# Earth Observation for MRV of Carbon Farming - Uncertainty and Benchmarking

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# Focus Group recommendation papers

2024: Earth Observation for MRV of Carbon Farming.

Framing the role of satellite-derived data in supporting carbon farming activities.

2025: EO for MRV of Carbon Farming - Uncertainty and Benchmarking.

More technical overview on challenges and opportunities for the use of EO-based data.

2026: EO for MRV of Carbon Farming - EO across the Carbon Value Chain.

Focus on stakeholders across the value chain, their needs and use-cases for EO MRV.

CREDIBLE
EU carbon farming

Funded by
the European Union

**Project CREDIBLE: "Building momentum and trust to achieve credible soil carbon farming in the EU".**

Funded by the European Union under the Grant Agreement n° 101112951.

www.project-credible.eu

# EO Capabilities & Limitations

## Can

- Detect land use changes (deforestation, crop rotation).
- Monitor practices like cover crops, mowing, residue management.
- Estimate above-ground biomass and topsoil carbon (with calibration).
- Integrate with the CAP Integrated Administration and Control System (IACS).

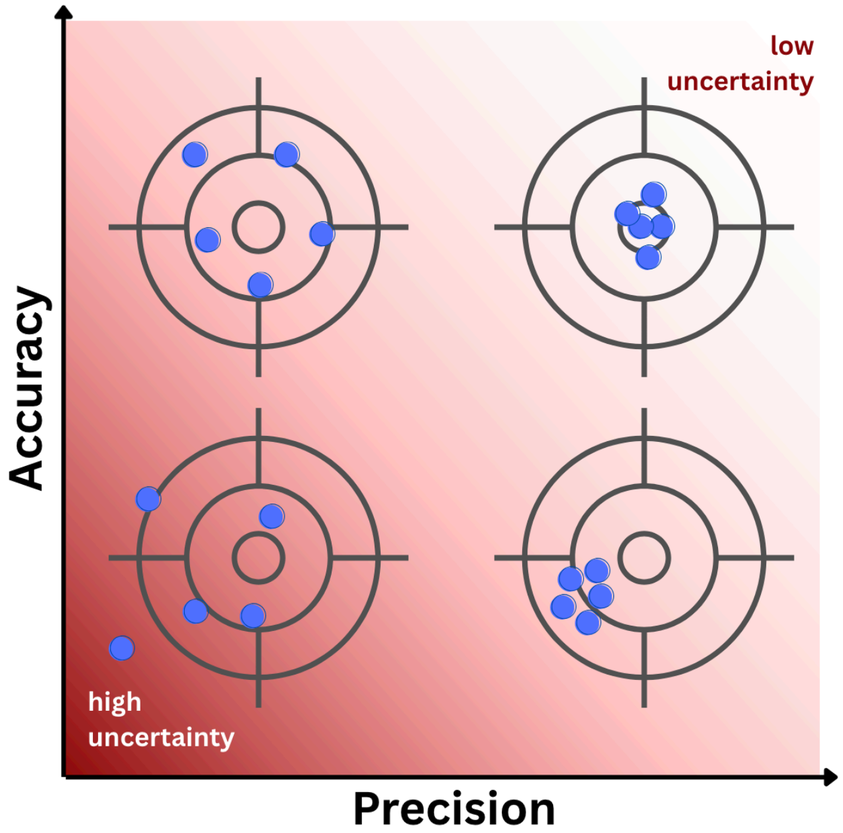
## Cannot (alone, now)

- Directly measure soil organic carbon (SOC, typically measured at 30cm depth).
- Detect subtle management practices (e.g., straw incorporation, organic amendments).
- Provide precise SOC stock changes without ground-truth calibration.

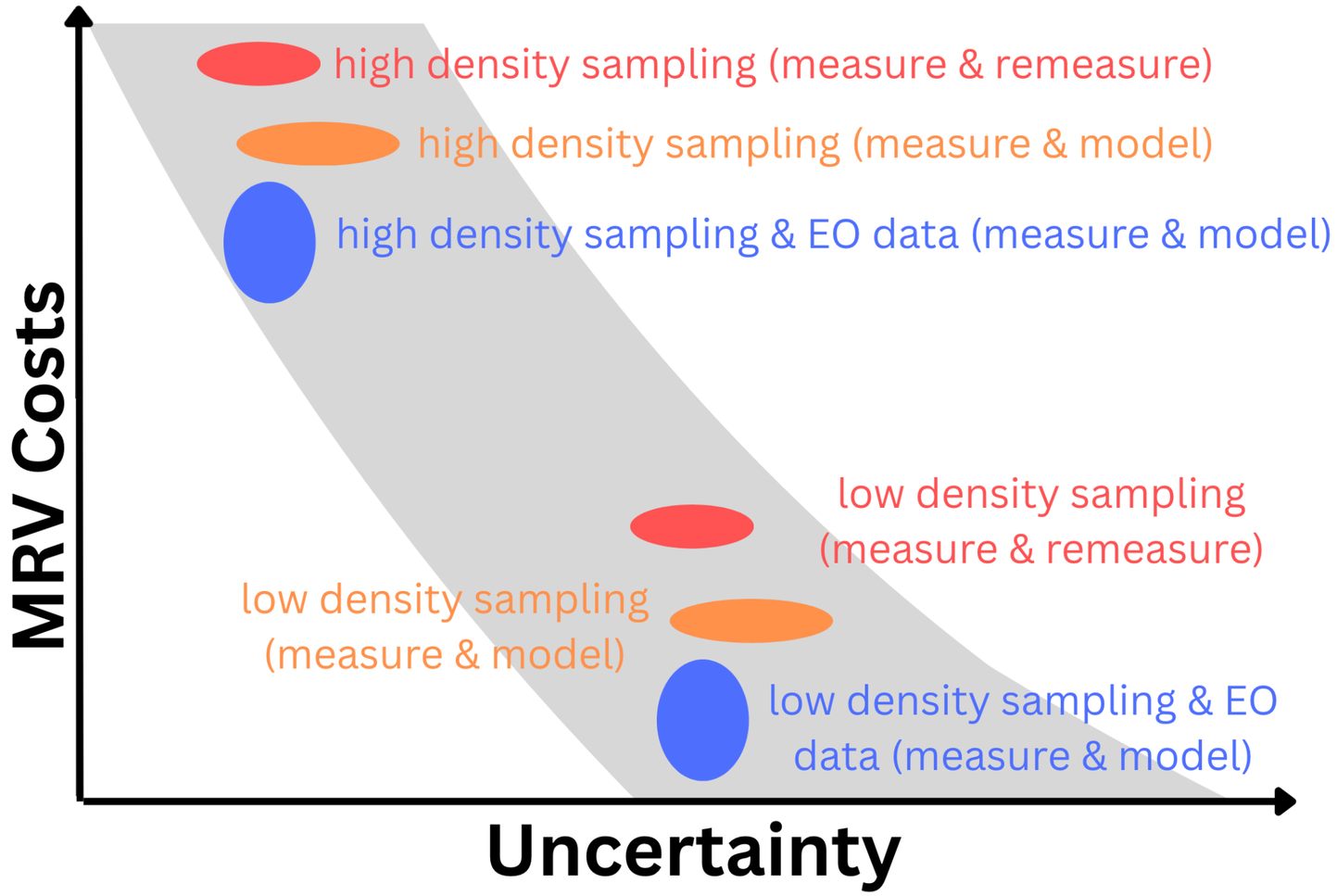
# We need good (=reliable) data

- Ground samples + satellite data must be both accurate (close to the truth) and precise (consistent over time).
- Low accuracy or low precision leads to unreliable carbon stock (changes) estimates.

Reducing uncertainty is a must in order to fairly reward farmers



# Trade-off: costs vs uncertainty




- More sampling = less uncertainty, but high expense.
- Models + EO can lower costs, but require careful calibration and validation.
- Sources of uncertainty: models, inputs, calibration data, EO assimilation.

# Bottlenecks

## Data gaps

- Many farms/forests missing in EU databases; parcel data often restricted; inconsistence across EU Member States.

## Harmonization

- Inconsistent land-use definitions (forest, grassland, wetlands) across EU Member States.

## Governance

- EU data policies strongly affect agricultural data; high hopes for the new Common European Agricultural Data Space (CEADS).

***Table 3: Key Challenges and Recommendations for Improving Ground Truth Data***

| Aspect | Challenge | Examples | Recommendations |
|---|---|---|---|
| Timeliness | Delayed data affects emergency response and short-term decision-making. | - Drought events where in-situ soil moisture data is weeks late.<br>- Forest fire recovery lacking near-real-time biomass loss updates. | - Use EO with short revisit times (e.g. Sentinel-2).<br>- Deploy automated ground sensors to reduce latency. |
| Data Coverage | Sparse in-situ data in remote or ecologically sensitive areas reduces representativeness. | - Few ground stations in alpine zones or northern peatlands.<br>- EO gaps due to surface interference. | - Fund densification efforts (UAVs, mobile labs, citizen science).<br>- Prioritise white-spot areas in EU data strategies. |
| Database Updates | Inconsistent definitions of key terms limit data interoperability and comparability. | - No mechanisms to revise reported values with improved techniques. | Create mandatory version-controlled systems in "living databases".<br>- Include mandatory uncertainty fields and traceability protocols. |
| Vocabulary | Short-term funding leads to unsustainable or fragmented data systems. | -“Depth inconsistencies (e.g., 0–20 cm vs 0–30 cm).<br>- Varying definitions of land cover types like “grassland” across MS. | - Promote Use standard vocabularies (INSPIRE, ISO).<br>- Support ontology tools to align classifications and terms. |

***Table 3: Key Challenges and Recommendations for Improving Ground Truth Data***

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|---|---|---|---|
| Public-Private Data Integration | Lack of guidelines for public-private data sharing | High-resolution imagery is often necessary to detect land management practices like tillage, cover cropping, or crop rotation – but licensing costs and usage restrictions limit broader public access.<br>- sensors deployed by private actors are often not standardized or openly available. | Create and promote standardized templates for data sharing aligned with GDPR and FAIR principles, Including clauses on liability, audit rights, and intended use.<br>Introduce rules for access for sensitive or commercial data (e.g., sensor networks used in voluntary carbon markets) which allow "read-only, non-commercial use" of private data for validation purposes, under data use agreements. |
| Funding mechanisms | Short-term funding leads to unsustainable or fragmented data systems. | - Sampling campaigns end with project funding.<br>- LPIS and IACS quality varies by Member State due to inconsistent investment. | -Promote co-financing via e.g. EU funds.<br>- Secure permanent funding for core infrastructures (e.g., flux towers, LPIS). |

# Model Benchmarking

- Models perform differently depending on soil, climate, and farming practices.
- Without benchmarks, it’s impossible to compare results and trust models.

## Needs

- Baselines tailored to pedo-climatic conditions and farm systems.
- Standard evaluation methods to reduce subjectivity in audits.

## EU-wide benchmarking platform

- Test MRV models on shared, curated datasets.
- Integrate ongoing research + private sector efforts.
- Continuously update with new EO and soil monitoring advances.

# Thank you for your attention!

Recommendation Paper

Still possible to leave a comment/feedback
on the CREDIBLE public consultation page!

& Save the date:
3rd European Carbon Farming Summit
17-19 March 2026
Padova, Italy.

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