# ESA CCI+ Phase 2 – Land









Shaun Quegan, Emilio Chuvieco, Pierre Defourny, Lorenzo Bruzzone, Jean-Francois Cretaux, Darren Ghent, Wouter Dorigo, Christiaan van der Tol

## Colocation Meeting - 26 October 2022

# Biomass

## Science Objectives

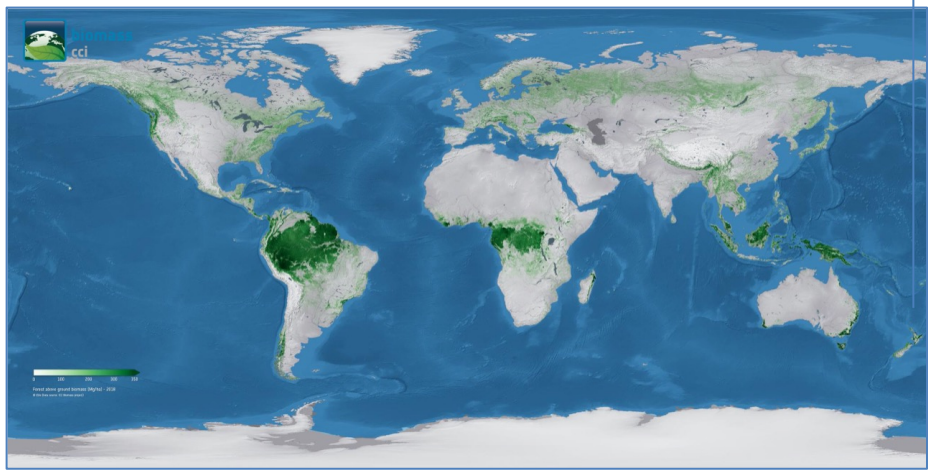
**Measuring forest biomass and its changes**

- exploiting in carbon and climate models
- supporting national reporting to UNFCCC

**Production of AGB products with associated standard error:**

- For epochs 2005/7, 2010, 2015/6, annually for 2017-2022, ensuring consistency.
- With development of algorithms for change products between these epochs together with uncertainty.

AGB at 100m resolution for 2018



**CEOS-led harmonisation of multiple AGB maps**

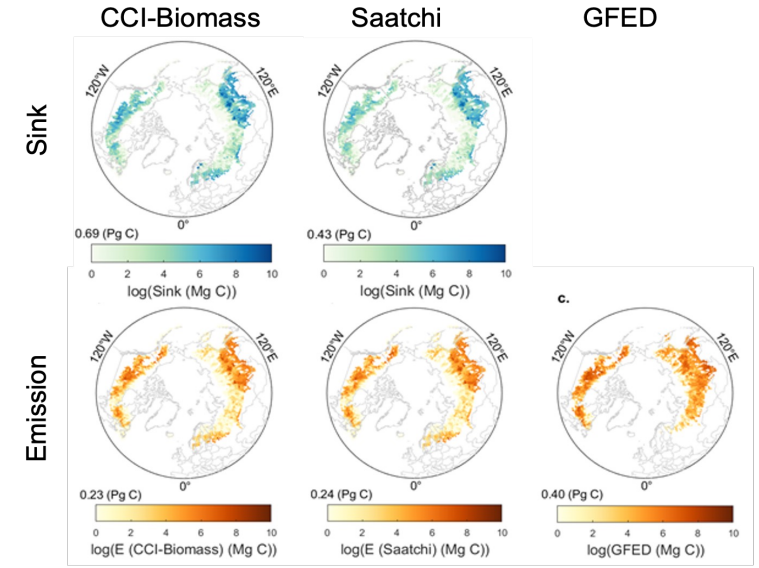
- Open science activity on ESA/NASA Multi-mission Algorithm Analysis Platform
- Prototype presented at COP26

**User exploitation in carbon modelling**

- comparison of carbon emissions and subsequent sink due to fire in the boreal region from 1985-2020 (CCI left, Saatchi AGB middle, GFED right)

post fire sink

emissions due to fire

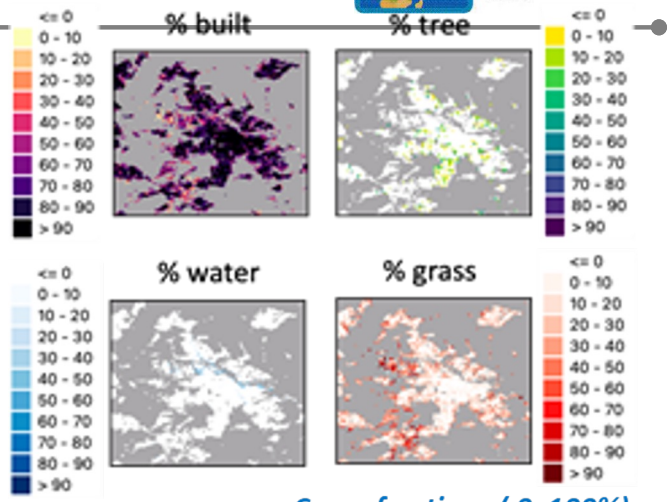


# Land Cover

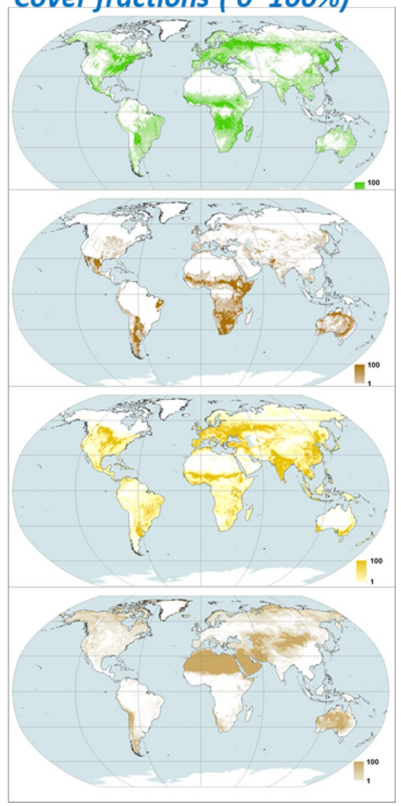
UCLouvain LSCE Met Office Hadley Centre Brockmann Consult GmbH land cover cci

- CCI+ aims to
  - Develop a brand new PFTs time series for climate models matching new GCOS requirements
  - Integrate all existing high resolution global LC data harmonized thanks to MRLC time series
  - Enhance the awareness of MRLC users community
- Key Outcomes
  - **New 29-year time series of annual Plant Functional Type** (PFT) fraction maps (pixel quantification at 10-30 m describing each 300m cell) and model impact assessment
  - End-to-end **uncertainty budget** at pixel level (from L0 data to land class level) using S3 time series
  - Assessment of **LC impact on LST** in the context of urban area heat island mapping using VHR LC

➡ Roadmap towards **harmonization of land ECVs**




*Cover fractions ( 0–100%)*



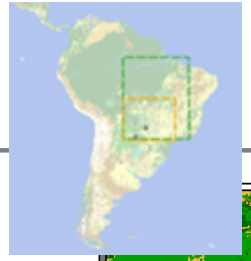
**4 TREE PFTs**
broadleaved deciduous/evergreen, needleleaved deciduous/evergreen

**4 SHRUB PFTs**
broadleaved deciduous/evergreen, needleleaved deciduous/evergreen

**2 GRASS PFTs**
natural, managed (herbaceous crops)

**4 ABIOTIC PFTs**
inland water, permanent snow & ice, bare soil, built

# HR Land Cover



high resolution land cover cci

## Main Science questions

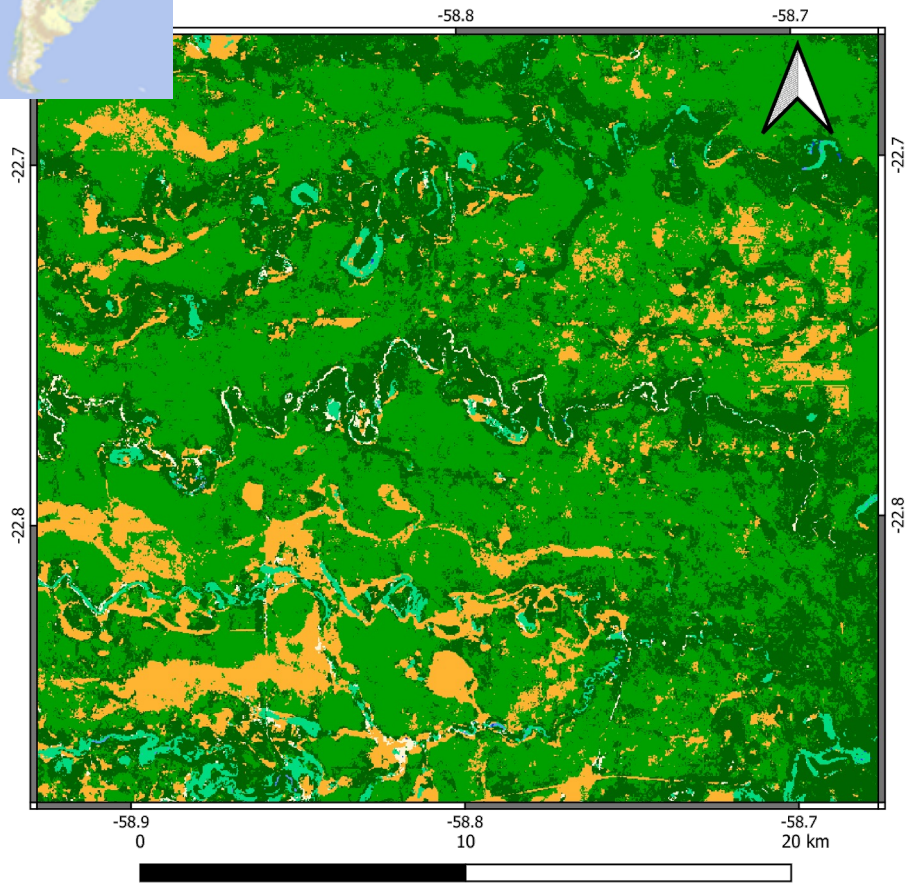
- Understand the role of land cover spatial resolution in climate modeling and research..
- Studying LCC in key regions exposed to extreme climate conditions or characterized by significant climate changes over the last decades.
- Understanding classification variability across spatio-temporal scales.

## Products:

- Generate reliable regional products at high spatial resolution.
- A static HRLC map at 10m for 2019 at subcontinental level as reference static input to the climate models.
- A time series of regional HRLC maps at 30m in the sub-regions every 5 years (2019 and 1990).
- The change information at 30 m on a yearly scale.

## Use cases:

- Siberia: Impacts of CC on northern displacement of the forest-shrubs-grasslands-transition zone, fate of permafrost carbon.
- Amazon: Impacts of deforestation, fires, agricultural expansion on water and carbon cycles changes.
- Africa: Impacts of CC on drought/flood events, West Africa and Indian Monsoon dynamics, mitigation studies (e.g., Green Belt).



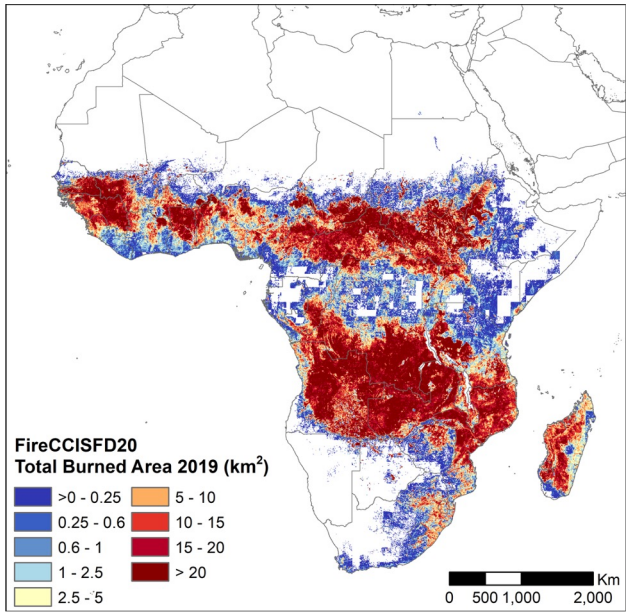

Regional HRLC in a deforestation area of Amazonia in the period 1990 – 2019.

## R&D topics:

- Design machine learning methods dealing with both nowadays large data volumes and sparse historical data.
- Guarantee temporal, seasonality and change coherence in time.
- Establish validation and intercomparison paradigms for HRLC.
- Update climate models to absorb HR products.

# Fire

- CCI+ aims to understand better fire trends and impacts by comparing coarse (MODIS - S3) and fine (S2) resolution burned area products.
- In addition, global BA algorithms are adapted to S3 SYN data and active forest from VIIRS and S3.
- Historical BA will be retrieved from Landsat-S2 data in three sites (coincident with HRLC CCI). Relations with land cover change (particularly deforestation and degradation).
- Merging of existing global BA products will be carried out to obtain a user-oriented single BA dataset.

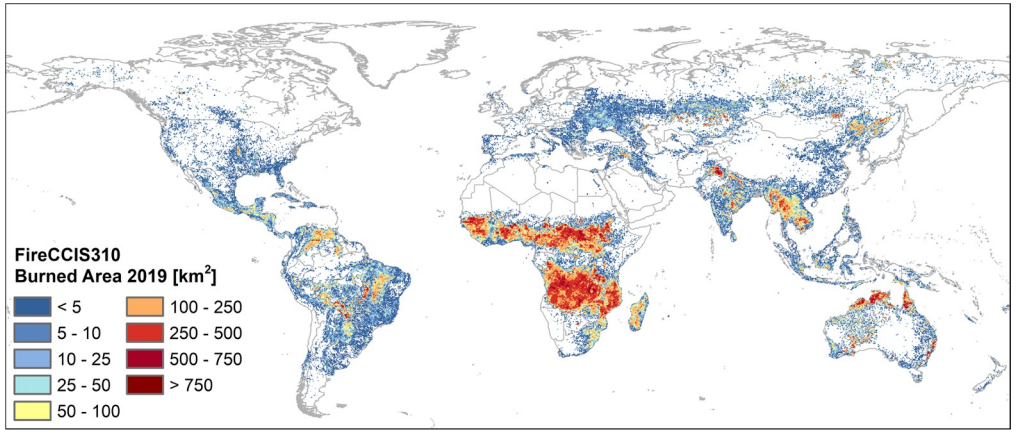



Burned area in 2019 from S-2 (Chuvieco et al., 2022, STOTEN)

80% more BA than FireCCI51 (based on MODIS 250 m)
120% more BA than NASA MCD64A1 (based on MODIS 500 m)

| Product | OE [%] | CE [%] | DC [%] |
|---|---|---|---|
| FireCCISFD20 | 8.5 | 15.0 | 87.7 |
| MCD64C6 | 56.5 | 21.1 | 56.0 |
| FireCCI51 | 52.2 | 25.1 | 58.4 |

Significantly better accuracy than existing global BA products




First Burned area product from S-3 SYN data and VIIRS active fires (2019): Lizundia-Loiola et al., 2022, RSE

# Vegetation

**Goal**: Long term, multi sensor product of FAPAR (-> plant productivity) and LAI (-> foliage density)

**Application**: for climate reanalysis, phenology, improving LSMs, study of extremes

**When**: March 2022- Febr 2025

**Key questions**

- Less sensor dependence -> consistency
- More direct link with photosynthesis
- Temporal resolution good enough to detect anomalies, seasonal phenology?

**Cycle 1 (2022-2023)**

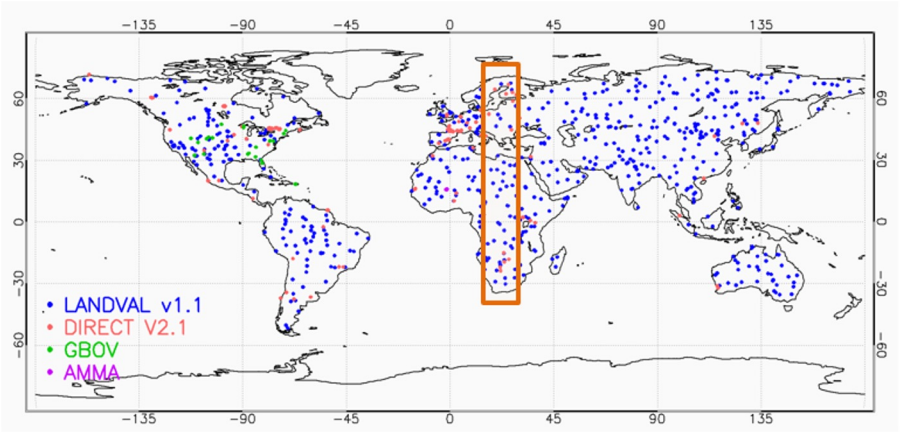
- Full 4-strm RT inversion versus albedo-TIP?
- Uncertainty budget from TOA -> product (error matrices)
- Inclusion of soil, snow residual cloud in inversion

**Cycles 2 & 3 (2023-2025)**:

- Progressive increase in # sensors
- science application:
  - phenology
  - test use in land surface models
  - synergy with SIF and stress indicators (formaldehyde), …

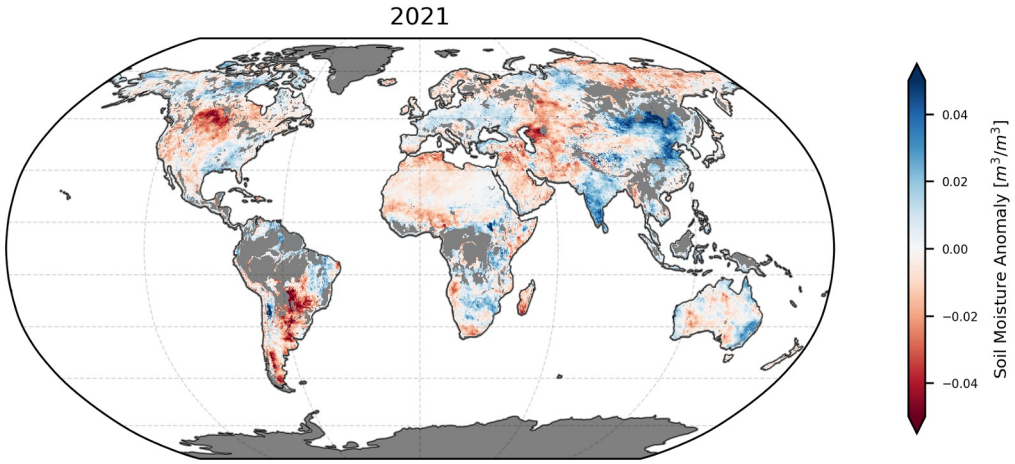
| Name | Cycle | Resolution | Sensors | ROI | Period |
|---|---|---|---|---|---|
| TDS-1 | 1-3/23 | 1000 m | SPOT4/5-VGT1/2, PROBA-V, Sentinel-3 OLCI | Selected sites | 2019 |
| CRDP-1 | 1 2/23 | 1000 m | SPOT4/5-VGT1/2, PROBA-V, Sentinel-3 OLCI | Selected sites + transect | 2000-2020 |
| CRDP-2 | 2 3/24 | 1000 m | SPOT4/5-VGT1/2, PROBA-V, Sentinel-3 OLCI, Metop-A/B/C-AVHRR, VIIRS | Selected sites + transect | 2007-2020 |
| TDS-2 | 2 3/34 | 300 m | (1) Terra/Aqua-MODIS, Envisat-MERIS (2) Terra/Aqua-MODIS, PROBA-V, Sentinel-3 OLCI | Selected sites + transect | 1 year |
| CRDP-3 | 3 3/25 | 1000 m | Selected from: SPOT4/5-VGT1/2, PROBA-V, Sentinel-3 OLCI, Metop-A/B/C-AVHRR, VIIRS | Global (*) | 2000-2020 |
| CRDP-4 | 3 3/25 | 300 m | Selected sensors from: Terra/Aqua-MODIS, Envisat-MERIS, PROBA-V, Sentinel-3 OLCI | Global (*) | 2000-2020 |

**Potential lines (Cycles 2-3)**
Green FAPAR?
Pigments?
TROPOSIF?



# Soil Moisture

At CCI+ Phase 2, we aim to respond to the needs of the climate modelling community, by: 1) providing fully model independent and gap-free data 2) improving the uncertainty estimate on SM 3) verifying the long-term trends of our products




## R&D topics in CCI+ Phase 2

- Seasonal adaptation of Triple Collocation theory (error characterisation)
- Algorithmic uncertainty characterisation
- Filtering of brightness temperature outliers in input data
- Model independency. Merging of (L-band) brightness temperature datasets in one rescaling reference
- Trends in products and agreement with reanalysis

## Upcoming CCI+ Phase 2 products:

- Continued: ACTIVE, COMBINED (break-adjusted), PASSIVE (v08.1, April 2023; v09.1, April 2024)
- New: Gap-filled COMBINED (v08.1, April 2023)
- New: L-band rescaled COMBINED (v08.1, April 2023)
- New: Fully model-independent COMBINED (v09.1, April 2024)
- New: 0.1° resolution PASSIVE, ACTIVE (v09.1, April 2024)

## Use Cases

- SM uncertainty from CCI SM will be used in SM assimilation in Land Surface Models
- An across scales study will be performed to assess the ability of data sets with different spatial resolutions (CCI SM 0.25º, 0.1º interpolated products, high resolutions 1 km products) to detect extreme events possibly related to climate impacts

# LST

land surface temperature cci

## Main science aims in CCI+ Phase 2

- Meeting the new ECV GCOS requirements in the 2022 IP
- Improving the long-term stability of our products, particularly for our multi-sensor CDRs
- Increase interaction on cross-ECV activities, and with climate services

## R&D topics in CCI+ Phase 2

- Intercalibration of level-1 data for CDRs
- Time difference corrections for multi-mission CDRs
- Consistency across all LST ECV Products for retrievals, uncertainties, and coefficient generation
- Developing first climate quality LST at high spatial resolution (<100m)
- Optimisation of best cloud clearing detection across new sensors
- Development of first climate IST product over sea-ice

## Upcoming CCI+ Phase 2 products:

- Extensions of existing products to end 2023 (ATSRs, SLSTRs, MODIS, SEVIRI, GOES, SSM/S & SSMIS
- Long-term time series from AVHRRs from the 1980s to present
- Global LST CDR from ATSR through to SLSTR with length of 28 years
- Time series from AMSR-E and AMSR-2 with length of over 21 years
- New products for Himawari and VIIRS

## Use Cases

- Investigate the feasibility of a satellite moderate temperature extremes data set to supplement the HadEX3 dataset
- Impact of ESA LST_cci IST products on the Arctic Copernicus Marine Service (CMEMS) SST/IST product
- Investigating the diurnal heating and cooling of cities, using LST data retrieved from high resolution IR sensors
- Comparison between LST and reanalysis ‘skin’ temperature time series

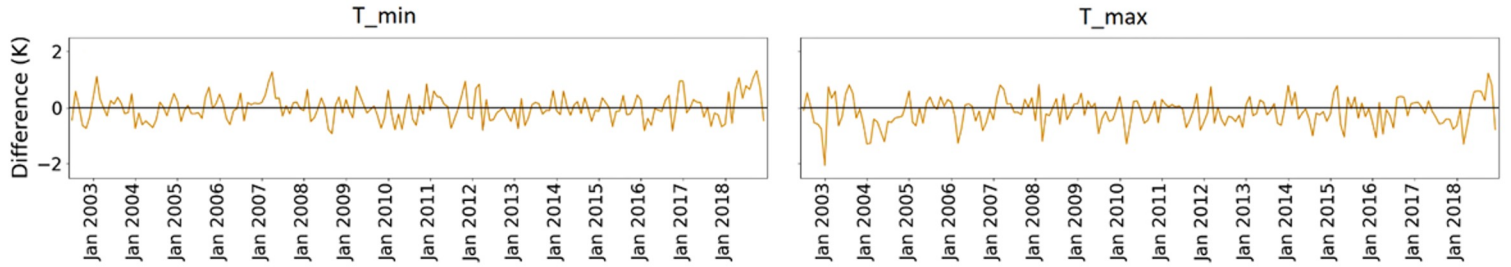



Figure: LST_cci anomalies for Aqua-MODIS compared with homogenised near-surface air temperature anomalies

# Lakes

## Main Science questions in phase-2

Improve ECV uncertainty assessments vs new GCOS requirements

Enhance interaction with climate research / limnology / cross-ECV activities

Assess potential for Coloured Dissolved Organic Matter, Lake Volume Change, light extinction

## R&D topics

Application of new methodologies for **Ice Thickness** and **Water Level**

Sentinel Lakes of Sub-Sahelian Africa

Computing efficiency of Lake Colour processing (sustainability)

## Product updates:

Expand the time series, keeping the same lakes

Condense Lake Colour variables for time series consistency

Introduce **Lake Ice Thickness** for a subset of lakes

Improve **data access** for single lakes/regions

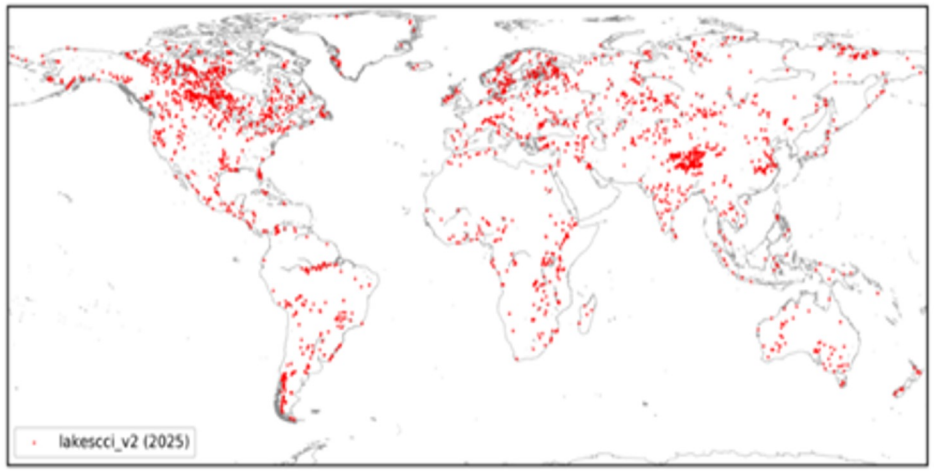
Additional **quality/confidence flags**

## Use cases

1)Heatwave and storm event impact on lakes

2)Water quantity in relation to water quality in a changing environment

3)Aggregate climate indicators for the global lakes dataset (link to policy)




2024 lakes (2000-2022)

**2023: V2.1.0**

**2025: V3.0.0**