Mapping soil organic carbon based on simulated EnMAP images and the LUCAS soil spectral library

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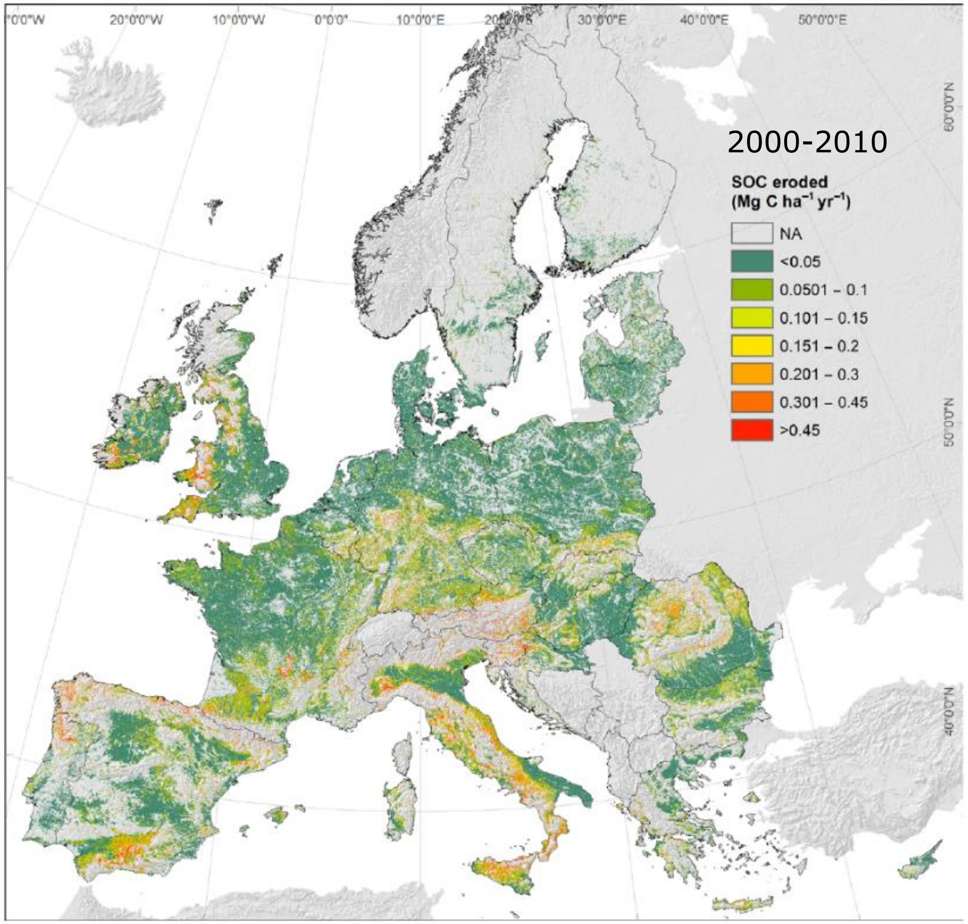
1. Introduction

- Soil degradation is a serious concern in Europe
  - e.g. reduction of carbon content
  - European Commission recommends research on monitoring of spatial and temporal changes of soils
- Traditional soil mapping is time consuming, expensive and point based

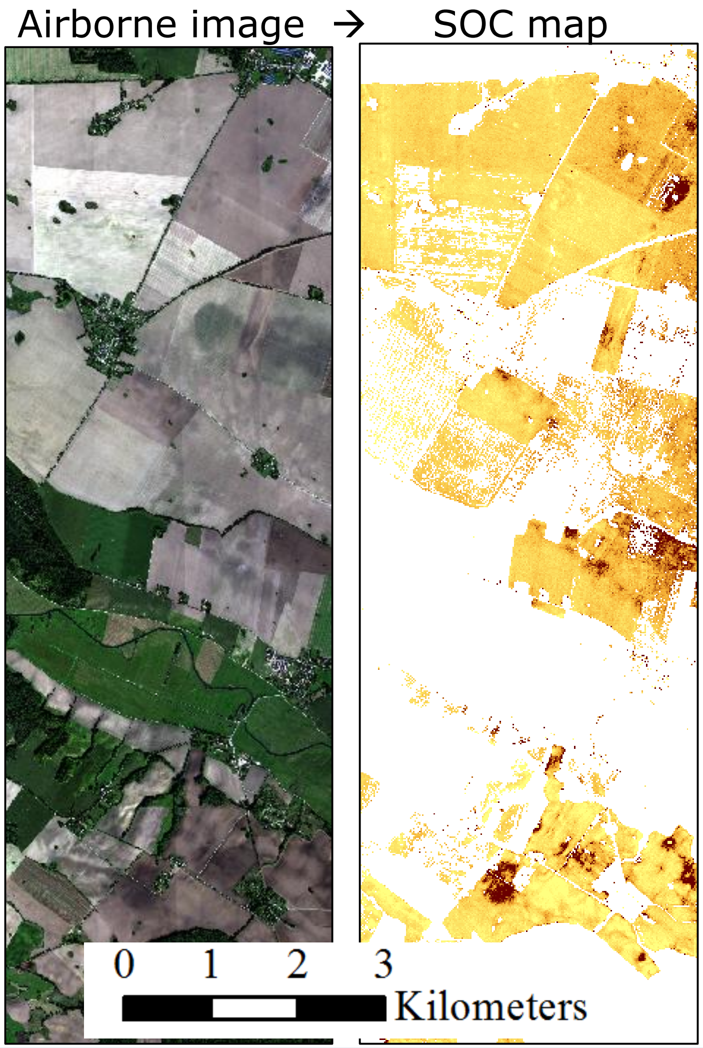
- Alternative: Quantification of soil properties by spectral reflectance in optical range
- Lower prediction accuracy on larger scales



Lugato et al. 2016: Quantifying the erosion effect on current carbon budget of European agricultural soils at high spatial resolution. Global Change Biology. 22. 1976-1984.

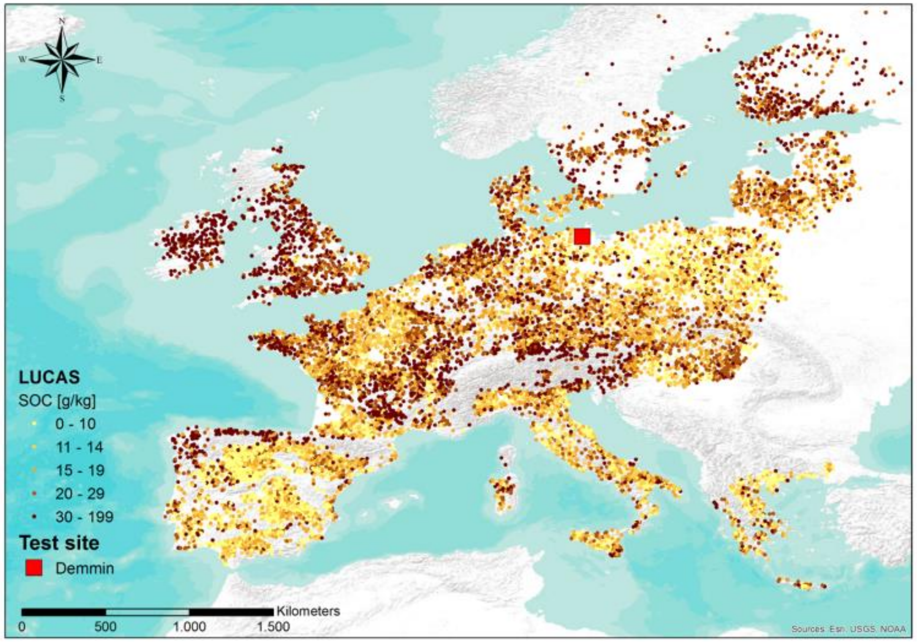
2. Goals

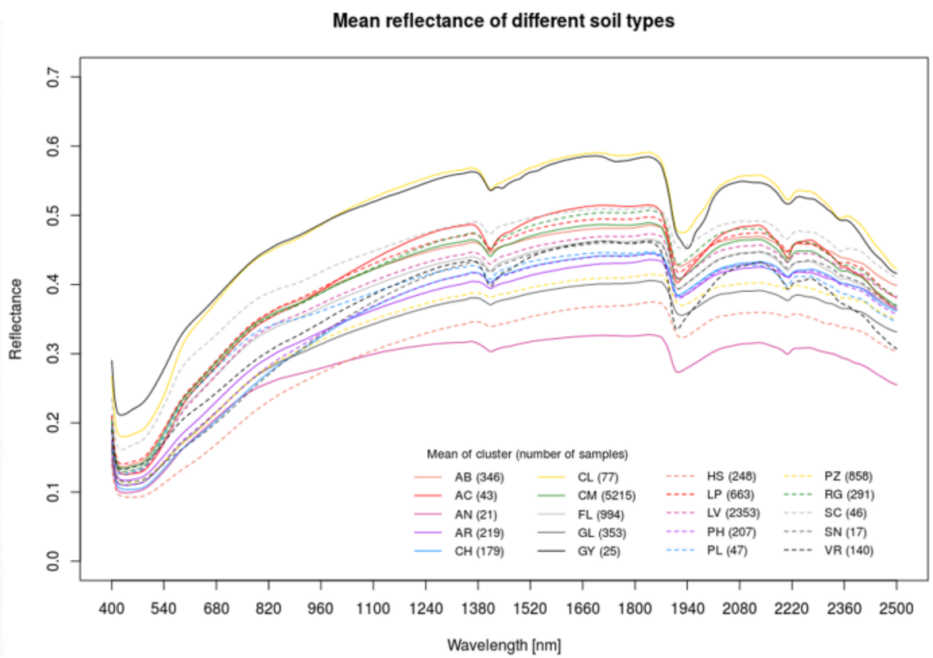
- Improve model accuracy on larger scales:
  - Calibration of robust models for the quantification of SOC using LUCAS' lab spectra
- Transfer point based lab approach to image data
- Application:
  - Validate on test site, also with simulated EnMAP scene
  - Create SOC maps



3. Data I: LUCAS Soil

- LUCAS = Land Use/Cover Area frame statistical Survey
- ~ 20,000 top soil samples → subset on agricultural areas (~ 8,000)
- 12 soil properties + lab spectra (400-2500nm, FOSS)
- Most complete and consistent soil spectral library at continental scale

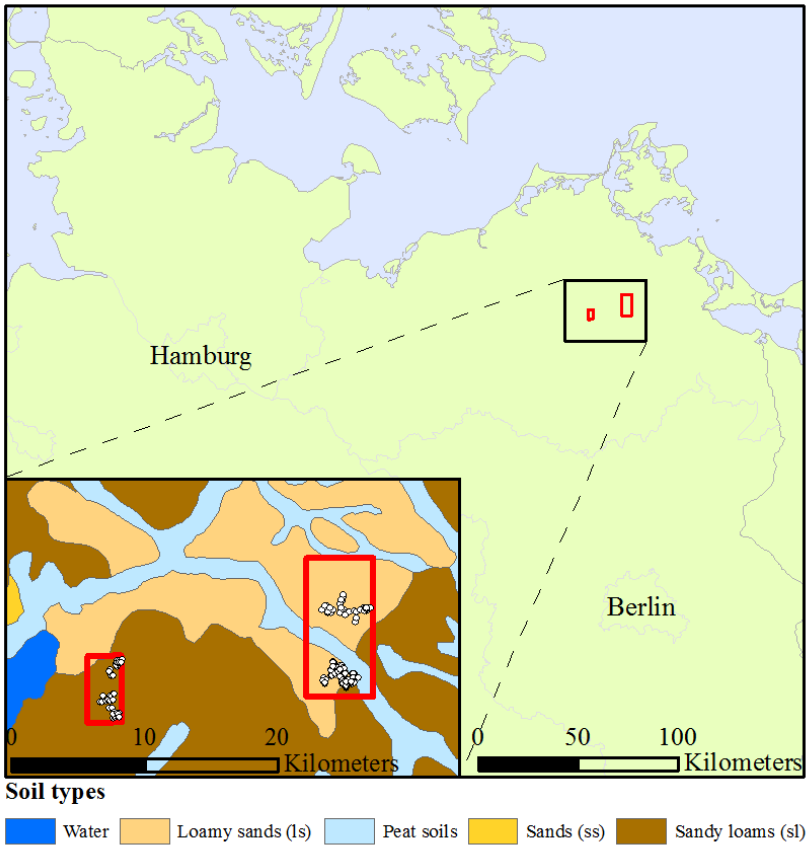




The LUCAS topsoil dataset used in this work was made available by the European Commission through the European Soil Data Centre managed by the Joint Research Centre (JRC), http://esdac.jrc.ec.europa.eu/.

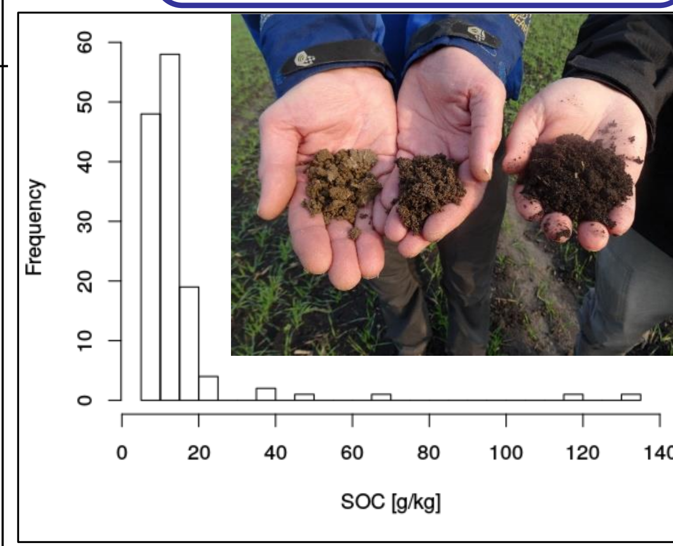
3. Data II: HySpex and EnMAP scenes, in-situ data

Test site:
TERENO NO Demmin, Germany



HySpex & simulated EnMAP (2015)

135 soil samples (2016/17)



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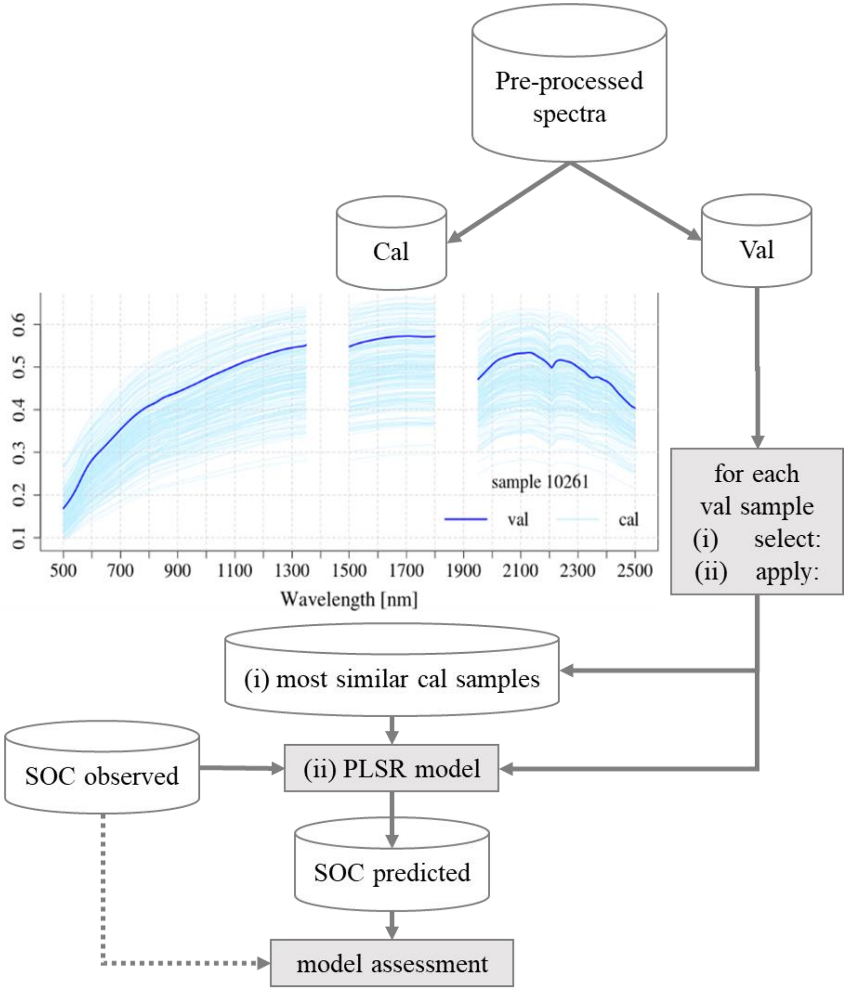
4. Methods: Local PLSR

i. Based on a spectral distance matrix for each validation sample the most similar calibration samples are selected

ii. Based on those calibration samples a PLSR model is caibrated and applied on this validation sample to predict the SOC content

These steps are repeated for each validation sample

Adaptive cluster based on spectral similarity are created



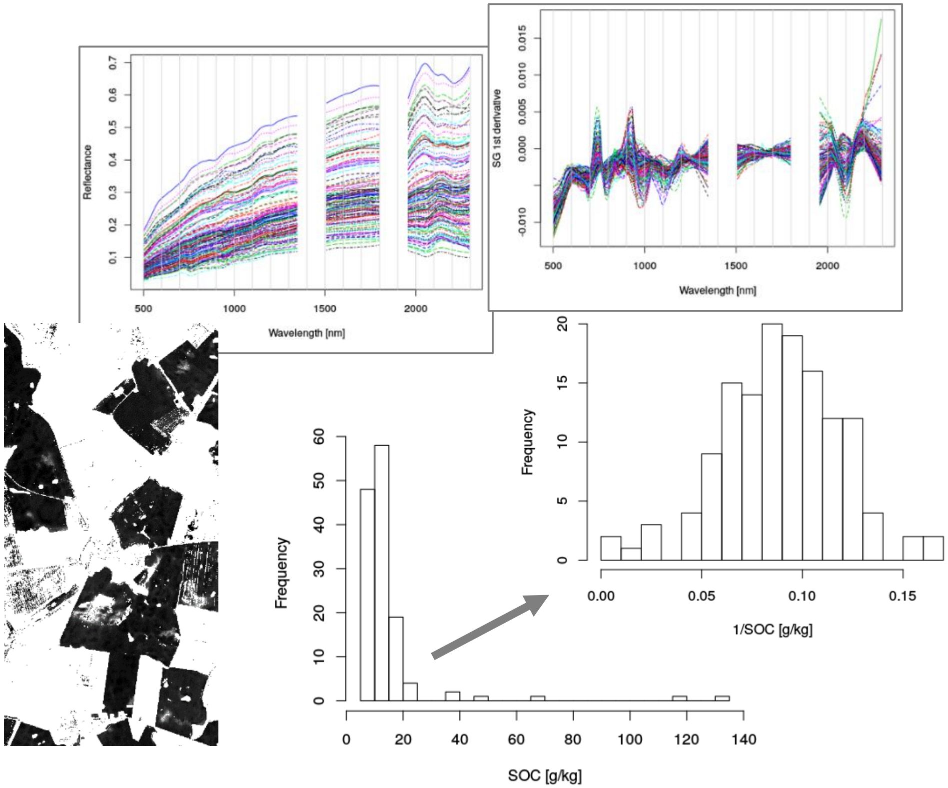
Adapted approach from: Nocita et al. 2014. Prediction of soil organic carbon content by diffuse reflectance spectroscopy using a local partial least square regression approach. Soil Biol. Biochem. 68, 337–347;

published in: Ward et al. 2019: A remote sensing adapted approach for soil organic carbon prediction based on the spectrally clustered LUCAS soil database. Geoderma. 353. 297-307

4. Methods: Local PLSR & airborne models

Pre-processing

- Removal of water and noisy bands
- Savitzky-Golay filter and first derivative
- Transformation of SOC content towards normal distribution
- Soil mask



Application

- No direct application of local PLSR to hyperspectral airborne images possible due to spectral differences lab/airborne and sensors
- Two-steps approach: Wet chemistry SOC measurements are replaced by SOC quantifications coming from local PLSR and LUCAS

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Ward, K.J., Brell, M., Castaldi, F., Spengler, D., Foerster, S. & S. Chabrillat 2020: Soil organic carbon mapping using simulated EnMAP imagery and LUCAS Soil. Remote Sensing. Subm. May 2020.

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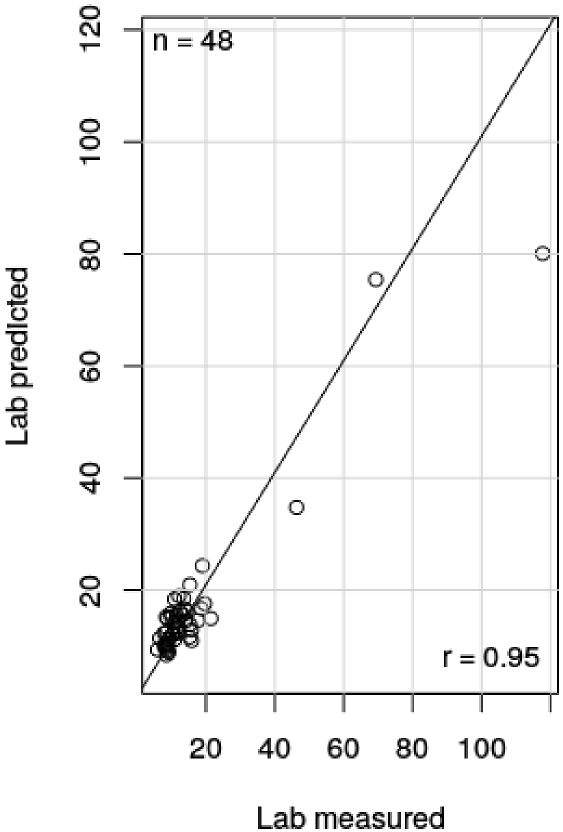
5. Results I

Preliminary results; SOC content in g/kg

Lab:

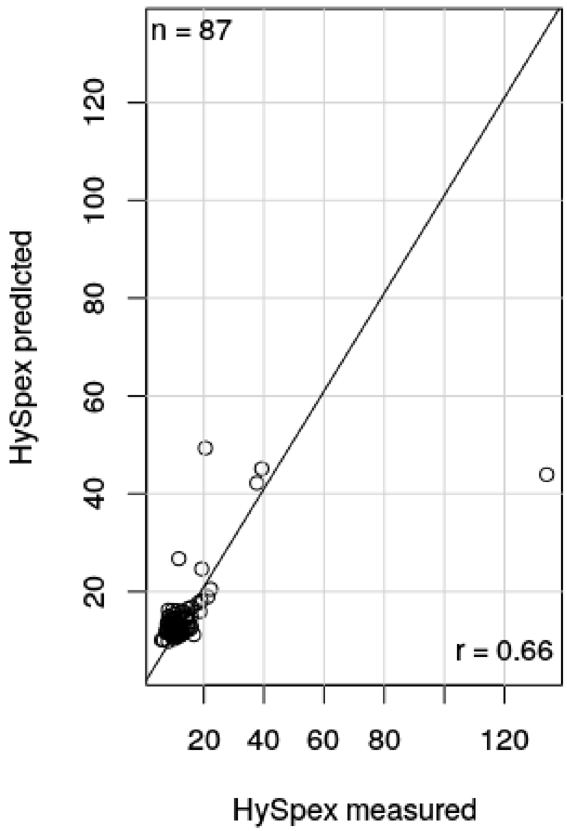
RMSE=6.77 g/kg
R^2=0.73
RPD=1.95



HySpex:

4x4m
416 bands

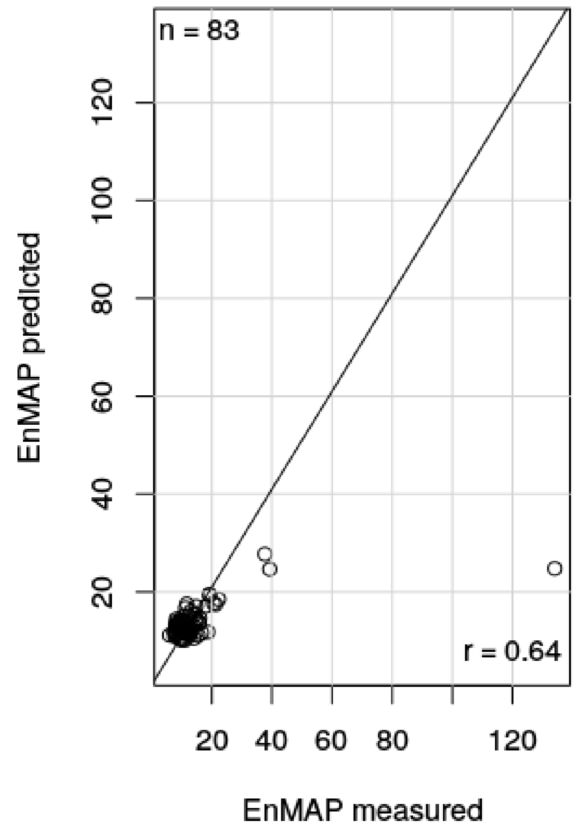
RMSE=3.33 g/kg
R^2=0.63
RPD=1.59



EnMAP:

30x30m
242 bands

RMSE=3.72 g/kg
R^2=0.55
RPD=1.45



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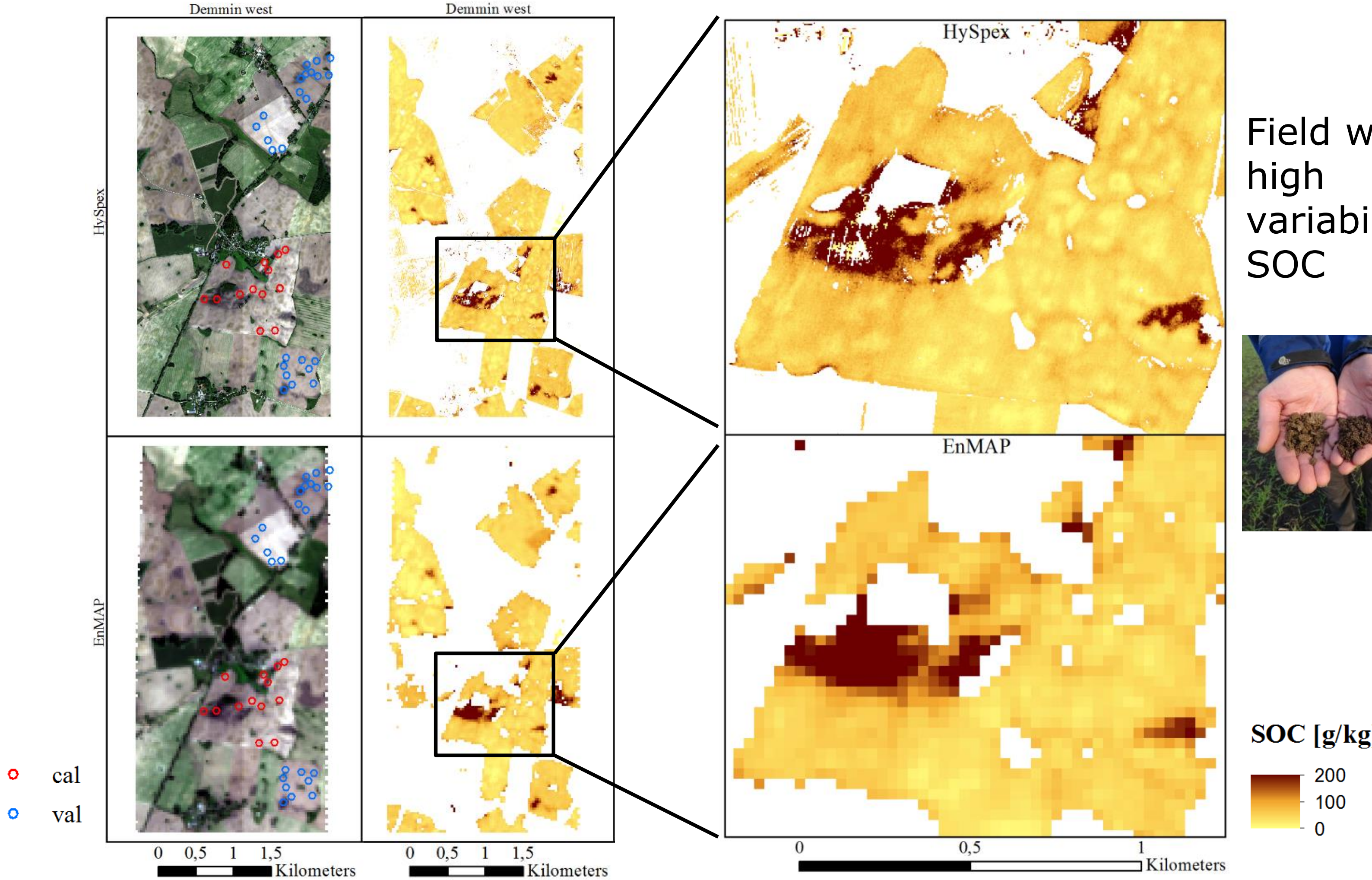
5. Results II

SOC maps, western study site

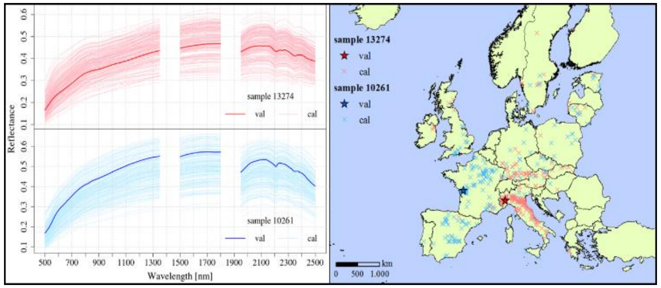


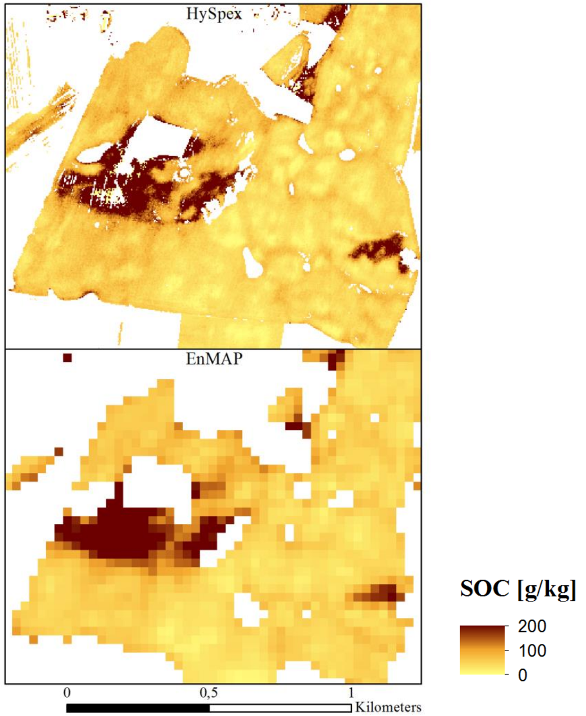
Field with high variability in SOC

Ward, K.J., Brell, M., Castaldi, F., Spengler, D., Foerster, S. & S. Chabrillat 2020: Soil organic carbon mapping using simulated EnMAP imagery and LUCAS Soil. Remote Sensing. Subm. May 2020.

6. Conclusion

- No direct application of local PLSR + LUCAS on image spectra → two-steps approach is a good alternative
- Applicable without knowledge of SOC content of soil samples
- Good results for simulated EnMAP images
- Quantification of higher SOC contents with higher uncertainties





7. Questions / Discussion

- Bridging the **gap between lab and air-/spaceborne** spectra: Applicability of predictive models using hyperspectral reflectance measured in the lab to those using image spectra?

- **Spatial transferability** of local site prediction models and how to find their spatial boundaries?

Thank you for reading the slides!

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