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Performance of different VNIR spectroscopic techniques for determining soil organic carbon contents

A. Stevens (1), B. van Wesemael (1), H. Bartholomeus (2), B. Tychon (3)and E. Ben-Dor (4)

(1) Department of Geography, Université catholique de Louvain (antoine.stevens@uclouvain.be), (2) Centre for Geo-Information, Wageningen University, (3) Department of Environmental Sciences and Management, University of Liège, (4) Department of Geography and Human Environment, Tel Aviv University.

Visible and Near InfraRed (VNIR) reflectance spectroscopy can be a suitable technique to rapidly quantify various soil characteristics simultaneously. Soil reflectance can be measured either in the laboratory or in-situ (proximal and remote sensing). Spectra can also be collected one point at a time (point spectroscopy) or as a one- or two-dimensional array of measurements (on-line and imaging spectroscopy). Here, performances of different instrumental settings (laboratory, field and airborne spectroscopy) in determining Soil Organic Carbon (SOC) content in agricultural soils are compared.

Three different study areas were monitored in the Belgian Ardennes and Lorraine with various soil types and a wide range of SOC content (5-37 g C kg^{-1}) during 2 different field campaigns in 2003 and 2005. A total of 201 bare plots were sampled and analysed for SOC content with the Walkley-Black method. The soil reflectance was measured in the laboratory with a VNIR spectrometer (ASD Fieldspec Pro, 350-2500 nm) and in the field with (a) a portable ASD and (b) an hyperspectral remote sensor (AHS160, 400-2500 nm). After standard spectral pre-treatments, the relationship between soil spectra and measured SOC content was calibrated with Partial Least Square Regressions (PLSR) and validated.

RMSE in the validation of laboratory and field spectroscopy reaches values of 1 g C

kg^{-1}. Those values are comparable to the limit of repeatability of the Walkley-Black method. The remote instrument has some difficulties to reach such values. This lower validation result was attributed to the poor quality of spectral data. Despite the low precision achieved by the airborne sensor the SOC content of the bare fields were predicted for each pixel. Maps show some differences between sampling points and predicted values but the overall variability is respected. The carbon content means, as estimated by field samples and the remote sensor, are equivalent (low bias, difference <1 C g kg^{-1}).

The use of different datasets (field spectroscopy) from different study areas and field campaigns showed that calibrations are currently site-specific and partly fail to predict, under a proper test set validation procedure, samples belonging to another study area or falling outside of the range of the calibration set. Further research is needed to develop regional spectral libraries and standard spectral measurement protocols under field conditions in order to be able to use field and airborne VNIR spectroscopy as an operational robust analytical technique.