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Hyperspectral imaging of soil cores reveals greatest C storage in subsoil biopores

Eleanor Hobley (1), Sara Bauke (2), Markus Steffens (3), Wulf Amelung (2), and Ingrid Kögel-Knabner (1)

(1) Technische Universität München, Soil Science, Freising-Weihenstephan, Germany (nellie.hobley@wzw.tum.de), (2) University of Bonn, Germany, (3) Forschungsinstitut für biologischen Landbau, Switzerland

In most soils, organic carbon storage decreases with increasing soil depth. However, localised hotspots of C storage can occur throughout the profile, in particular in non-mixed soil horizons. Traditional sampling methods involve sampling discrete depth intervals or horizons and subsequent mixing of the samples. This masks the presence of hotspots for C storage in the profile, only enabling overall trends in the depth distribution to be investigated. Hyperspectral imagery of soil profiles overcomes this limitation, providing information on the distribution of C in the soil profile at high spatial resolutions.

Here we present a hyperspectral approach to the characterisation of soil organic carbon down the soil profile. Soil cores with a diameter of 6 cm were sampled to a depth of 1 m from an agriculturally used, cropped loam in western Germany. The cores were sliced in half vertically and air-dried prior to hyperspectral imaging in the region 400-1000 nm. 'Regions-of-interest' of $\sim$1 cm^2 were visually identified based on characteristic features (structure, colour) within the soil profiles and sampled for C analysis. randomForest models were then trained to predict the C content based on the spectral features of the regions of interest for the entire soil cores. The models performed very well (R^2>0.9) at predicting profile C content.

Using these predictions, we were able to investigate the distribution of C down the continuous soil profiles. The ploughed topsoil was more homogeneous than the undisturbed subsoil, with an average C content of 9 $\pm$ 1 mg/g. Although the C content decreased overall from the surface to the deeper subsoil (C content 3 $\pm$ 1 mg/g at 80 to 100 cm), the highest C content in any sample was detected in a subsoil biopore, at 15 mg/g. Measures to increase the density of biopores in the subsoil, such as enrichment of subsoil nutrients or reduction of subsoil compaction are therefore likely to sequester C in subsoil horizons.