C stocks and subsoil management in agroecosystems: application of hyperspectral imaging to study organic matter dynamics in the top one metre of soil

SSS10.7: Scaling soil processes across space and time: leveraging models and data syntheses

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SOM dynamics and spatial scales

- Biological, physical and chemical influences on SOM changes act at a very small scales. While new techniques allow characterisation and understanding of mechanisms down to the nanometre scale, upscaling these results is necessary but still very challenging

- Evaluation of soil C management and modelling both require quantification at relatively large scales (field, landscape, region, …)

→Hyperspectral imaging offer the possibility to identify sub-millimetric features and variability **and** to upscale

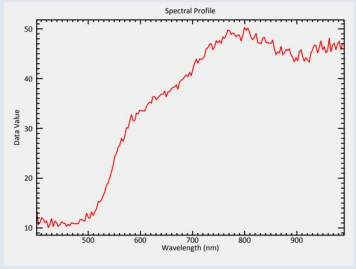
- What follows: introduction of **2 studies** showing how we can use this technique to resolve (i) small-scale SOM distribution through soil depth and (ii) decomposition of POM, with the potential for upscaling

Hyperspectral imaging of soil cores

Sampling of 1-m soil cores
Cut in 2 halves lengthwise

1st half for HS imaging

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



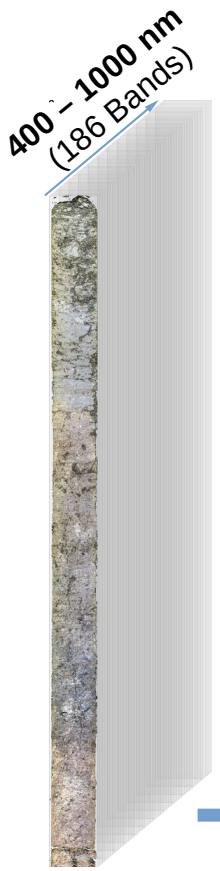
PCA
Dimensionality reduction

2nd half of the core divided
by depth increments
C, N, pH, density,...

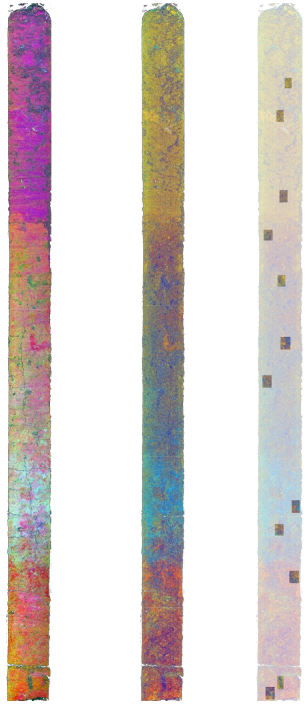
Select
12 to 20 ROIs based on
visualized variability
(PCA)

≈ 100 mg for
C and N meas.

Hyperspectral imaging of soil cores – SOC mapping



SNV
Normalisation of spectral information

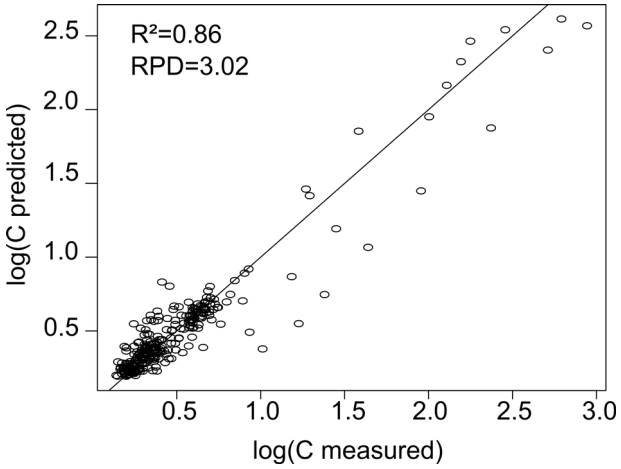


PCA

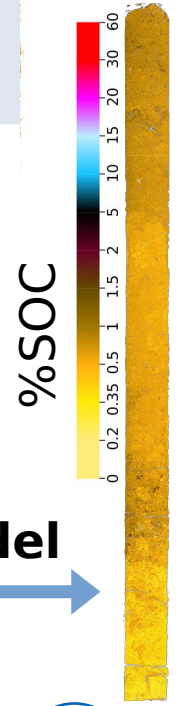
Extraction of spectral signature of all ROIs (measured SOC)

Training of multivariate models to predict C from the spectral information.

Model comparison: PLS vs Random Forest vs ANN



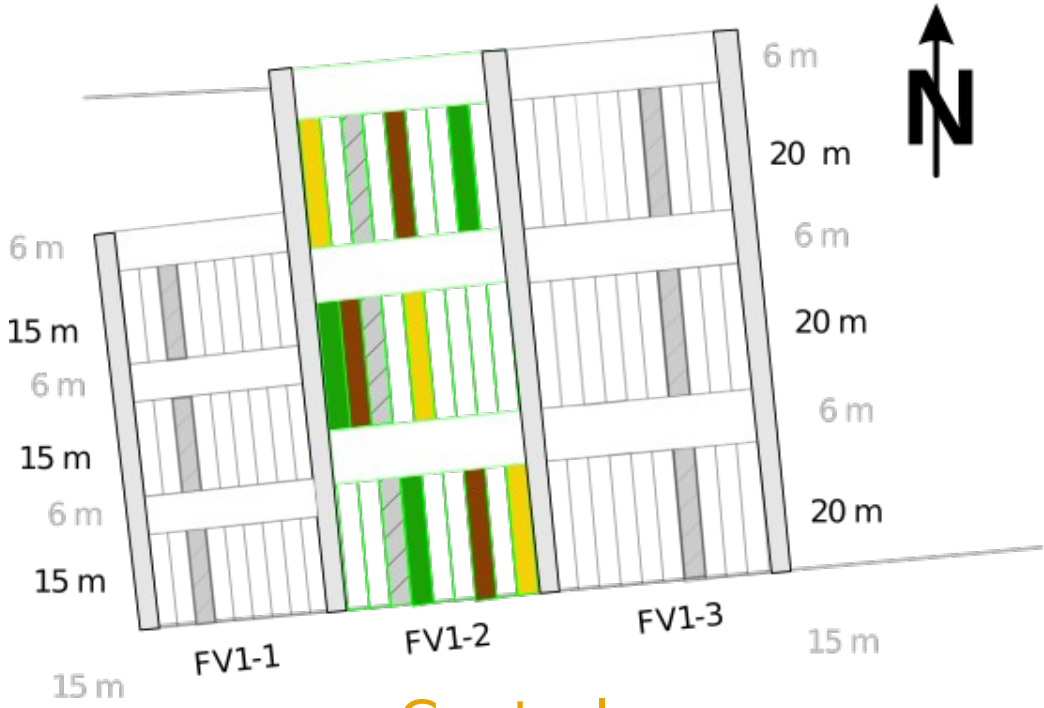
Apply RF model



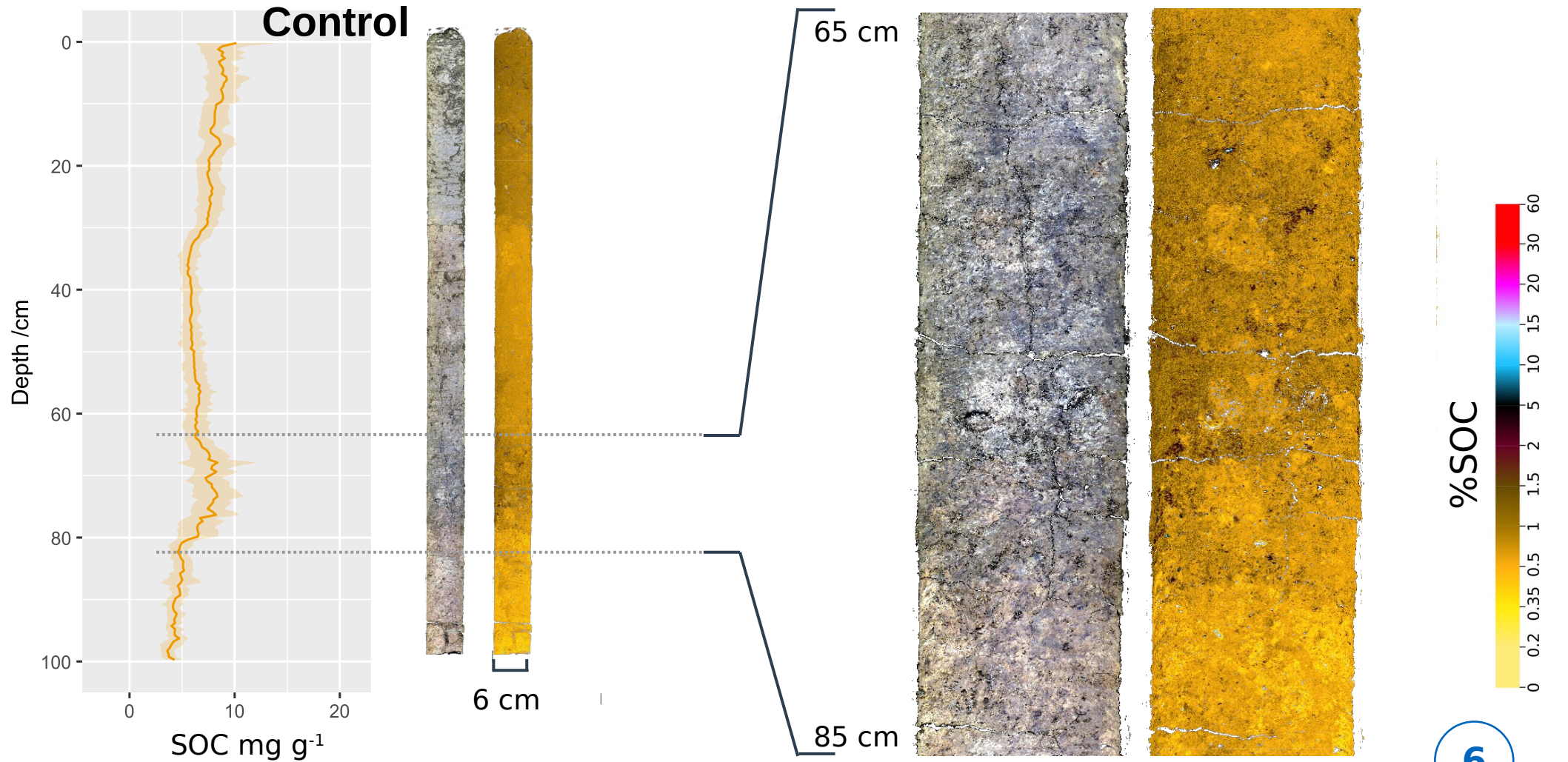
Hyperspectral imaging of soil cores – monitoring SOC stocks in a field experiment

- Experimental field @ Campus Klein-Altendorf (NRW, Germany)
- Effect of deep-loosening (**DL** 0-60cm) with incorporation of OM (11% vol.)

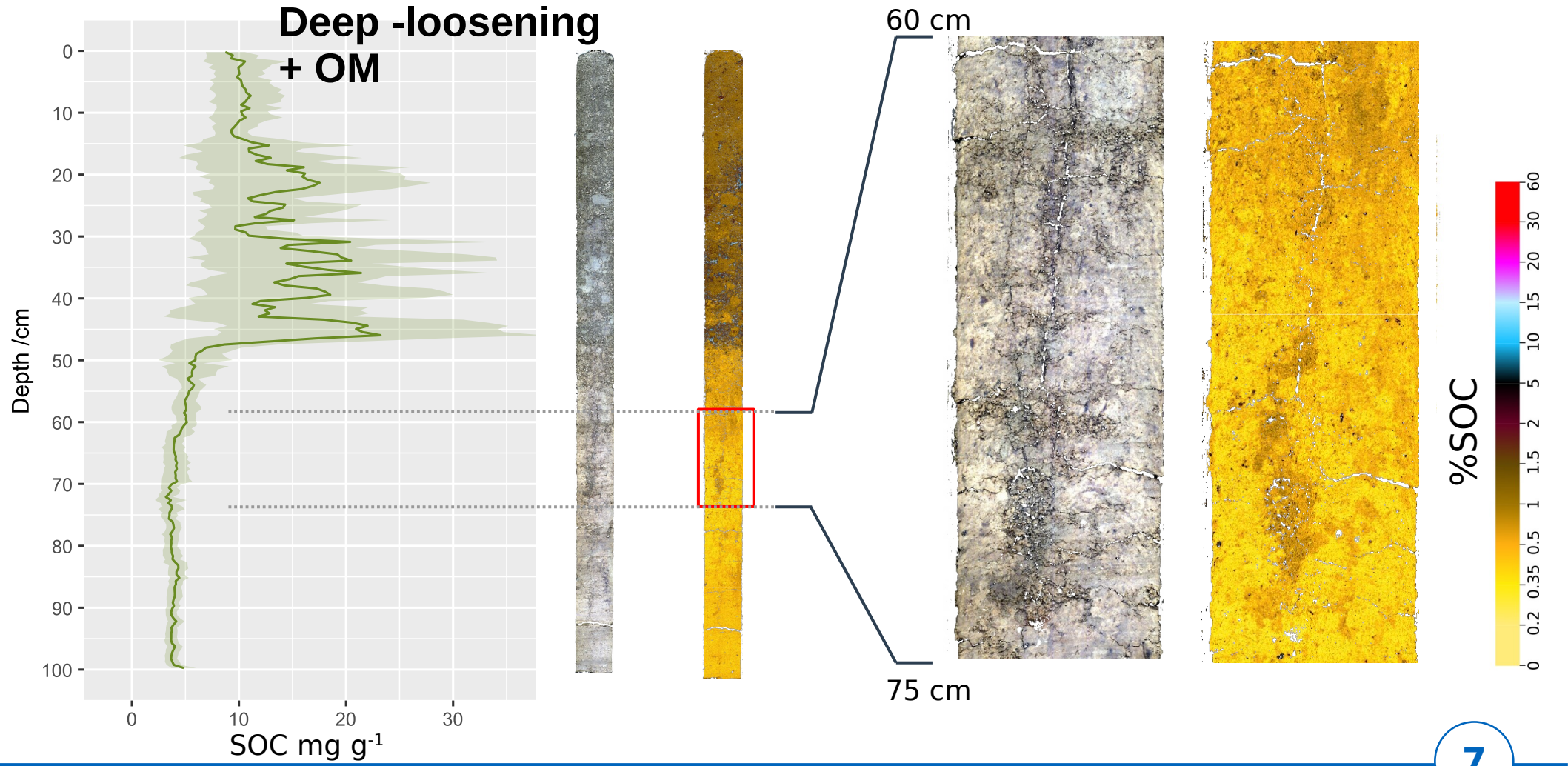
  done in 2016, sampled in 2018
- MAT=10.3 °C, MAP=670 mm
- Haplic Luvisol, derived from quaternary Loess, pH≈7.8



Hyperspectral imaging of soil cores – monitoring SOC stocks in a field experiment



Deep loosening + OM incorporation

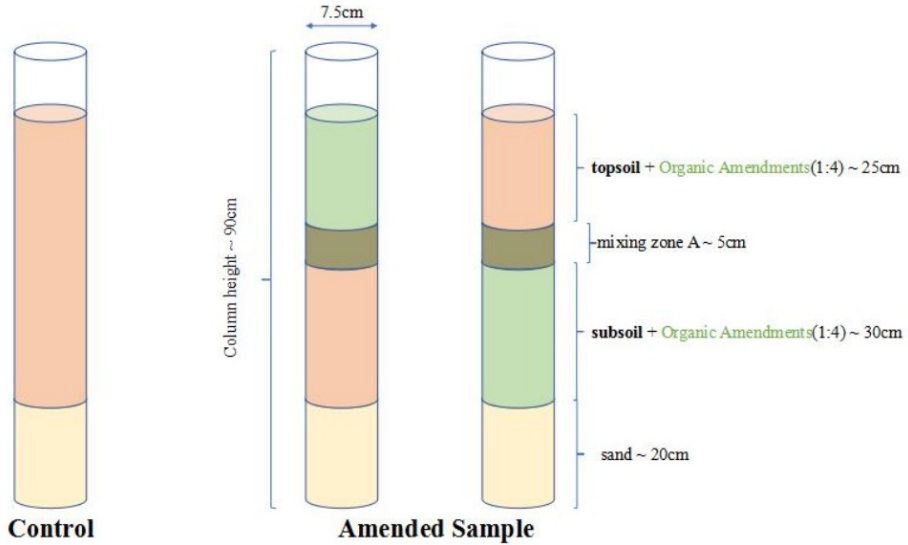


Hyperspectral imaging of POM – molecular composition

- Experimental design

- 180 days of incubation
- OM added into topsoil or subsoil
- Characterisation of POM (^{13}C NMR, C, N)

- Hyperspectral imaging
- Ensemble ANN models to predict **alkyl ratio** and **C/N**

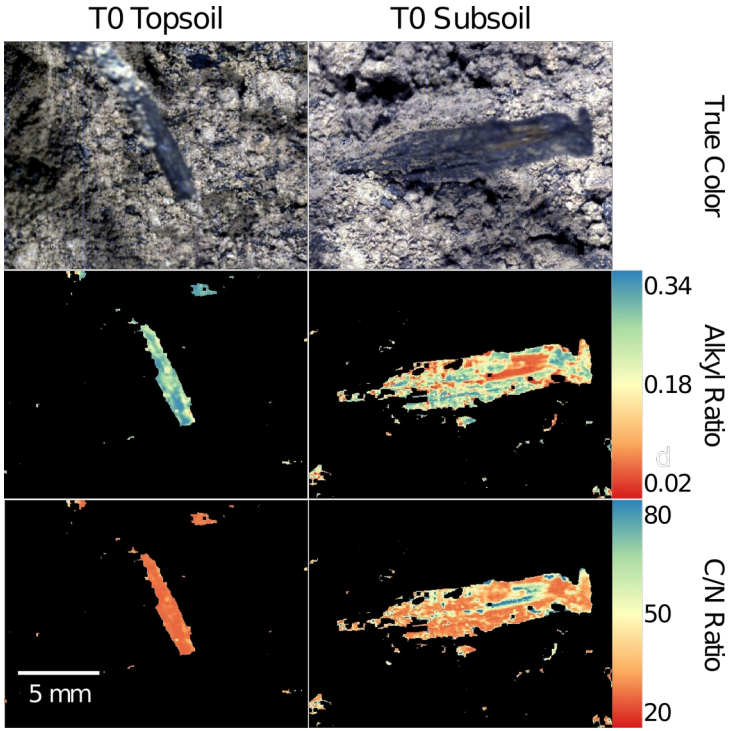


Hyperspectral imaging of POM – molecular composition

- C to N and alkyl ratio

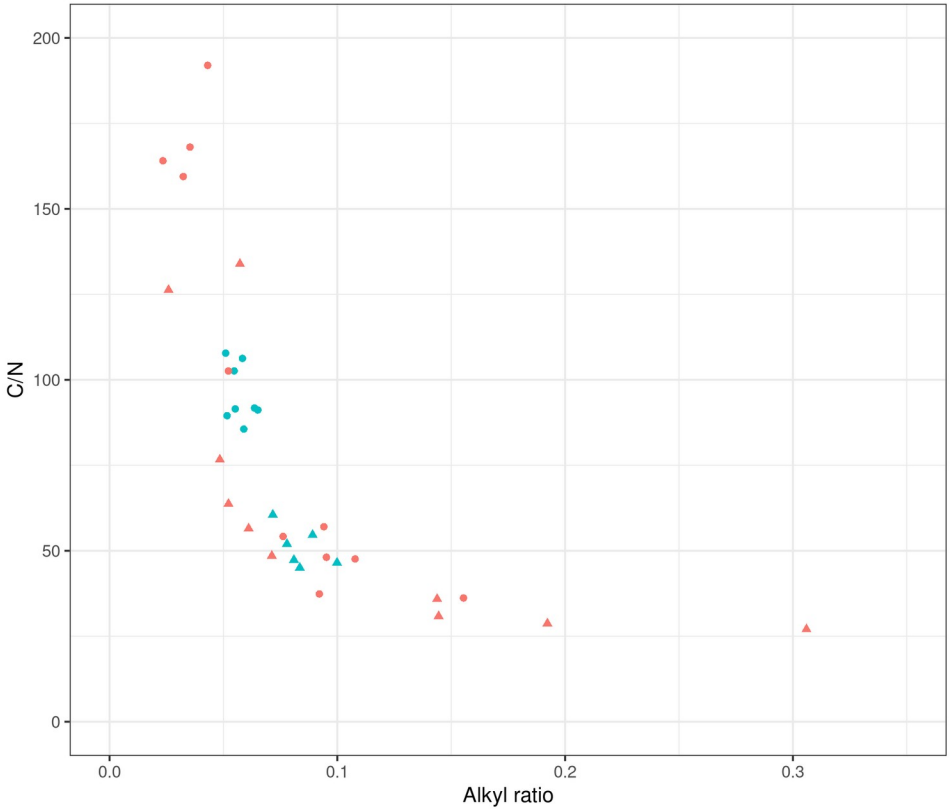
Model	RMSE	MAE	R^2
Alkyl ratio	0.020	0.014	0.86
C/N ratio	14.9	10.7	0.88

RMSE : root mean squared error, MAE : mean absolute error, R2 : coefficient of determination.



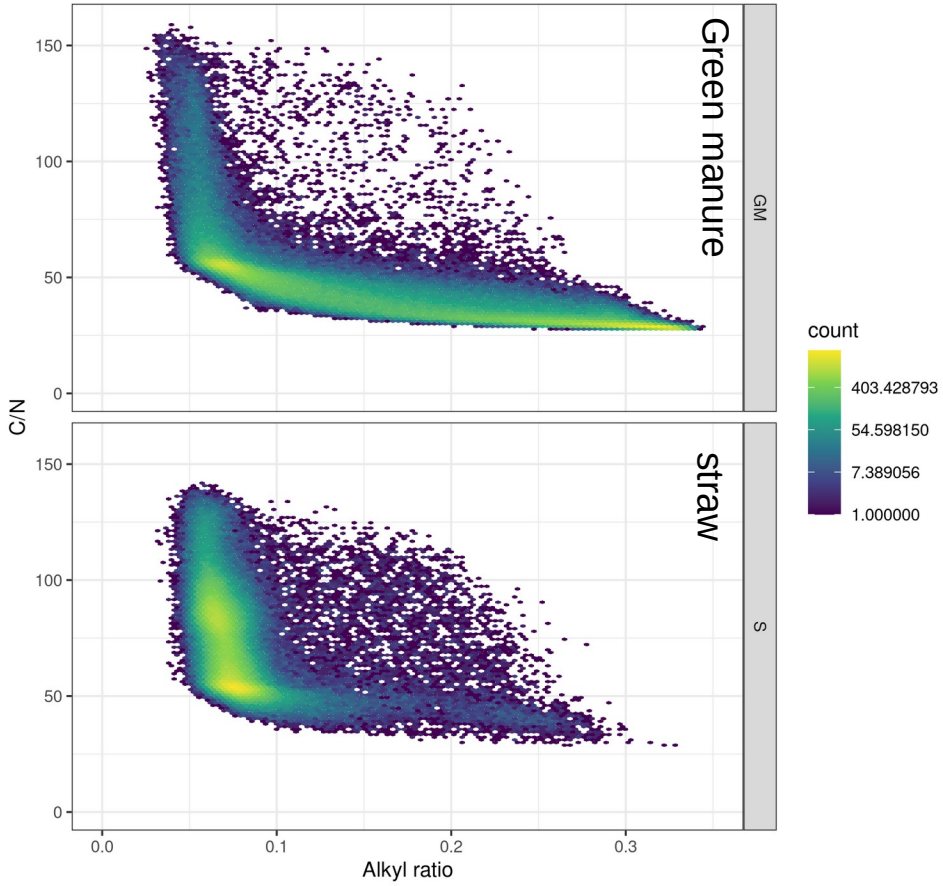
Hyperspectral imaging of POM – molecular composition

Measurements: ROIs



Relationship between Alkyl ratio and C/N measured in ROIs

Prediction: pixels



Relationship between Alkyl ratio and C/N predicted for each pixel

Summary

- Hyperspectral imaging of soil cores from an on-going field experiment
  Fine scale mapping of SOC distribution down to 1 meter

  → Allow to locate where changes resulting from management occur (hotspot/spread)
  → Guide for subsequent subsampling and nano/micro scale characterisation
  → Can be used for upscaling at the field/landscape level

- Hyperspectral imaging of POM coupled with molecular composition
  The first steps of POM decomposition spatially resolved

  → Link POM decomposition with surrounding environment?
  → Determine change in POM occurrence, particle size and molecular composition
  → dynamics of sub-millimetric features quantified in a 30 cm layer

- Sensors with broader range of wavelength and higher spatial resolution yield a great potential for SOM research

Thank you

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