TOWARDS AN INTERGENERATIONAL

OPEN GEOSPATIAL CARBON REGISTRY (OGCR)

EO for Monitoring, Reporting, and Verification of Carbon Removals 2025

Copenhagen, Denmark

9th October, 2025

Funded by the European Union

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Dr. ICHSANI WHEELER
FOUNDER/RESEARCH COORDINATOR
OGCR PROJECT COORDINATOR

Summer Schools 2007 → OpenGeoHub Foundation

Open Geospatial Carbon Registry

- 15+ summer schools
- 20+ tailored trainings
- 10+ hackathons
- 1000+ hours of teaching & video archive
- 3000+ students

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OGCR Project partners

Open Geospatial Carbon Registry

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GFZ
Helmholtz Centre for Geosciences

IIASA

EEB
European Environmental Bureau

Institute for European Environmental Policy

Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

UNDO
PUTTING CARBON IN ITS PLACE

RACE.

INVESTING IN REGENERATIVE AGRICULTURE AND FOOD

1495
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Food Water Wellness Foundation

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MultiOne

Project consortium

Open Geospatial Carbon Registry

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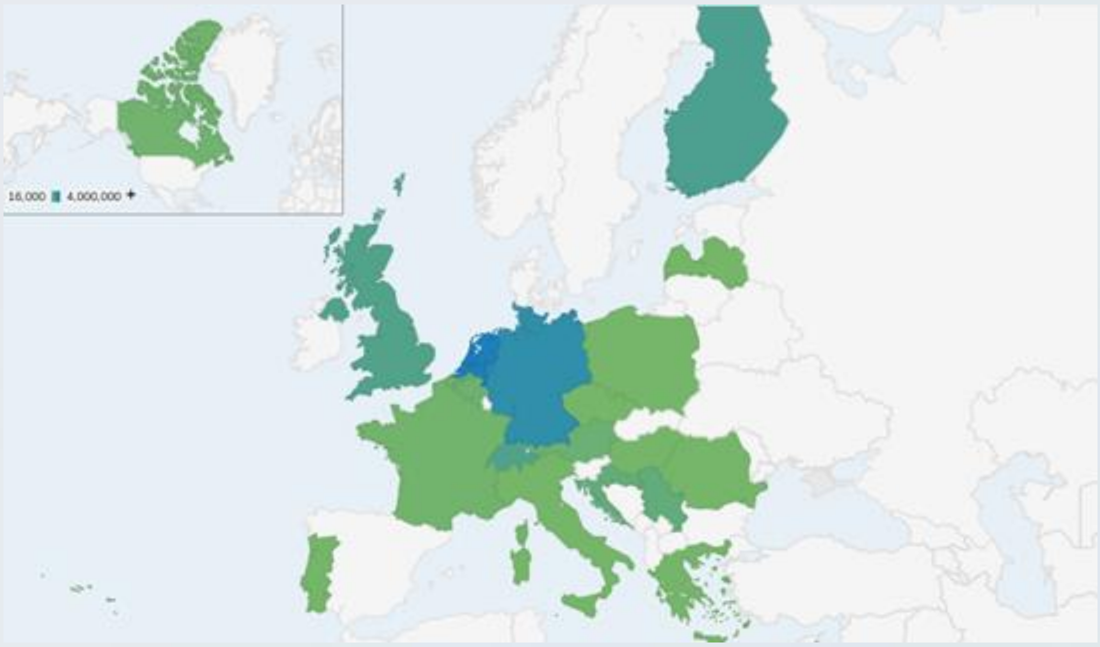


OGCR in a nutshell → Three working areas

Open Geospatial Carbon Registry

1

Carbon Farming

2

Carbon Products

3

~~Permanent~~ Centennial Carbon Removals

OGCR in a nutshell → Participatory Tier 3 (all land)

Open Geospatial Carbon Registry

1. To provide a low-cost / easy access system, which connects the 9.1m farmers & forest managers

2. To build an open-source, FAIR & CARE-compliant MRV ecosystem from parcel to continental scale

3. To provide unified frameworks for <u>all</u> major carbon farming categories, with uncertainty calculations, to standardise carbon removals / reductions

4. To support a just transition for rural communities promoting environmental integrity, social fairness, and economic viability

OGCR in a nutshell → Participatory Tier 3 (all land)

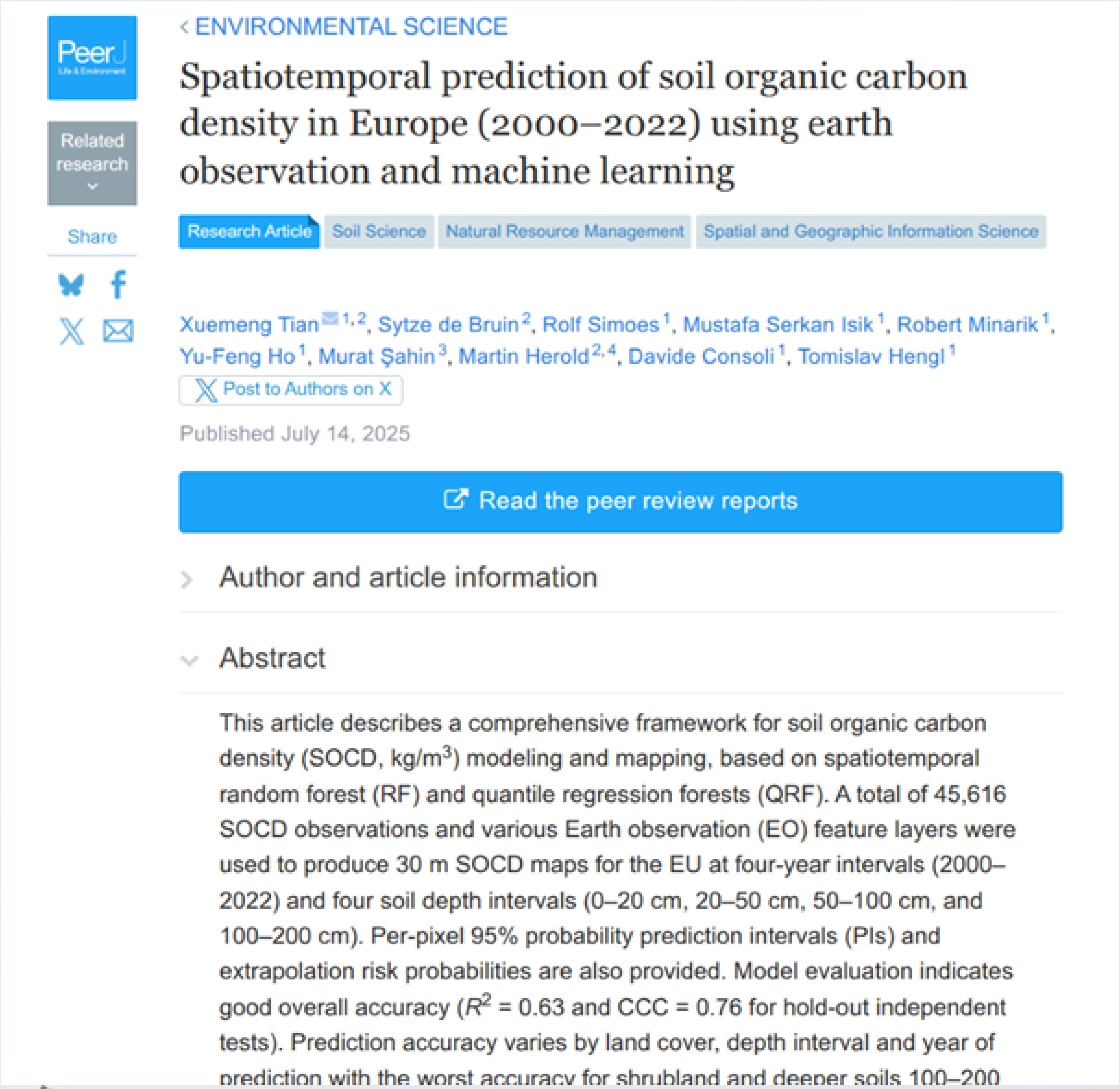
Open Geospatial Carbon Registry

→ Build robust, open-source geospatial data infrastructure using **participatory monitoring**, remote sensing, new AI & hybrid ML methods & blockchain technology

→ We recently produced spacetime (2-year) predictions of SOC for pan-EU (0–20 cm, 20–50 cm and 50–100 cm) with uncertainty (for the needs of the AI4SoilHealth.eu project)

→ The results were promising, although uncertainty is much wider than for the above ground biomass estimates

→ Data was made available via Zenodo, EcoDataCube.eu + the code is available via Github.com



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ENVIRONMENTAL SCIENCE

Spatiotemporal prediction of soil organic carbon density in Europe (2000–2022) using earth observation and machine learning

Research Article | Soil Science | Natural Resource Management | Spatial and Geographic Information Science

Xuemeng Tian[1,2], Sytze de Bruin[2], Rolf Simoes[1], Mustafa Serkan Isik[1], Robert Minarik[1], Yu-Feng Ho[1], Murat Şahin[3], Martin Herold[2,4], Davide Consoli[1], Tomislav Hengl[1]

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Published July 14, 2025

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Author and article information

Abstract

This article describes a comprehensive framework for soil organic carbon density (SOCD, kg/m^3) modeling and mapping, based on spatiotemporal random forest (RF) and quantile regression forests (QRF). A total of 45,616 SOCD observations and various Earth observation (EO) feature layers were used to produce 30 m SOCD maps for the EU at four-year intervals (2000–2022) and four soil depth intervals (0–20 cm, 20–50 cm, 50–100 cm, and 100–200 cm). Per-pixel 95% probability prediction intervals (PIs) and extrapolation risk probabilities are also provided. Model evaluation indicates good overall accuracy (R^2 = 0.63 and CCC = 0.76 for hold-out independent tests). Prediction accuracy varies by land cover, depth interval and year of prediction with the worst accuracy for shrubland and deeper soils 100–200

AI 4 Soil Health

Funded by the European Union

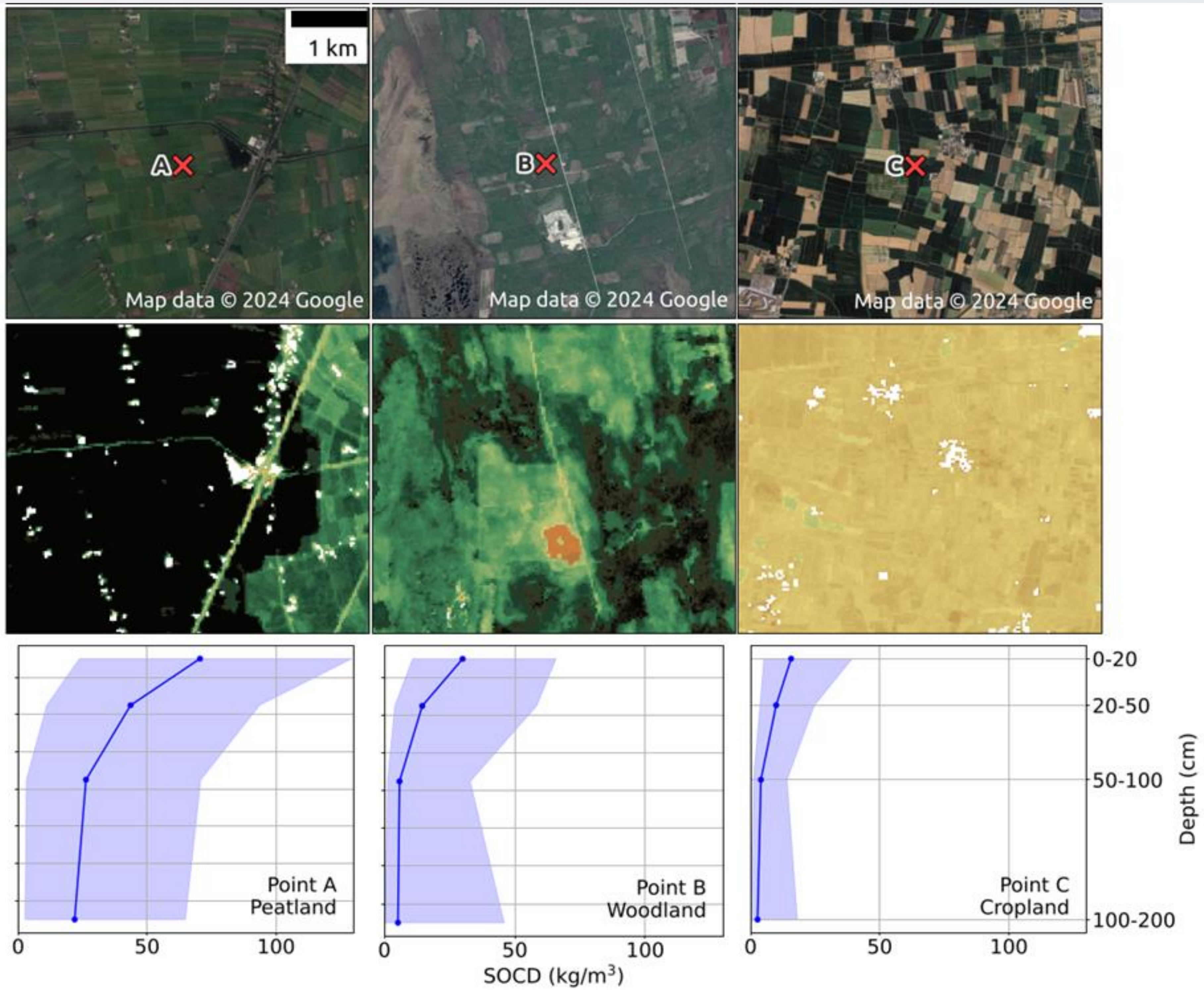

Figure 14 SOCD predictions for the topsoil (0–20 cm) across continental Europe from 2020 to 2022 (available at https://doi.org/10.5281/zenodo.13754343). The top row presents an overview of the predictions (middle), including the upper bound (P0.975 at left) and lower bound (P0.025 at right). The middle two rows provide zoomed-in SOCD predictions and corresponding satellite images for the same period at three specific locations: (A) a peatland site in the Netherlands (lon: 6.177, lat:52.583), (B) a woodland area in Finland (lon: 22.531, lat: 62.351), and (C) a cropland site in Italy (lon: 10.339, lat: 45.101). The bottom row illustrates the variation of SOCD predictions with depth at these three points, with the pale blue shading indicating the corresponding PI. Google Maps (2024, CNES/Airbus, Maxar Technologies), available through https://www.google.com/maps/, last accessed: 30 August 2024.

Full-size DOI: 10.7717/peerj.19605/fig-14

➔ Can we use these estimates to detect changes? What if the uncertainty of estimates is much wider than actual difference?

➔ There are obvious limits to using EO data for soil carbon mapping.

➔ How many years do we have to wait until the change in carbon is “detectable”?

➔ How can we reduce local uncertainty

Open Geospatial Carbon Registry

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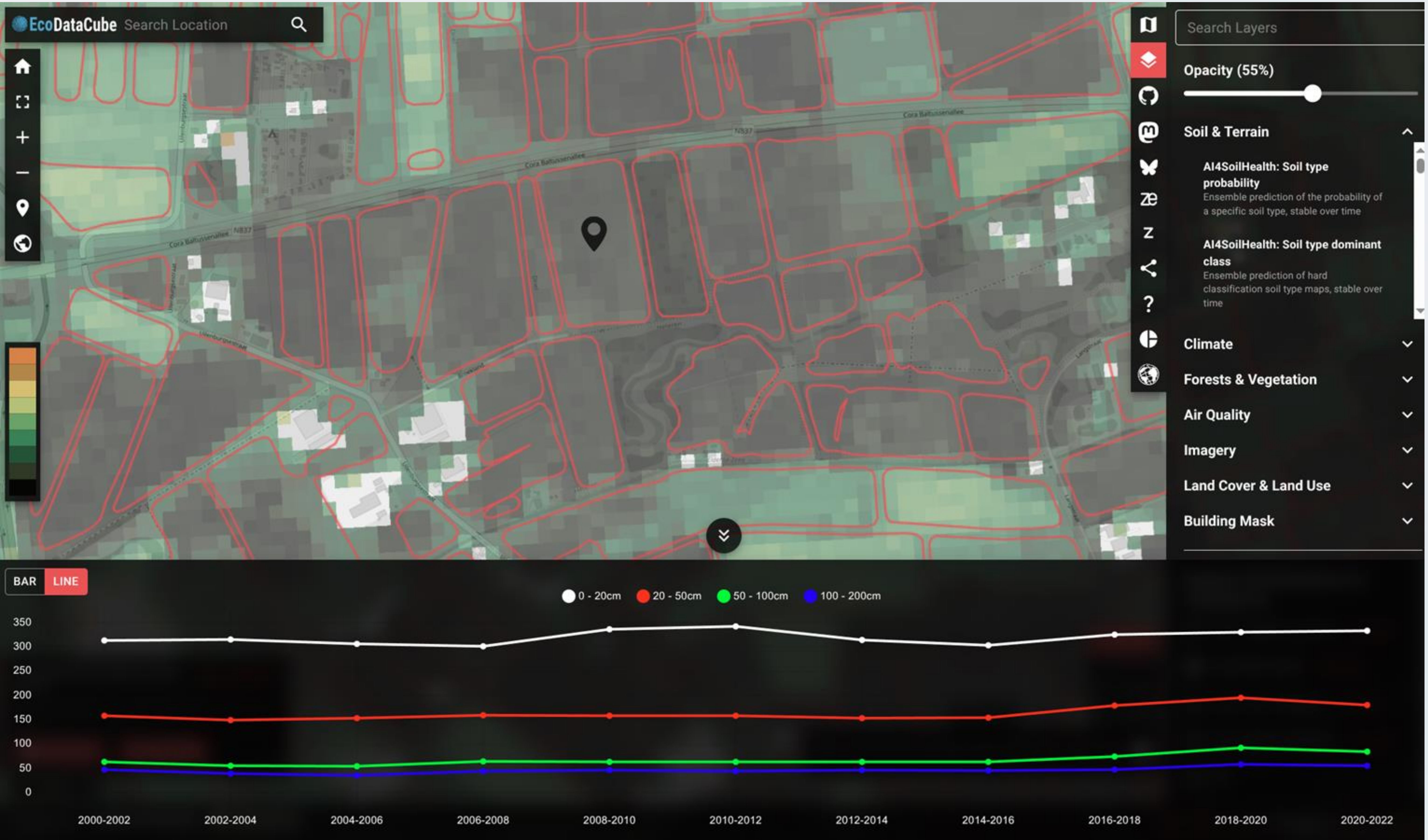
Planet Lab 51m parcels → cadastral/legal parcels

Open Geospatial Carbon Registry



AI 4 Soil Health

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Global SOC → monitoring challenges common

Open Geospatial Carbon Registry

Earth System Science Data

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Preprint

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Abstract Assets Discussion Metrics

24 Jun 2025

Status: this preprint is currently under review for the journal ESSD.

OpenLandMap-soildb: global soil information at 30 m spatial resolution for 2000–2022+ based on spatiotemporal Machine Learning and harmonized legacy soil samples and observations

Tomislav Hengl, Davide Consoli, Xuemeng Tian, Travis W. Nauman, Madlene Nussbaum, Mustafa Serkan Isik, Leandro Parente, Yu-Feng Ho, Rolf Simoes, Surya Gupta, Alessandro Samuel-Rosa, Taciara Zborowski Horst, José Lucas Safanelli, and Nancy Harris

Abstract. There is increasing interest in global dynamic soil information with changes in soil properties mapped over time and at high spatial resolution. Thanks to long-term, multi-temporal, and fine- and medium-resolution satellite missions such as Landsat, MODIS, Copernicus Sentinel and similar, it is possible to produce globally consistent predictions of key soil variables that match other 10–30 m spatial resolution global data sets. This paper describes data preparation, modeling, and production of OpenLandMap-soildb: global dynamic predictions of soil organic carbon content, soil organic carbon density, bulk density, soil pH in H_2O, soil texture fractions (clay, sand and slit) and USDA subgroup soil types (USDA soil taxonomy subgroups) at 30 m spatial resolution based on spatiotemporal Machine Learning (Quantile Regression Random Forest with output predictions showing the mean plus the lower and upper prediction intervals of 68 % probability). To train the models, a large compilation of soil samples imported from legacy soil projects was used: 216,000 soil samples with soil carbon density (kg m^{-3}), 408,000 soil samples with soil carbon content (g kg^{-1}), 272,000 samples with soil pH in H_2O, 363,000 samples with clay, silt, and sand (%), and 134,000 samples with bulk density oven dry (t m^{-3}). Soil carbon and soil pH were mapped with 5 year time-intervals; soil texture fractions, bulk

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Short summary
We used satellite data and thousands of soil samples to create detailed global maps showing how...
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Land & Carbon Lab

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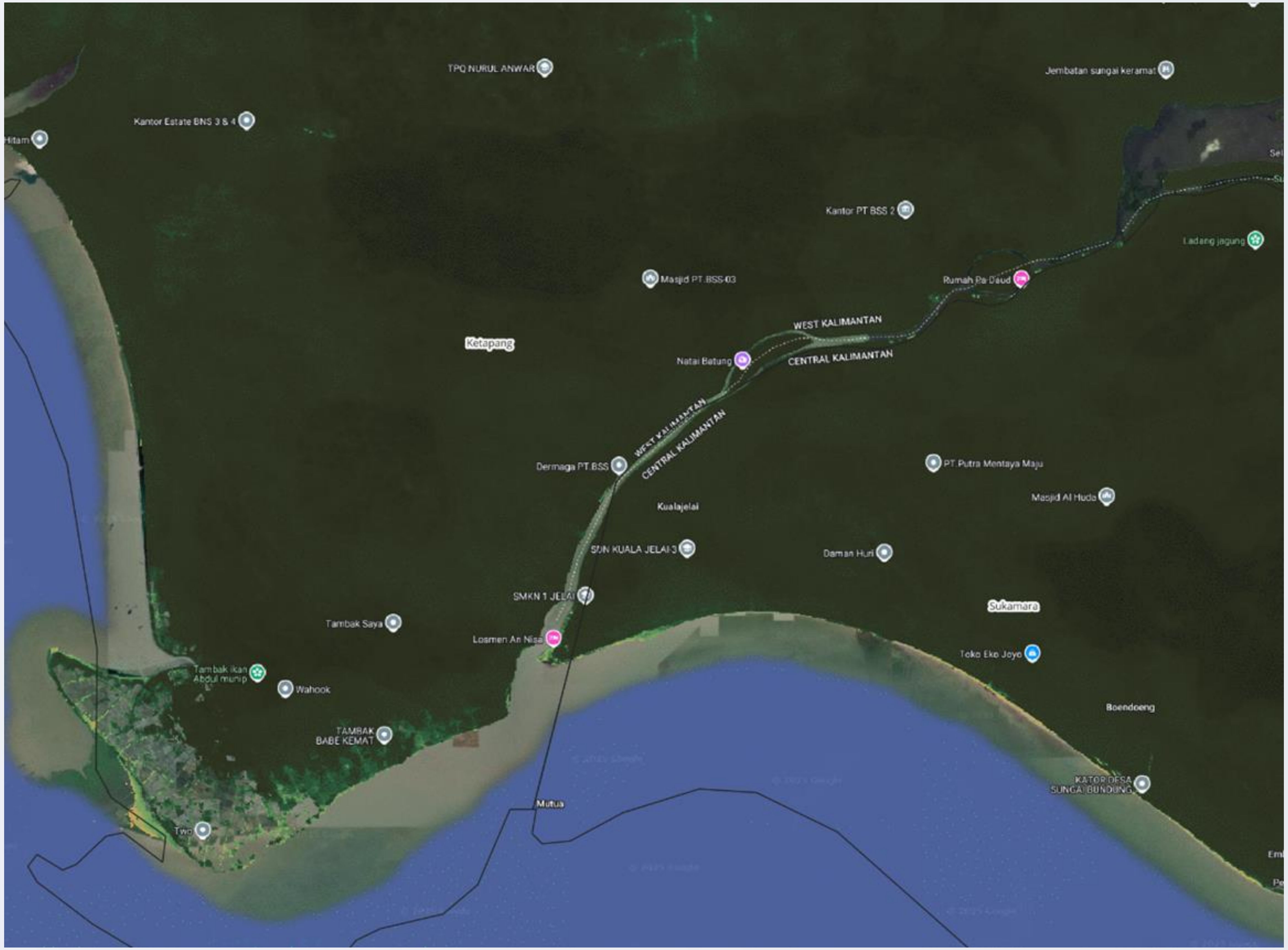
https://doi.org/10.5194/essd-2025-336

Global SOC → LULUCF is visible



- ➔ Example from Kalimantan (Indonesia)
- ➔ Deforestation of tropical forests clearly leads to a loss in SOC
- ➔ Land degradation comes also with a loss of SOC / loss of soil health

Global SOC → LULUCF challenges common

Open Geospatial Carbon Registry

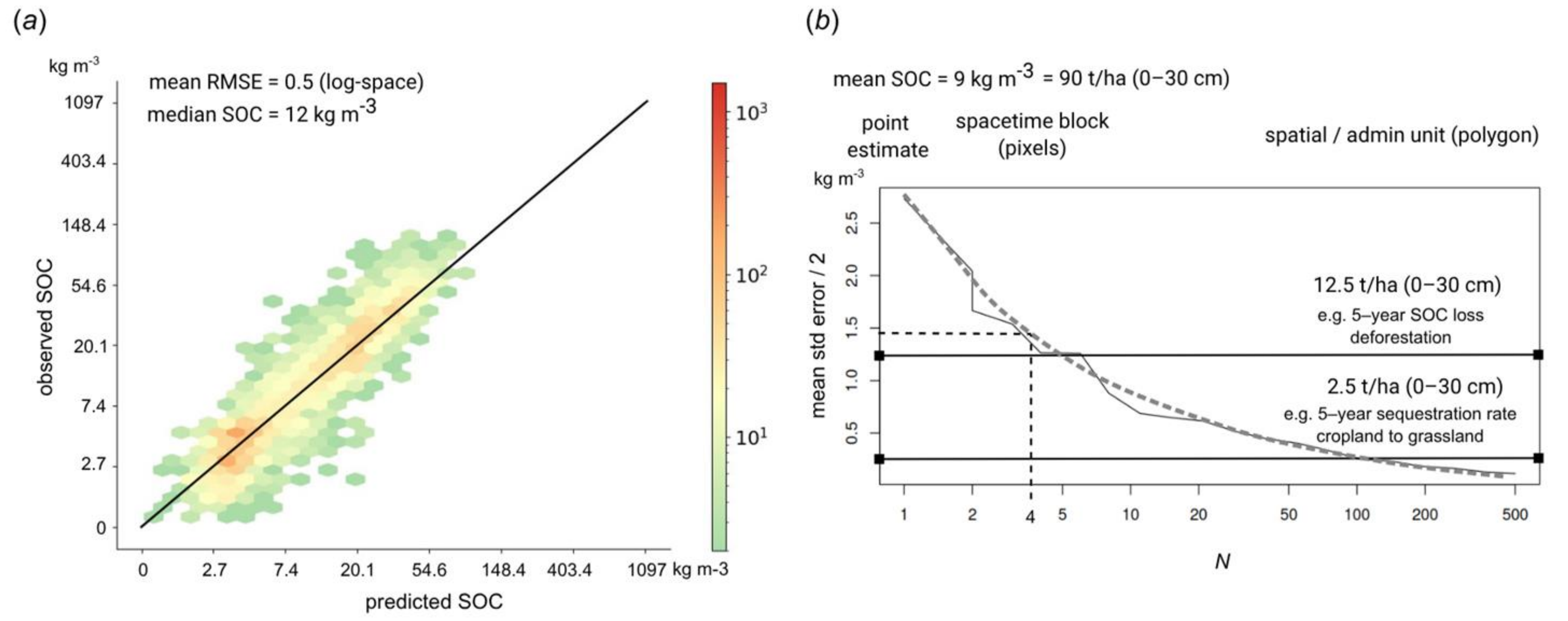


Figure 21. Simulated example of how SOC density prediction errors estimated through validation (a) relate to detection limits for different SOC sequestration / SOC loss rates (b).

Global SOC → LULUCF with local updating

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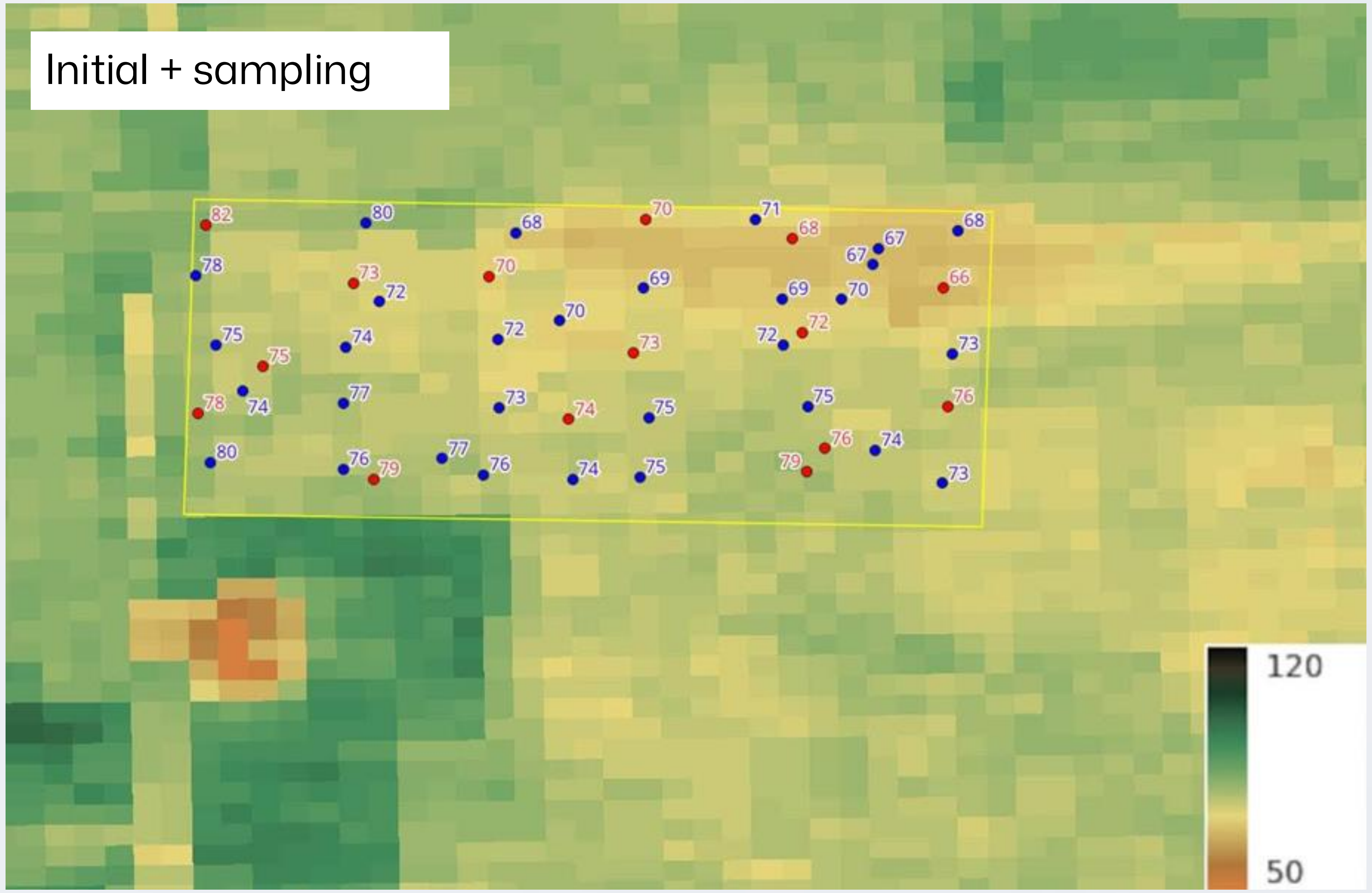
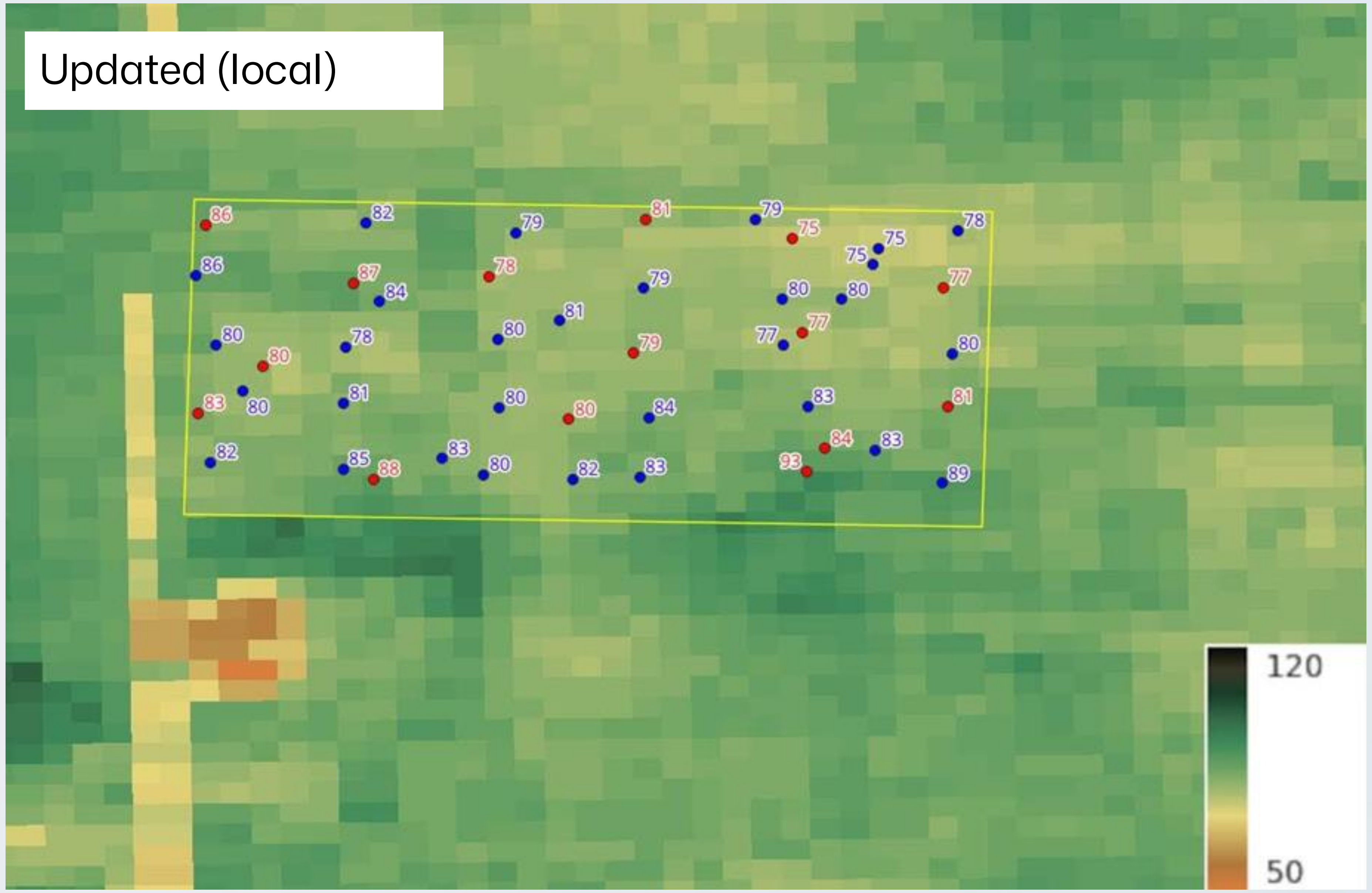
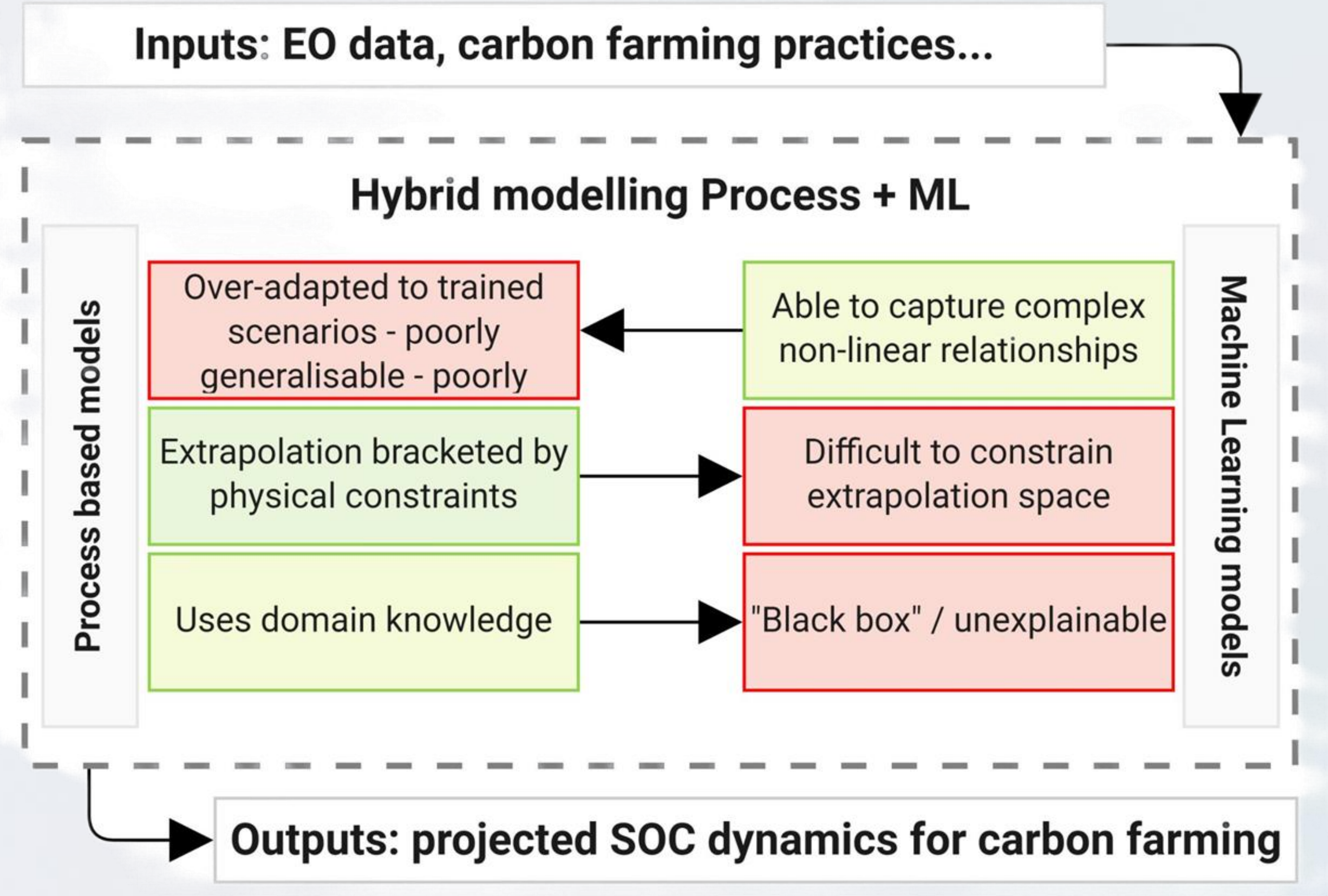




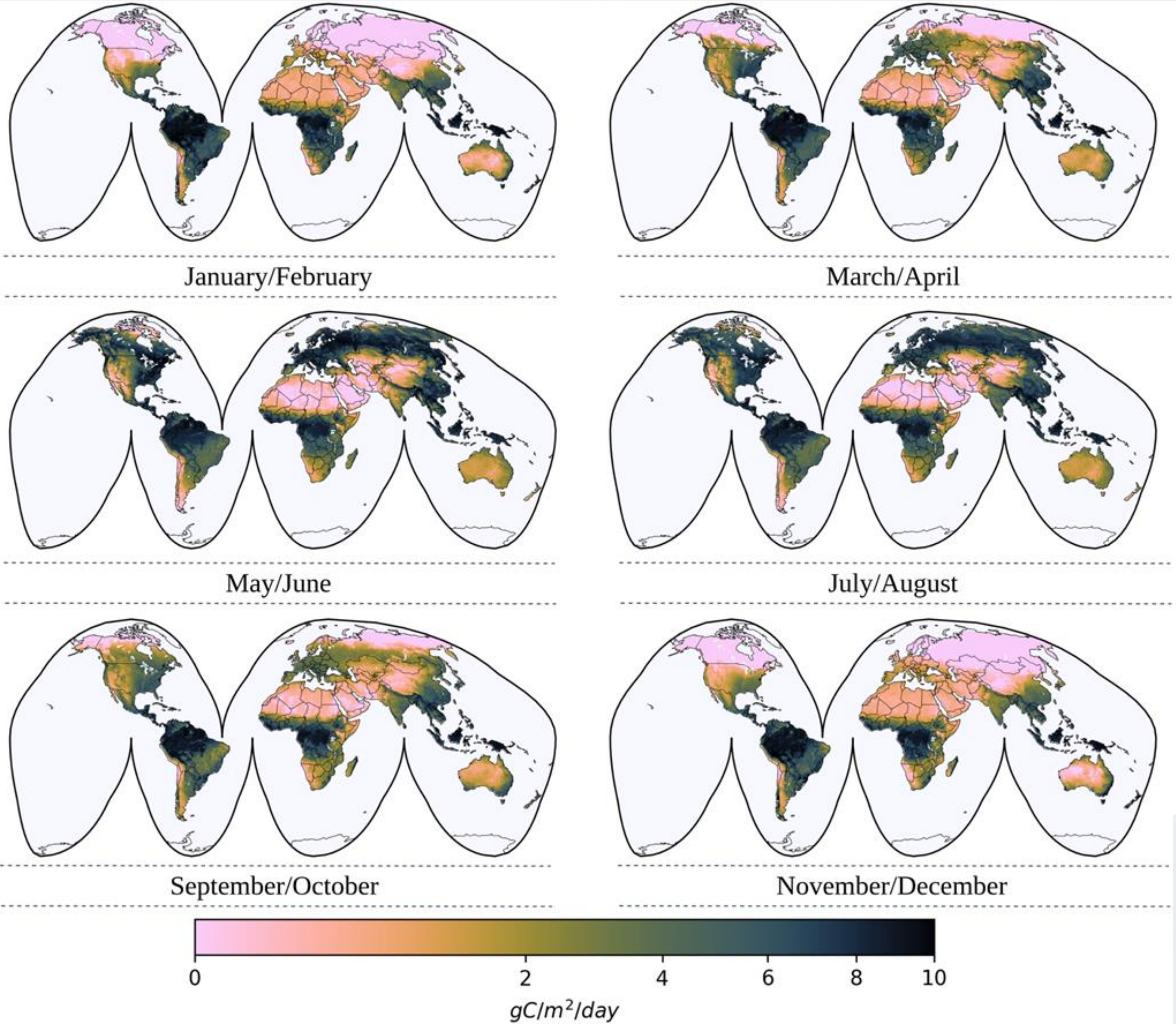
1. Initial predictions g/kg (global)
2. Generate a sampling design using uncertainty of the global predictions
3. Do field work and sample SOC (e.g. 20 locations)
4. Add new samples and re-run global models (**re-analysis**)
5. Update and share predictions (uncertainty for specific farm much smaller)

ML Data driven vs process models → HYBRID :)



ML Data driven vs process models ➔ HYBRID :)

Open Geospatial Carbon Registry



‹ ENVIRONMENTAL SCIENCE

PeerJ Life & Environment

Related research

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Light use efficiency (LUE) based bimonthly gross primary productivity (GPP) for global grasslands at 30 m spatial resolution (2000–2022)

Data report/analysis | Ecosystem Science | Natural Resource Management | Environmental Impacts | Spatial and Geographic Information Science

Mustafa Serkan Isik[1], Leandro Parente[1], Davide Consoli[1], Lindsey Sloat[2], Vinicius Vieira Mesquita[3], Laerte Guimaraes Ferreira[3], Simone Sabbatini[4], Radost Stanimirova[2], Nathalia Monteiro Teles[3], Nathaniel Robinson[5], Ciniro Costa Junior[6], Tomislav Hengl[1]

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Published August 12, 2025

Read the peer review reports

Author and article information

Abstract

The article describes production of a high spatial resolution (30 m) bimonthly

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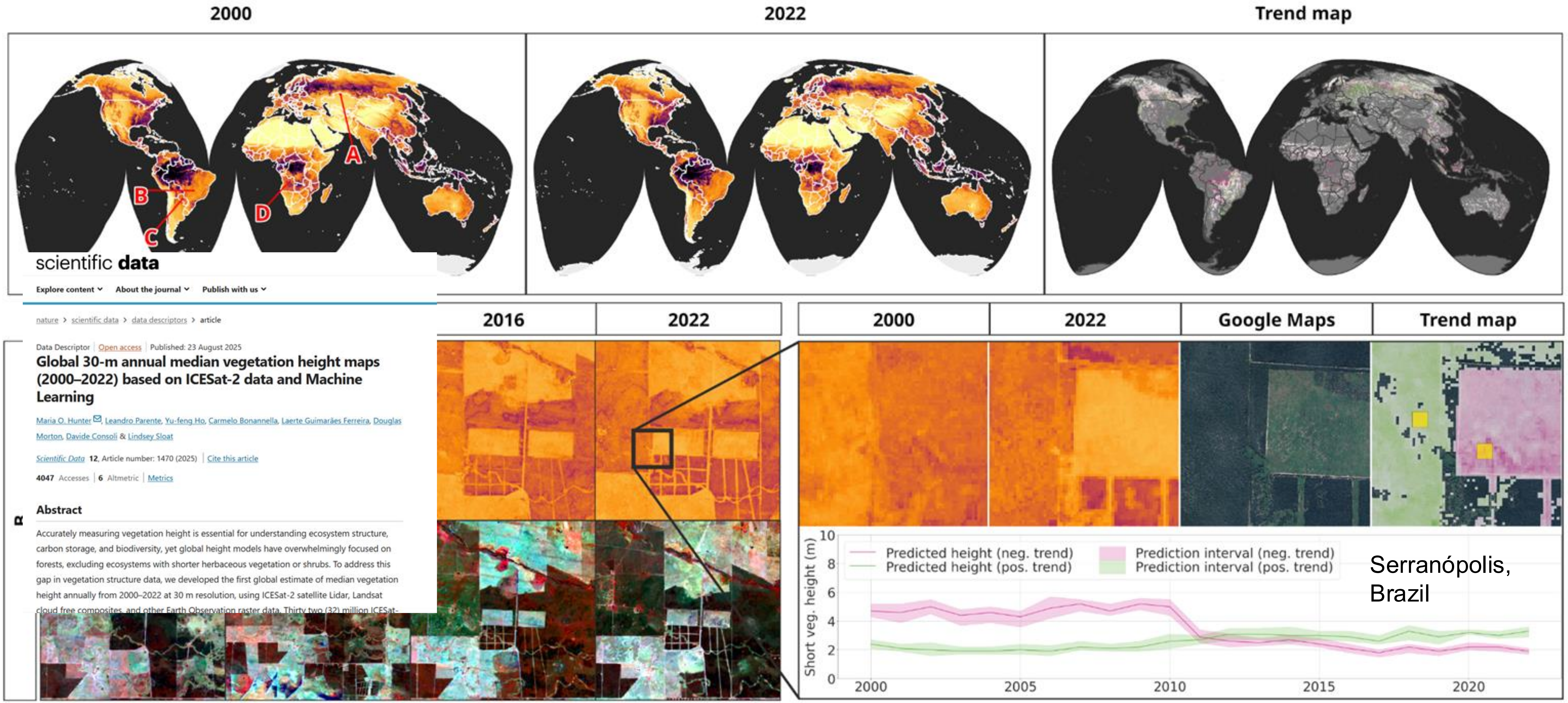
Structure monitoring → + local lidar surveys



Serranópolis, Brazil

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Data Descriptor | Open access | Published: 23 August 2025

Global 30-m annual median vegetation height maps (2000–2022) based on ICESat-2 data and Machine Learning

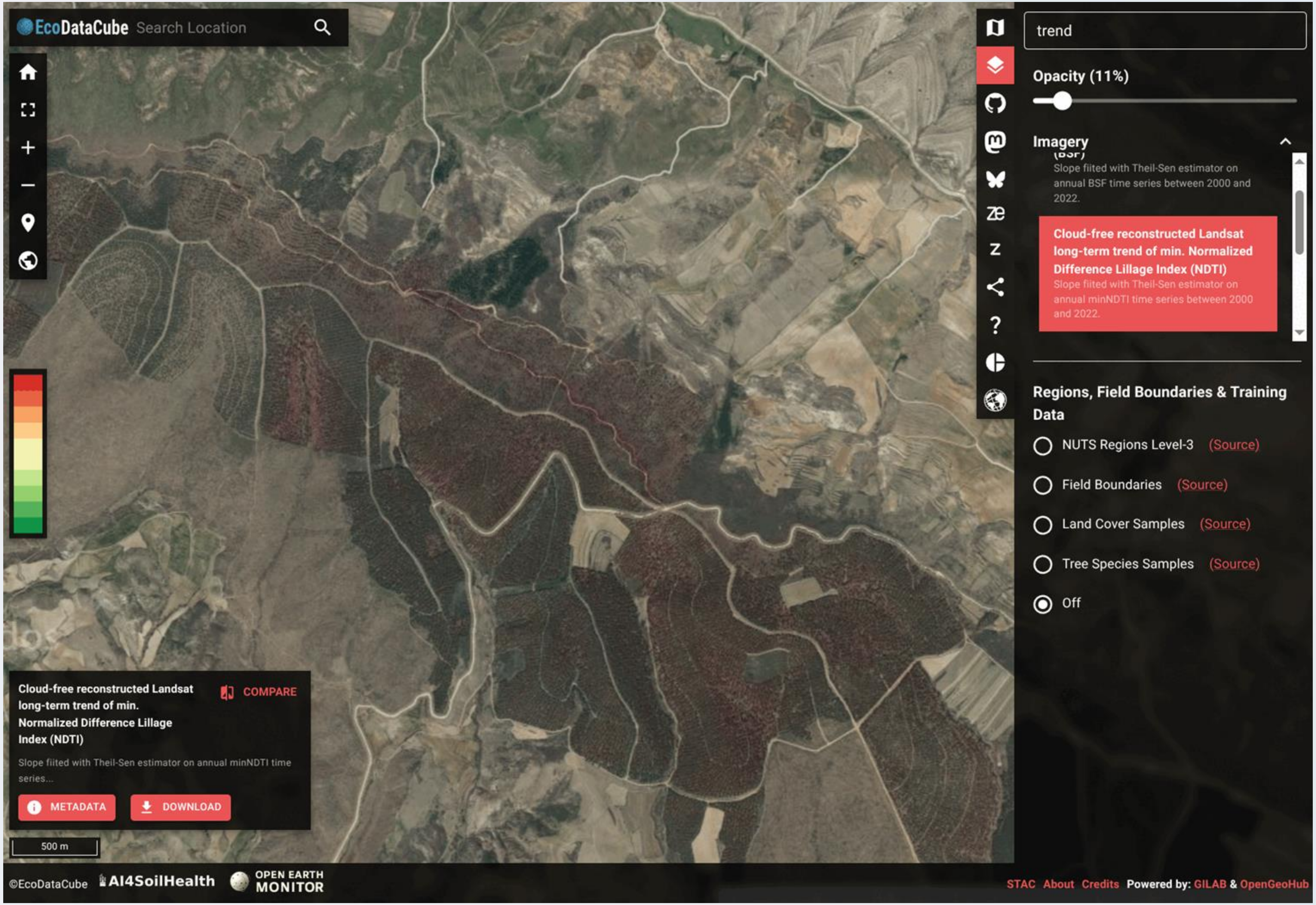
Maria O. Hunter, Leandro Parente, Yu-feng Ho, Carmelo Bonannella, Laerte Guimarães Ferreira, Douglas Morton, Davide Consoli & Lindsey Sloat

Scientific Data **12**, Article number: 1470 (2025) | Cite this article

4047 Accesses | **6** Altmetric | Metrics

Abstract

Accurately measuring vegetation height is essential for understanding ecosystem structure, carbon storage, and biodiversity, yet global height models have overwhelmingly focused on forests, excluding ecosystems with shorter herbaceous vegetation or shrubs. To address this gap in vegetation structure data, we developed the first global estimate of median vegetation height annually from 2000–2022 at 30 m resolution, using ICESat-2 satellite Lidar, Landsat cloud free composites, and other Earth Observation raster data. Thirty two (32) million ICESat-



Open Geospatial Carbon Registry

AI 4 Soil Health

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OGCR geospatial infrastructure → MODULAR :)

Open Geospatial Carbon Registry

GCDC - Geospatial Carbon Data Catalog
Pan-EU standardised carbon baselines & environmental maps
(Soil, AGB, peat.)

→ Connects participatory monitoring with local re-calibration of **high spatial resolution (10 m to 30 m pan-EU coverage) products** to reduce the costs of direct measurement systems

CPMP - CRCF Project Management Platform
Project preparation and monitoring
(Parcel data & automated reports)
Support to multiple carbon MRV methods
(sampling approaches & farming modeling scenarios)

→ Open-source, FAIR & CARE-compliant MRV ecosystem (Monitoring, Reporting, Verification) **from parcel to continental scale**

CCEP - CRCF Certifier Platform
POV - Parcel Ownership Verifier
Certification and approval of carbon credits
(Accounting framework & MRV guidelines)

→ Unified methodology frameworks for all major carbon farming categories, **including calculation of uncertainties for national harmonisation, replication and improvement** of carbon removals

DCR - Distributed Carbon Registry
Track all carbon credit transactions
(including transfer, cancellation & retirement operation)

→ Blockchain-based Distributed Carbon Registry (DCR) for traceability, validation, and trade of carbon credits.

CCM - Carbon Credit Marketplace
Manage carbon credit market exchanging
(Monetary transactions involving carbon credits)

→ Develop user-friendly platforms (registry, marketplace, APIs) to **maximize landholders economical benefits** while also serving other stakeholders

How to get involved → subscribe & follow :)

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