Towards more efficient carbon, nitrogen and phosphorus cycling in European agricultural soils: Circular Agronomics (CA) program

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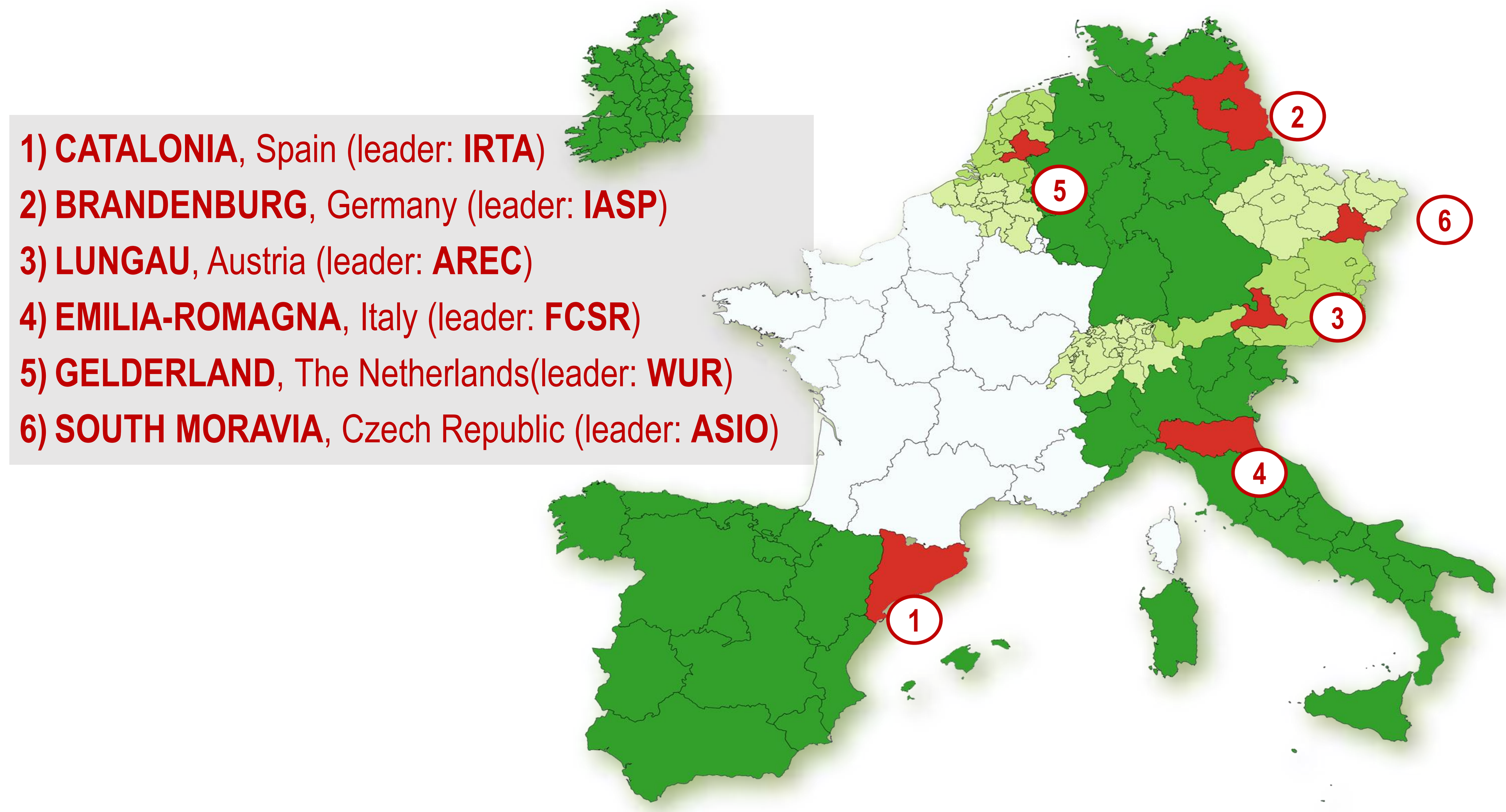
Introduction

- **Mineral fertilizers**: **low recovery efficiency by crops**. E.g., 30-50 % for nitrogen (N) and 45 % for phosphorus (P) (Tilman et al., 2002).
- **Loss of nutrients** into the environment : severe negative influence on soil (e.g. unbalanced N cycle), water (e.g., eutrophisation) and air (e.g., greenhouse gas emissions) (Elser and Bennett, 2011; Erisman et al., 2008).
- Less than 2% soil organic carbon (SOC) in 45% of European soils (Jones et al., 2012) and **projected decline of agricultural SOC stocks** of up to 24 % (Wiesmeier et al., 2016).
- Soil carbons stocks: not only topsoils, but also **subsoils** are reactive to agricultural change (Hobley et al., 2017).
- Impacts of **organic amendments** (e.g., digestate, manure) versus traditional mineral fertilizers on SOC contents and stocks are uncertain at the long-term (e.g., Chenu et al., 2019).
- Within the project Circular Agronomics - production of **new organic fertilizers**: residues (manure, digestate) treated with vacuum degasification for nitrogen depletion of residues and recovery of fertilizer.

One of the objectives of Circular Agronomics

Exploring medium and long-term effect of **new organic fertilizers** versus classical organic and mineral fertilizers on **SOC**, **N** and **P** distribution, stability and bioavailability in **agricultural topsoils** and **subsoils** of Europe.

Case Study Sites



Material and methods

Organic and **inorganic amendments**

- **Different organic** and **inorganic amendments** according to the case study.
- E.g., mineral fertilizer, pig slurry (solid or liquid fraction), manure, whey, biogas digestate, nitrogen-depleted digestate.

Soil sampling for every case study

- Soil sampling to a **depth of 1 m** using a hydraulic corer.
- One **un-disturbed** half of the **core** for hyperspectral imaging
- The other half of the core for laboratory analyses.
- Five depths: 0-10 cm,10-20 cm, 20-40 cm, 40-80 cm and 80-100 cm.

Laboratory analyses

- **Classical bulk chemical analyses**. E.g., bulk density, pH, CEC, texture, total and available C, N and P
- State-of-the-art **imaging technique**: hyperspectral camera to reveal horspots of C and N storage in the soil profile (Hobley et al., 2018).

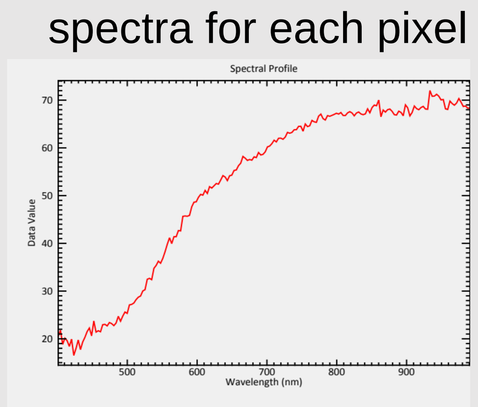
A focus on hyperspectral soil analysis

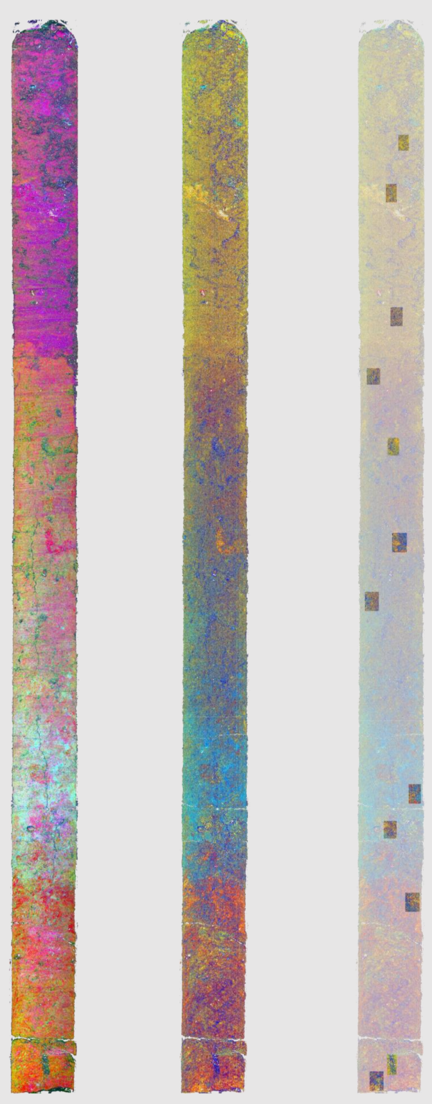
SNV transformation
Normalisation of spectral information

PCA
Dimensional reduction

Selection of ROIs (12 to 20), based on visualized variability. About 100 mg of sample is collected and analysed for element of interest

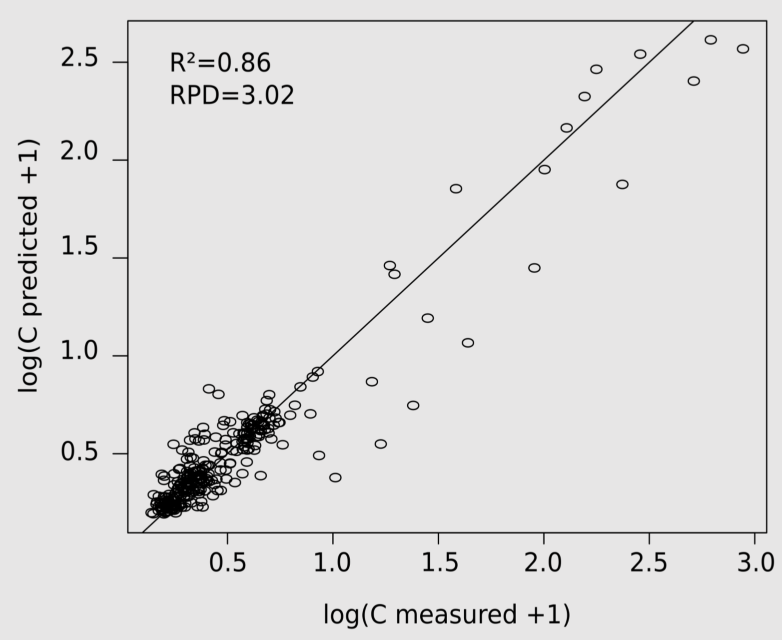
Resolution
53 x 53 µm² per pixel
One Vis-NIR reflectance spectra for each pixel





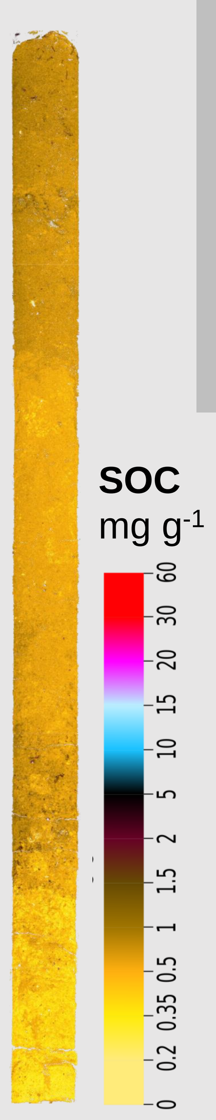
Extraction of spectral signature of all ROIs

Training of **multivariate model** to **predict C, N or P** from the spectral information. Comparison of various modelling algorithms (i.e. partial least square regression, random forest regression, artificial neural networks).



Model application

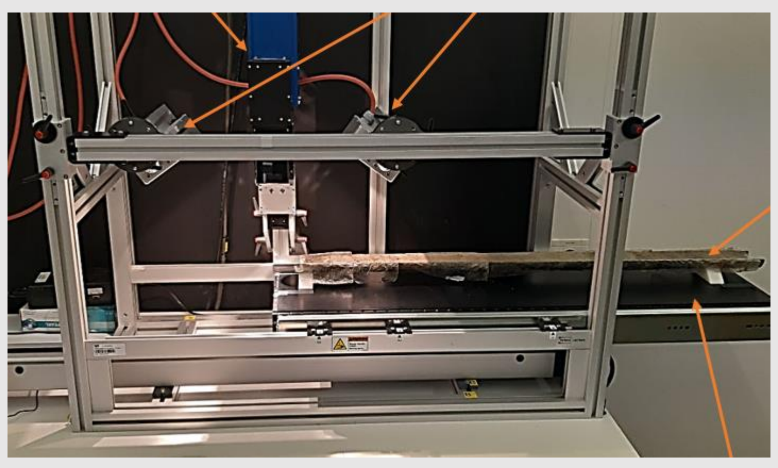
Example of C mapping using Random Forest



Advantages of hyperspectral imaging

Consider soil **small scale heterogeneities** in estimation of C, N and P stocks and changes

High spatial resolution provides more insights for process understanding



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