

The challenges of monitoring carbon farming by remote sensing

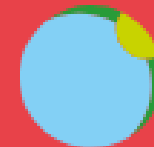
Bas van Wesemael, Klara Dvorakova, Manon Ferdinand, Uta Heiden, Karin Pepers, Gera van Os

UCLouvain



DLR

Earth Observation Center



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Requirements for SOC monitoring

- National or regional inventories
 - Digital soil mapping based on soil monitoring networks or data from routine soil analysis
- Demand for increased spatio-temporal resolution
 - Policies are increasingly based on results rather than actions e.g. CAP 2023-2027: Conditionality, Ecoschemes and Agro environmental climate measures
 - Carbon farming in the framework of the European Green Deal



Improving the ecological and economic performance of agri-environment schemes: Payment by modelled results versus payment for actions

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Carbon removal activities



PERMANENT STORAGE

E.g. Bioenergy with Carbon Capture and Storage (BECCS), Direct Air Carbon Capture and Storage (DACCS)

Industrial leadership for climate-neutral technologies

At least 5 MtCO₂ removed in 2030, and up to 200 MtCO₂ in 2050



CARBON FARMING

Soil and forest activities in the scope of the LULUCF Regulation, including: Peatland restoration, agroforestry, sustainable forest management, soil carbon sequestration,

Strong synergies with biodiversity

Contribute to LULUCF target of -310 MtCO₂ removals in 2030 and climate-positive bio-economy in 2050

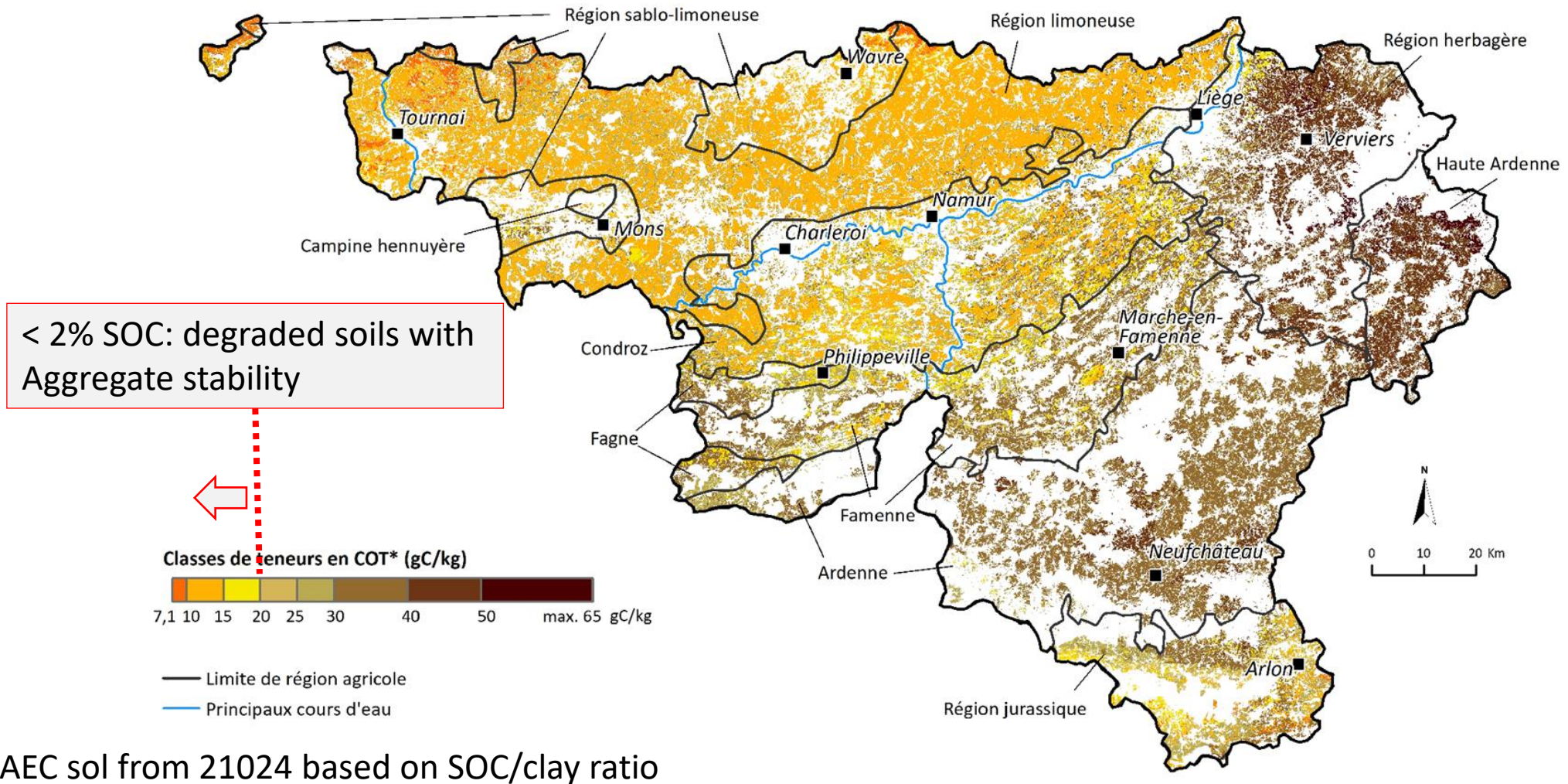


CARBON STORAGE IN LONG-LASTING PRODUCTS

E.g. wood-based construction materials and other carbon-storing construction products

New European Bauhaus

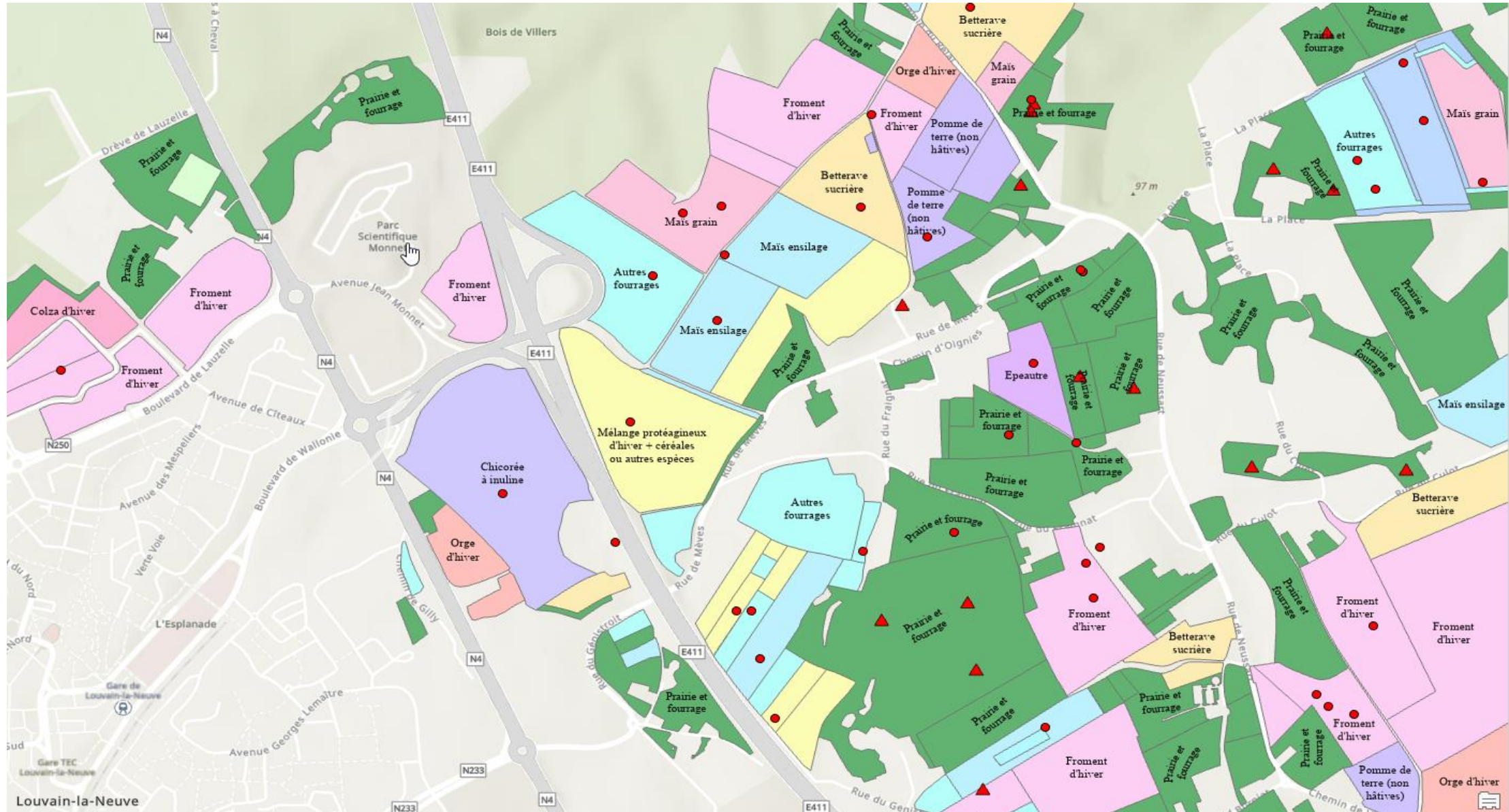
Teneurs en carbone organique total (COT)* des sols agricoles en Wallonie (2015 - 2019)



MAEC sol from 21024 based on SOC/clay ratio

* Teneurs en surface prédites par modélisation à partir des données REQUASUD collectées entre 2015 et 2019 (39 086 échantillons d'horizons de surface de sols sous cultures et 8 277 échantillons d'horizons de surface de sols sous prairies permanentes ; prairies temporaires non incluses dans l'analyse) - Maille de 90 m x 90 m
REEW . Sources : UCLouvain - ELI - TECLIM ; REQUASUD (licence A09/2016)

Zoom Wallonia land parcel information system (2019) with sample points (2018-2021)



SOC monitoring in croplands from Earth observation



<https://www.world-soils.com/>

SOC contents of bare topsoils in croplands



Remote sensing based on spectroscopy

Some commercial applications of visNIR spectroscopy

Global Operations from Cincinnati
Delivers on the promise of infrared analysis



Solution provider based on IR/NIR technology

Eurofins Wet chemistry capability
+
QTA Infrared expertise



www.eurofinsus.com



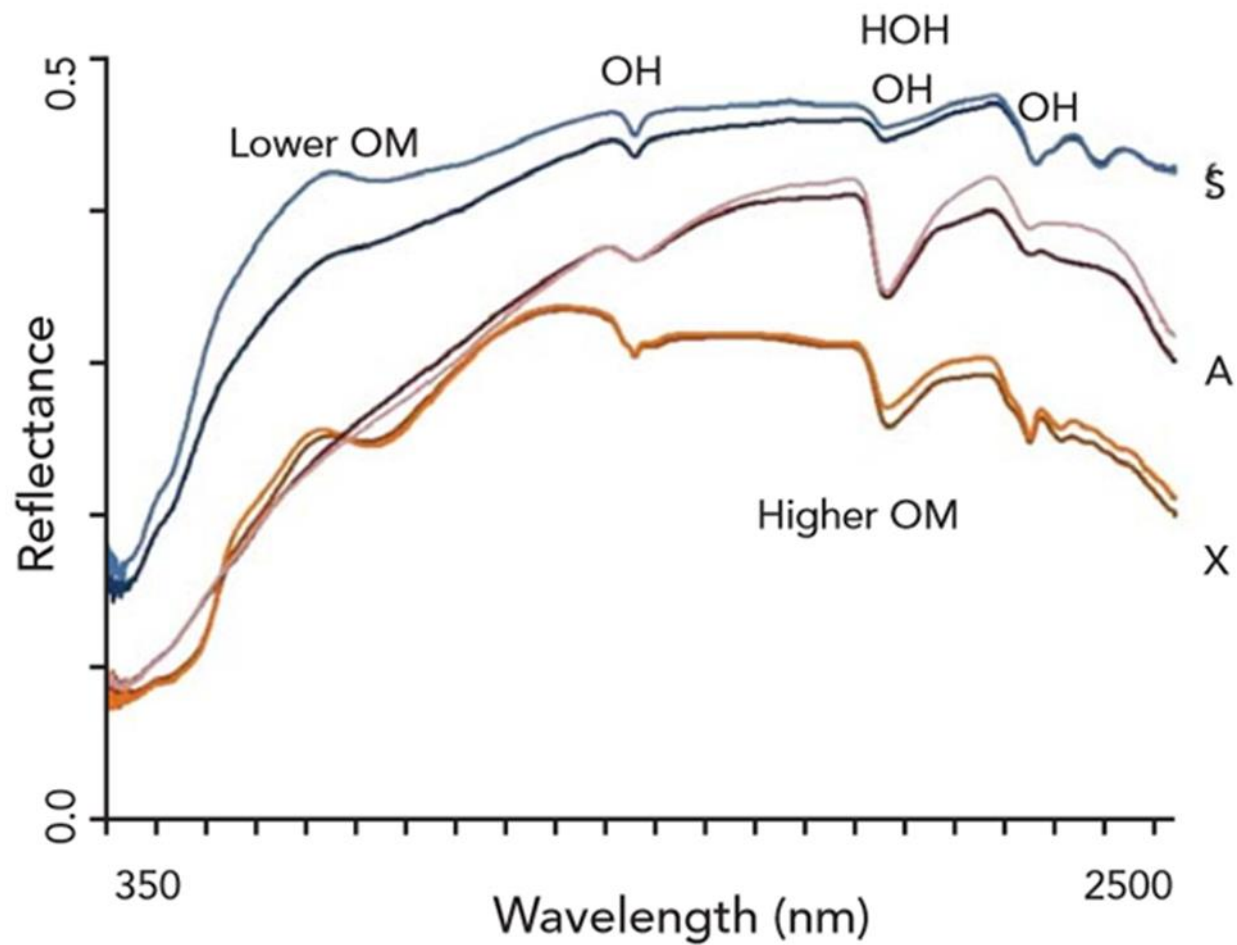
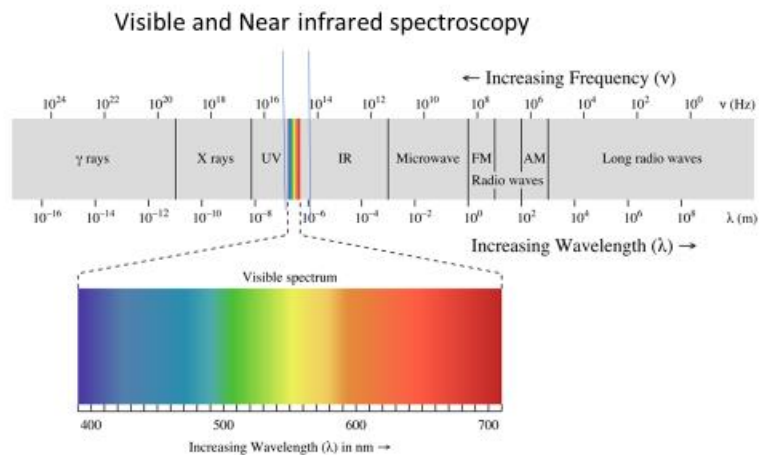
 **AgroCares
Nutrient
Scanner**

Instant, on-the-spot monitoring of nutrients in soil, feed and leaf

[▶ Play the video!](#)

<https://www.agrocares.com>



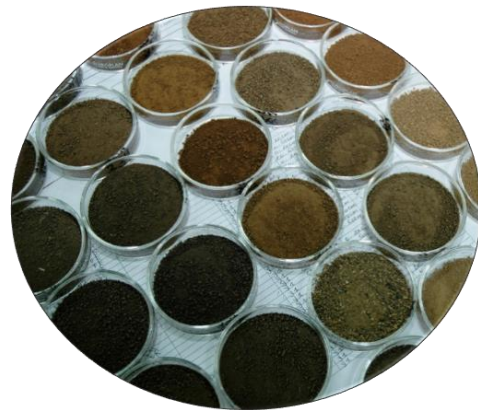


Challenges of spectroscopy at different scales

Laboratory

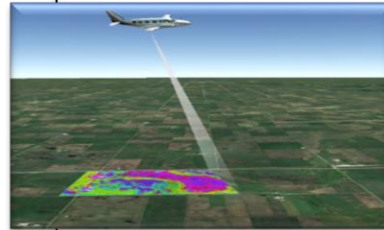


- Air dried and sieved sample



Signal of a dry soil?

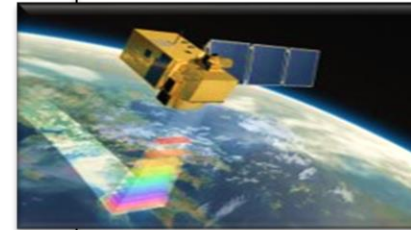
Hyperspectral airborne



- Area (30m x 30m)
- One off



Satellite multispectral



- Area (1000km x 1000km)
- One off



SOC monitoring from Earth Observation

What do we need?

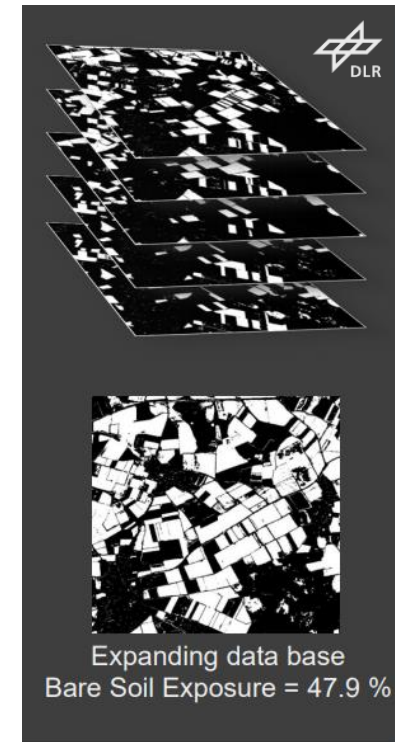
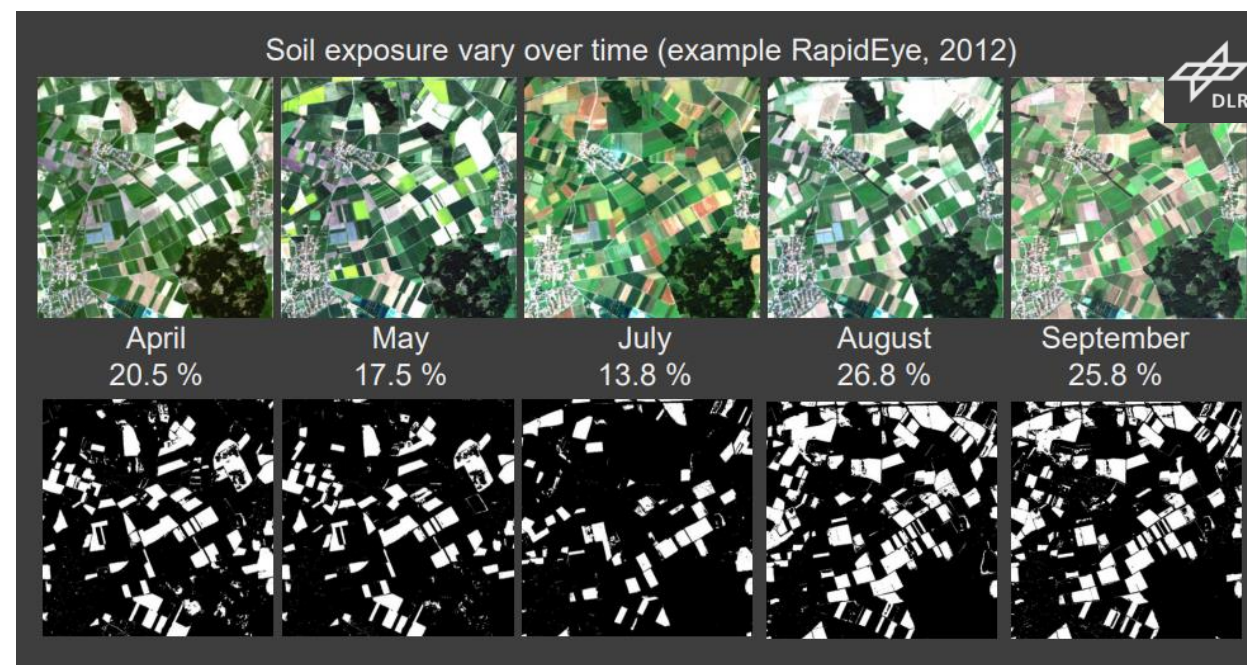
Algorithms that allow SOC predictions

- over large areas
- at low costs (i.e. no recurrent field work)

How to achieve this?

Sentinel-2 mission

Exposed soil composites



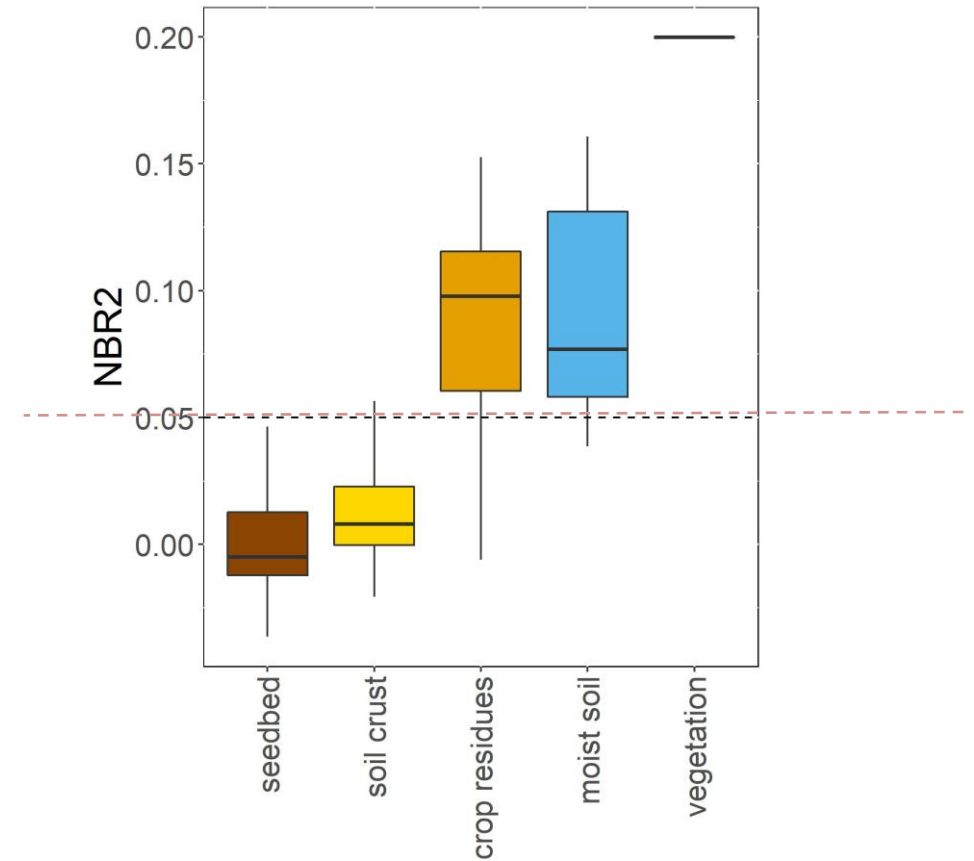
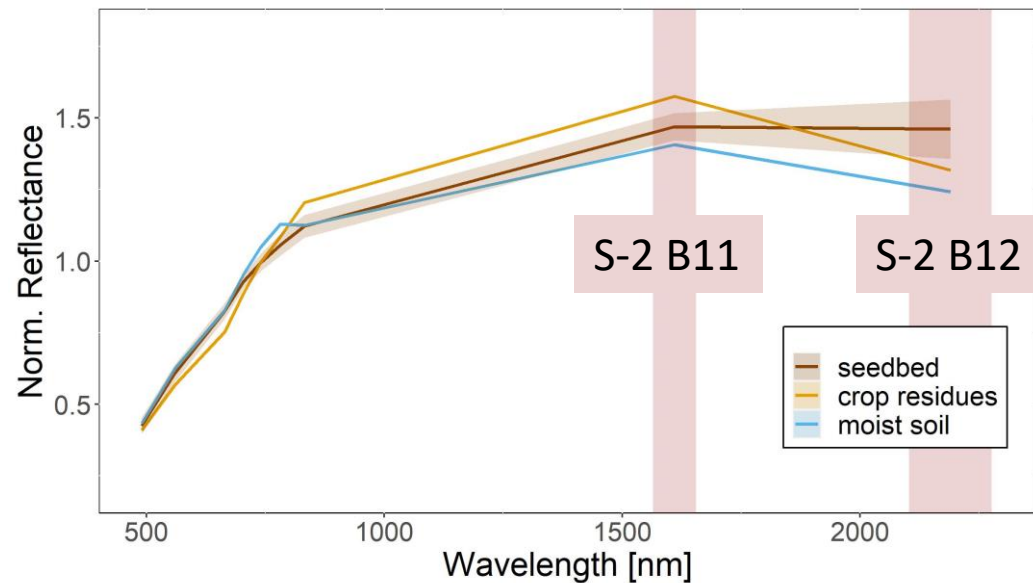
How do we eliminate/correct Sentinel-2 reflectance spectra that are affected by crop residues, soil moisture and crusts?



Solved since the 70ies (NDVI)

NBR2 to remove crop residues and soil moisture

$$\text{NBR2} = \frac{B11 - B12}{B11 + B12}$$



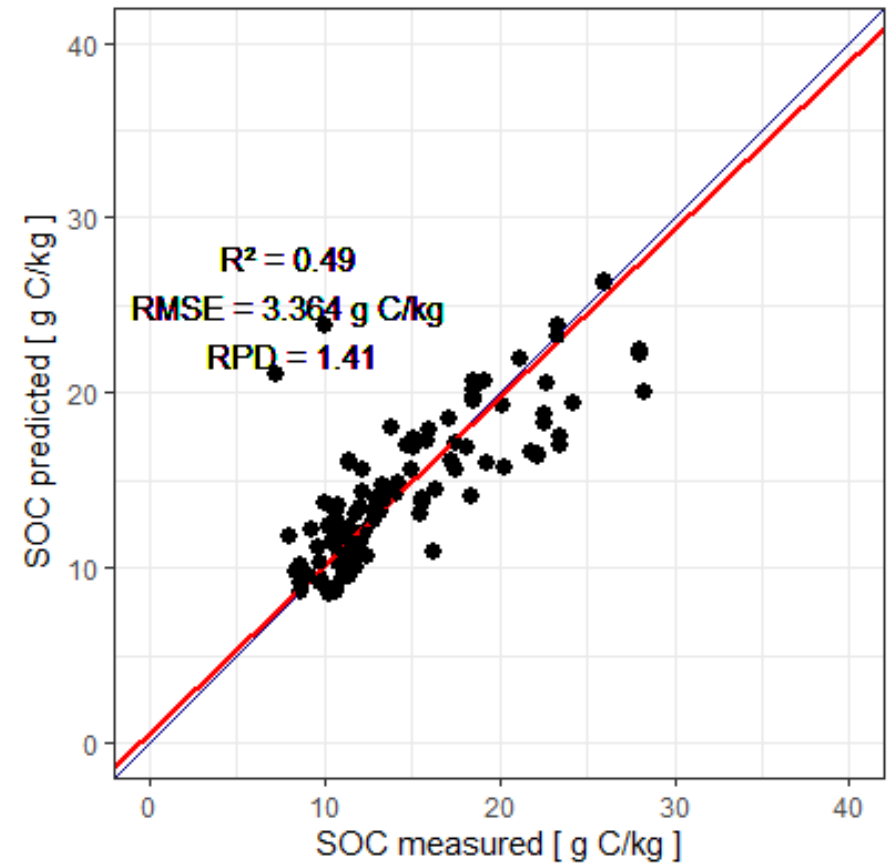
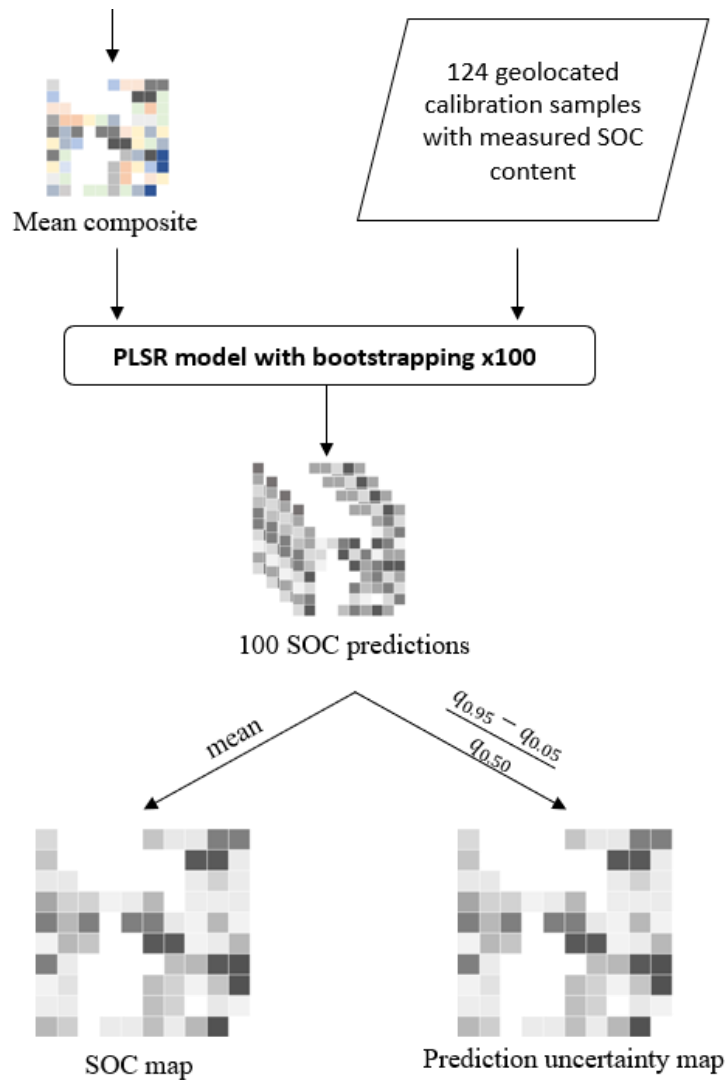
NBR2 < 0.05 is effective to mask soil moisture and crop residues

Example of SOC mapping from Sentinel 2 composites

- 3 S2 tiles covering croplands
 - Belgian loam belt
 - Dutch polders
- 124 geolocated calibration samples (in blue)
- PLSR model



Partial Least Square Regression model & Uncertainty

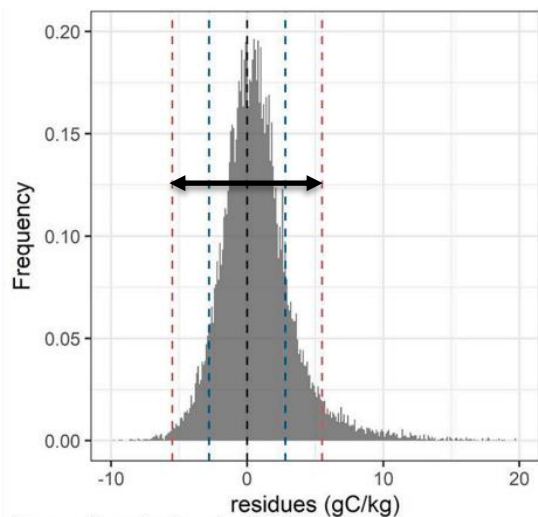


SOC maps for North Holland and Wieringermeer



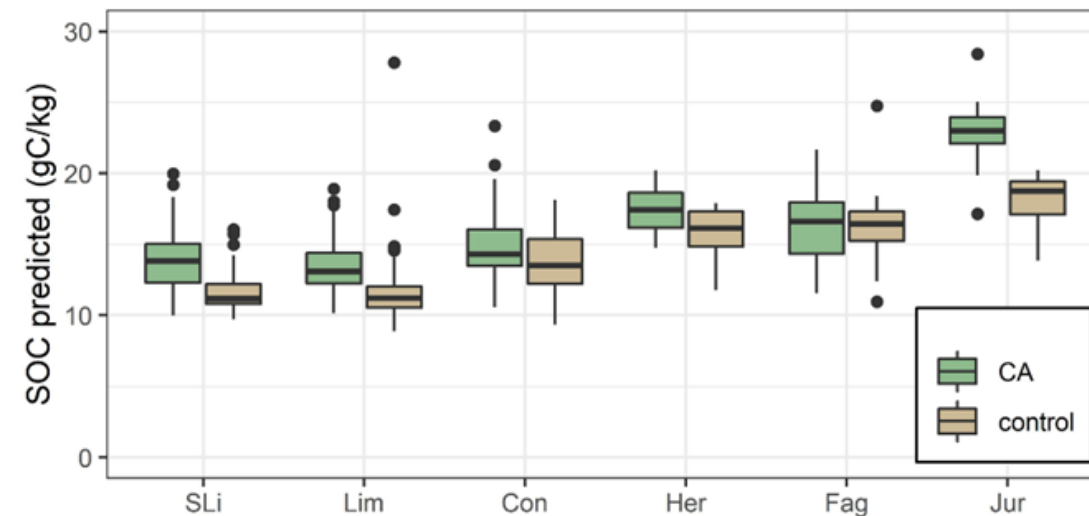
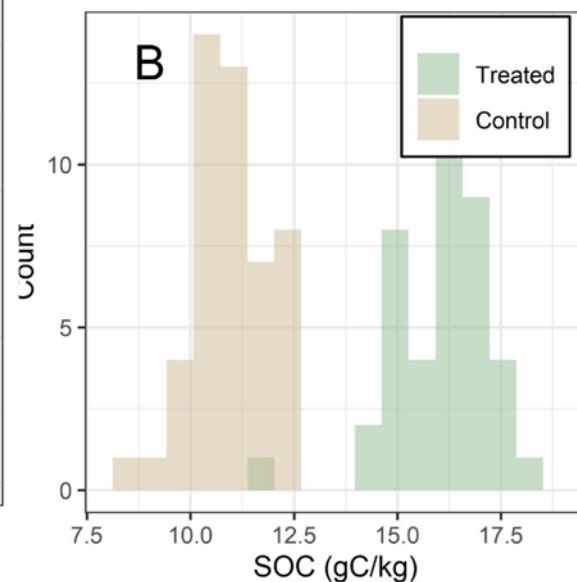
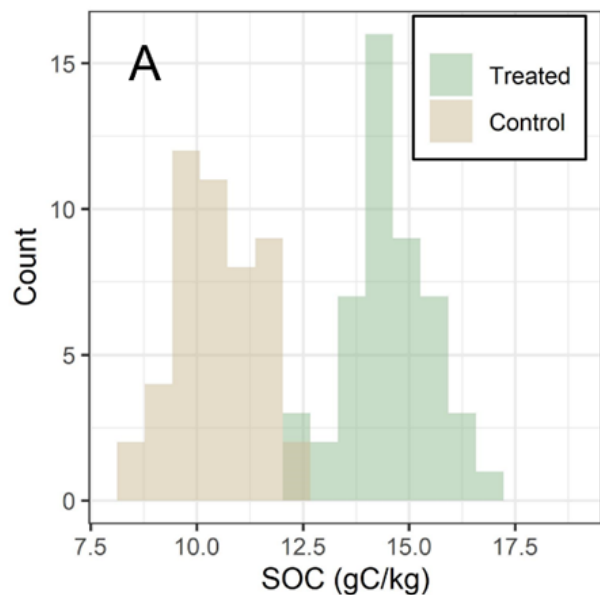
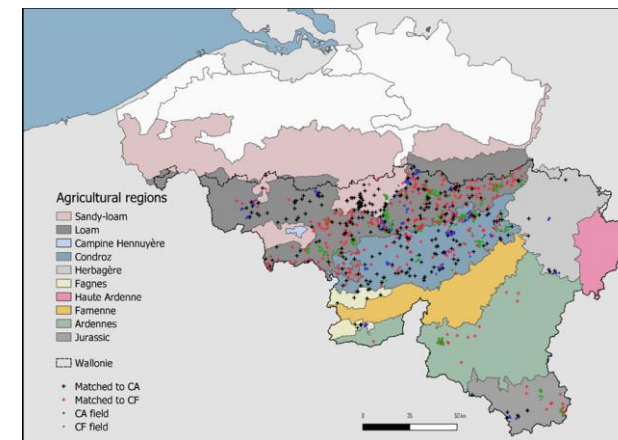
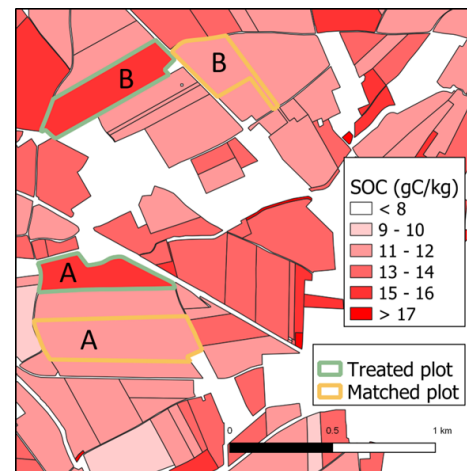
Effect of the number of scenes used for the composites for each pixel on prediction uncertainty

Effects of conservation agriculture on mean SOC content per field



Source: Base de données REQUASUD
Licence n.: A07/2021

Uncertainty: 5 g kg⁻¹



Bootstrapping: differences between fields

Paired fields : differences within a region

Horizon Europe project MRV4SOC



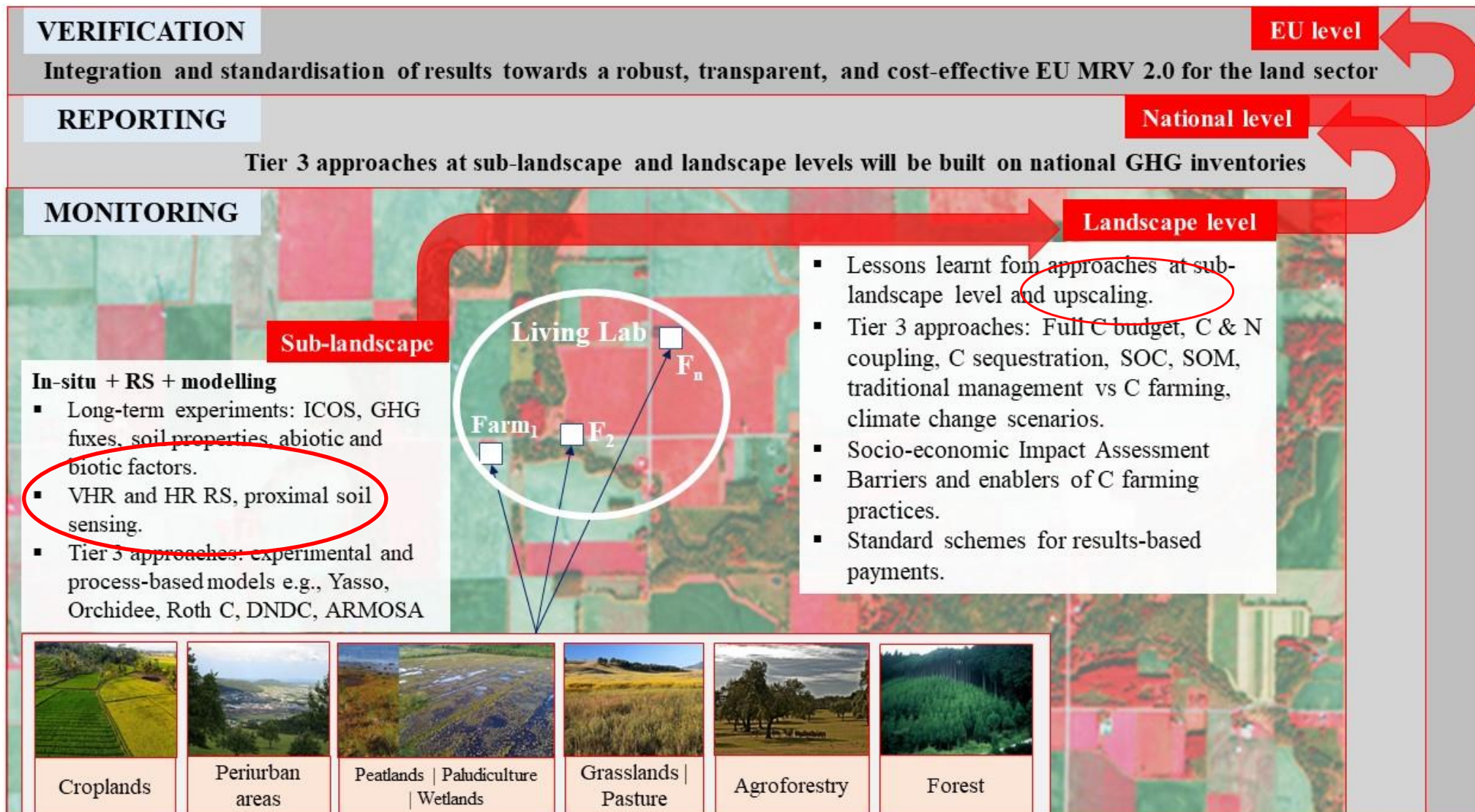
1	GMV
2	UCLouvain
3	ARISTOTLE UNIVERSITY OF THESSALONIKI
4	TAU
5	CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE
6	STICHTING INTERNATIONAL SOIL REFERENCE AND INFORMATION CENTRE
7	CREA
7.1	ENTE REGIONALE PER I SERVIZI ALL' AGRICOLTURA E ALLE FORESTE
8	UANTWERPEN
9	DLR
10	CNRS
11	CSIC
12	ICONS
13	Soil Capital
14	Evenor Tech
15	K&I srls
16	UVIGO
17	NIBIO
18	ULIEGE
19	GFZ
20	UG

WORLD SOILS
<https://www.world-soils.com/>

NOVASOIL

INBESTSOIL

Implementation



Future steps

- Validation of SOC prediction in three test areas
- Stabilization of the Worldsoils SOC tool
- Testing the performance of GHG models fed by Remote sensing products on flux tower sites and long term trials
- Upscaling from the site to the landscape using variables from remote sensing (e.g. SOC content)

