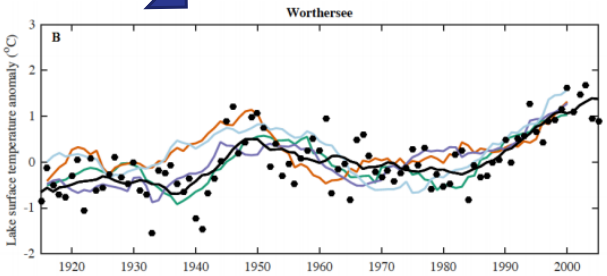




- Meromictic
- Amictic
- Oligomictic
- Cold monomictic
- Warm monomictic
- Dimictic
- Discontinuous warm polymictic
- Discontinuous cold polymictic
- Continuous warm polymictic
- Continuous cold polymictic

Trained model predicts current mixing-type of lake with high accuracy

Trained model reproduces centennial changes



100 year timeseries

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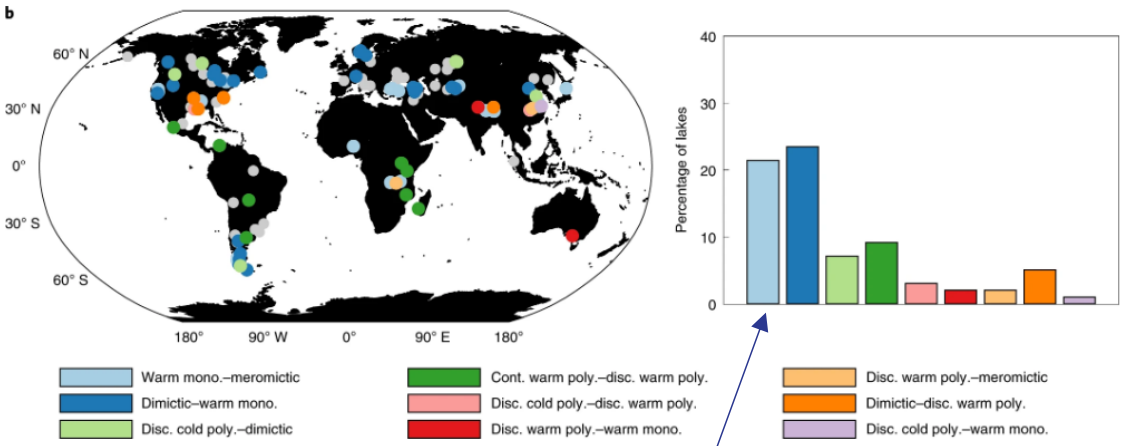
Many lakes in future will mix less



Second most common change is that lakes stop mixing, putting their ecosystem functioning at risk

Projections: **reduced ice cover** (25% to become ice-free by 2080–2100). Surface **waters warming** by about 2.5°C and up to 5.5°C. 100 out of 665 lakes will undergo **changes in mixing regime**, with 25 becoming permanently stratified.

Woolway and Merchant,

Nature Geoscience, 2019

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Please interact with us, not just our data

Lake CCI v1 data released this year (2020)

Individual data streams + an “all variable” collection

ESA Open Data Portal https://climate.esa.int/en/odp

We welcome feedback on experiences using our data as we work towards creating v2 next year

- data strengths and weaknesses
- formats, download, technical requirements
- science results

If you use the data, cite the papers!

User feedback contact:

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Do you have data you might share for validation? 👍🏽

Complete list of contacts:

https://climate.esa.int/en/projects/lakes/contacts/