Optimal bare soil reflectance extraction over European agricultural land

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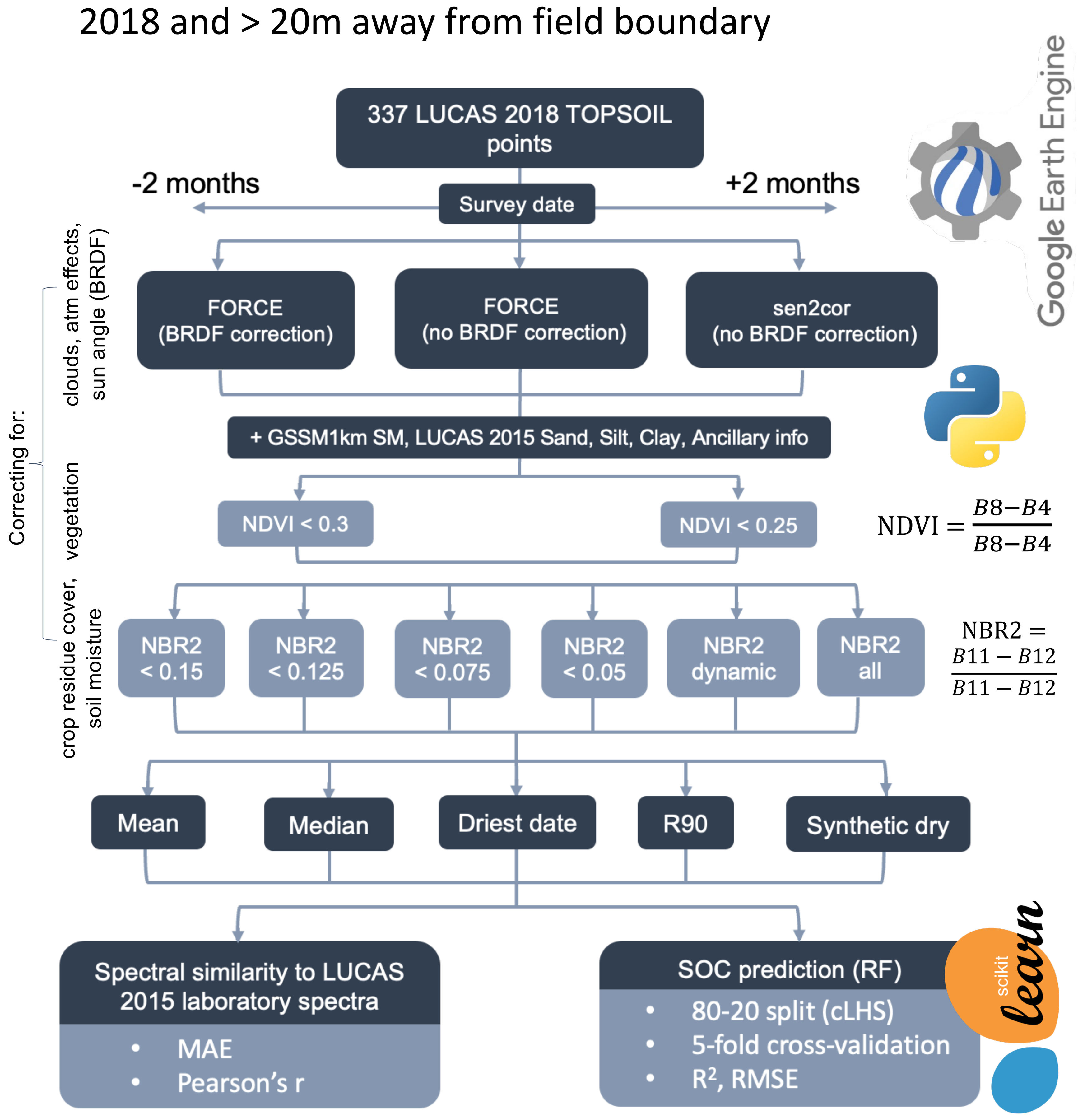
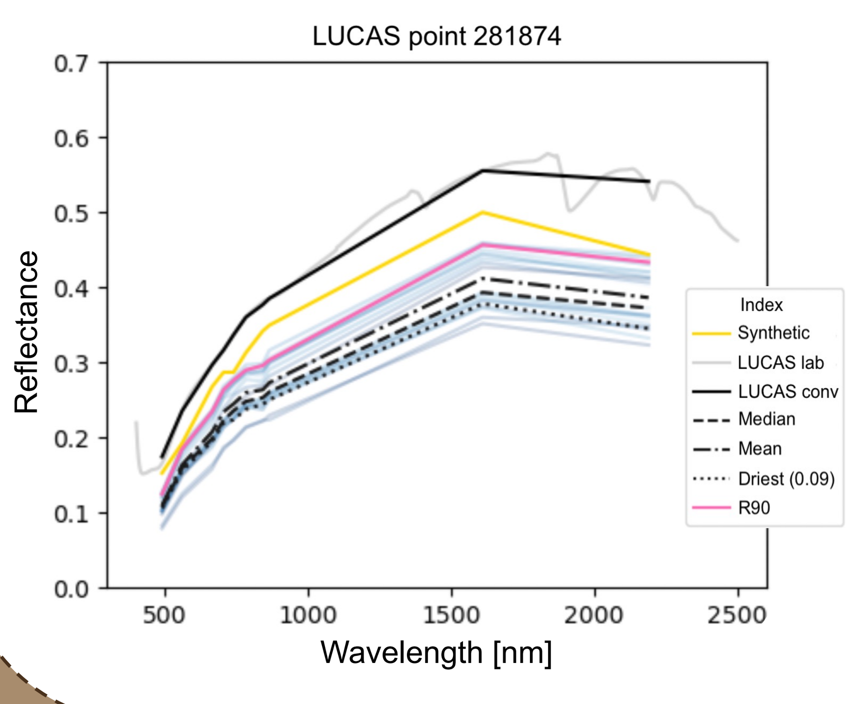
Background

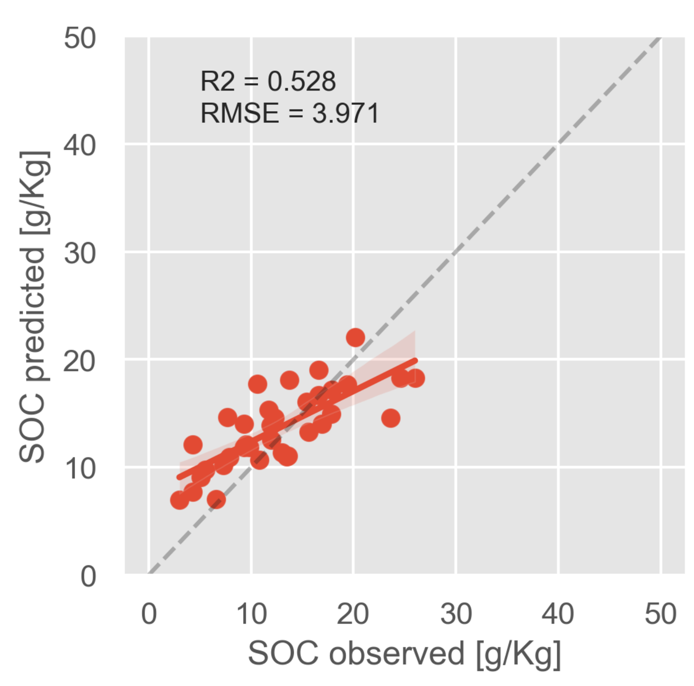
- **Increasing soil organic carbon (SOC) stocks in agricultural land worldwide could offset 3 to 7 years of global man-made emissions while increasing soil fertility and soil quality [1]**
- **Remote sensing can be used to complement traditional soil sampling campaigns for cheaper SOC monitoring at scale**
- **There is a need to improve the prediction performance of remote sensing-based SOC models, especially at continental (e.g. European) scale**
- **This work aims to improve SOC content estimates at European scale using LUCAS pictures as ground truth**

Methods

- Data sources: LUCAS Harmonised [2], Sentinel-2 SRF, Sentinel-2 FORCE processed imagery, LUCAS 2018 TOPSOIL, LUCAS 2015 TOPSOIL and Ancillary data, GSSM1km soil moisture dataset [3]
- Identified 337 agricultural/fallow land use points in LUCAS picture database that were **bare** at the time of survey in 2018 and > 20m away from field boundary







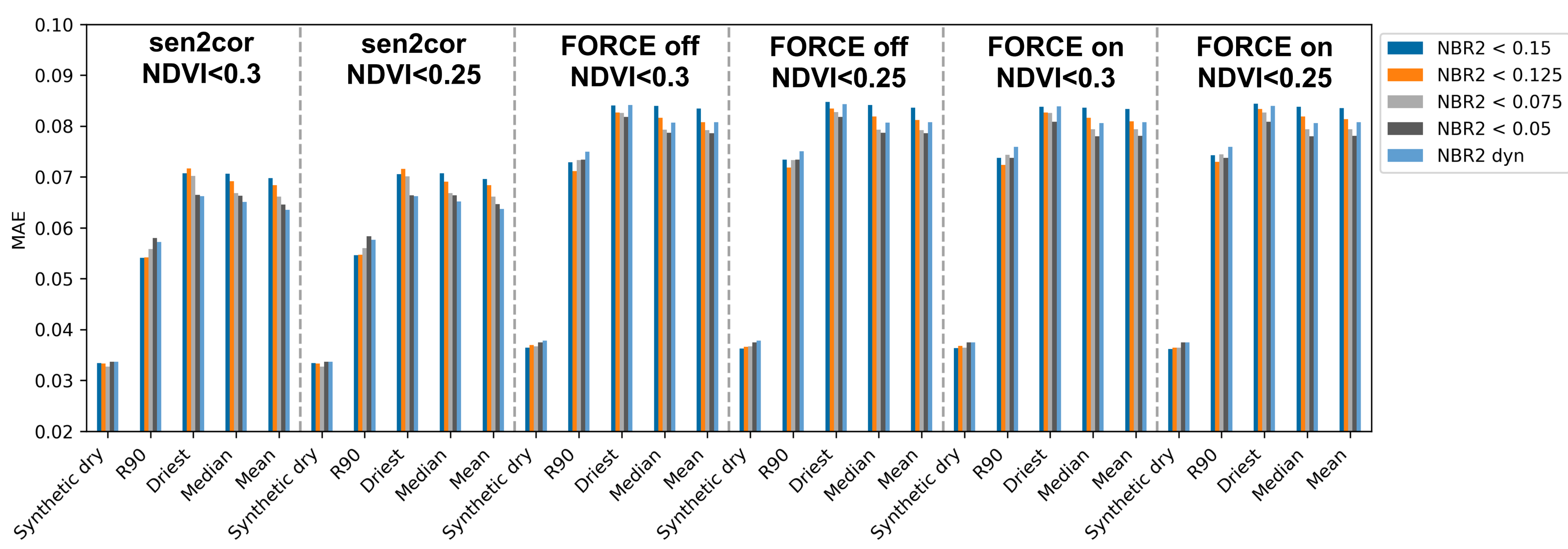
Initial findings

Dynamic NBR2

- A NBR2<0.05 masks out 26% of Calcisols, 19% of Umbrisols, 17% of Regosols and 22% of Vertisols in the LUCAS spectral database, so we threshold these at their 85th NBR2 quantile.

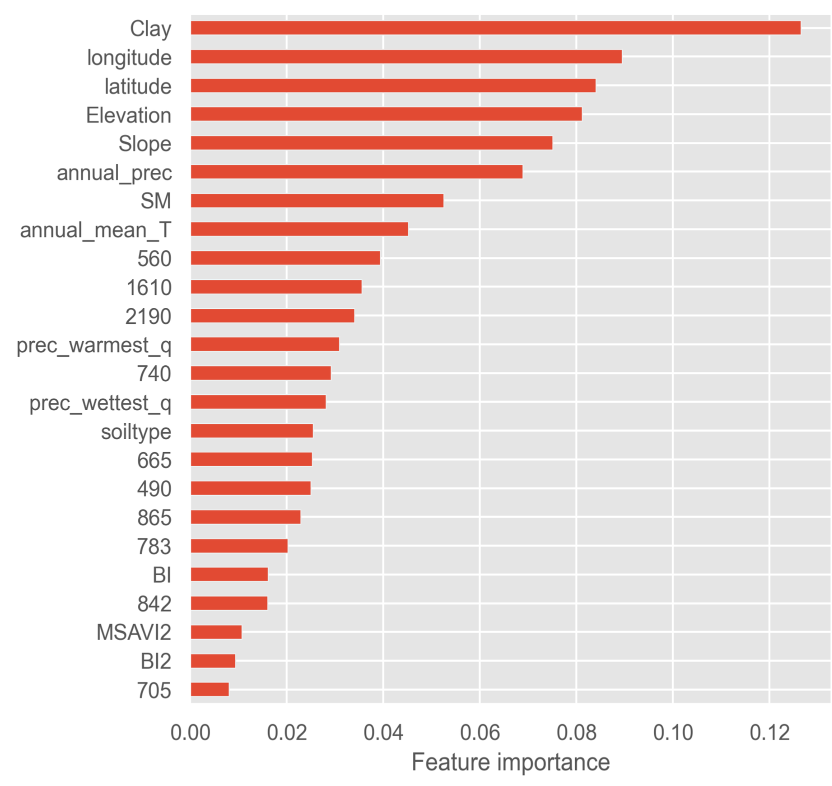
Spectral similarity

- FORCE shifts reflectance in B11 and B12, leading to an NBR2 on average 0.026 higher than sen2cor-processed data
- sen2cor-processed data has lower MAE than FORCE data
- Synthetic dry, R90 are a closer match to laboratory spectra
- Lower NBR2 threshold consistent with decreasing MAE for Driest date, Mean, Median approaches (not R90!)
- All methods have high Pearson's r (> 0.5)



SOC prediction performance

- sen2cor NDVI < 0.3, NBR2 < 0.05 (n=174) provided highest R^2 (0.53) and lowest RMSE (3.97 g/kg) than any other method
- Small sample size + cLHS stochastic as sample size decreases



Approach	R2	RMSE	n
R90, sen2cor, NDVI < 0.3, NBR2 < 0.05	0.53	3.97	174
Driest date, FORCE BRDF off, NDVI < 0.25, NBR2 < 0.15	0.52	4.06	156
R90, FORCE BRDF off, NDVI < 0.3, NBR2 < 0.125	0.48	4.03	157

Next steps

- Expand our methodology to the whole of LUCAS 2018 TOPSOIL agricultural and fallow land use points, using Sentinel-2 sen2cor imagery acquired over a longer observation period
- Include additional covariates to model SOC at European scale

References

[1] Padarian, J., Minasny, B., McBratney, A., Smith, P., 2022. Soil carbon sequestration potential in global croplands. PeerJ 10, e13740. https://doi.org/10.7717/peerj.13740
[2] d'Andrimont, R., Yordanov, M., Martinez-Sanchez, L., Eiselt, B., Palmieri, A., Dominici, P., Gallego, J., Reuter, H.I., Joebges, C., Lemoine, G. and van der Velde, M., 2020. Harmonised LUCAS in-situ land cover and use database for field surveys from 2006 to 2018 in the European Union. *Scientific data*, *7*(1), p.352.
[3] Han, Q., Zeng, Y., Zhang, L., Wang, C., Prikaziuk, E., Niu, Z., Su, B., 2023. Global long term daily 1 km surface soil moisture dataset with physics informed machine learning. Sci. Data 10, 101.

FORCE data was kindly provided by Mundialis Gmbh as part of BESTMAP. This project receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817501.
This research has been supported by the Natural Environment Research Council (NERC) through a SENSE CDT studentship (grant no. NE/T00939X/1). The LUCAS 2018 and 2015 topsoil datasets used in this work were 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

EARTH OBSERVATION FOR SOIL PROTECTION AND RESTORATION
06–07 March 2024 | ESA-ESRIN | Frascati (Rome), Italy

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