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# Validation of soil organic carbon predictions based on airborne imaging spectroscopy and multivariate regressions

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During the last decade, airborne imaging spectroscopy has been recognised to hold a strong potential in the quantitative mapping of soil properties at different scales. A given soil property is usually predicted using an empirical/statistical approach, during which a relationship is established between the property and spectral information using calibration samples analysed through conventional methods. The specific nature of spectral data (high-dimensionality and multi-collinearity) requires the implementation of specific multivariate calibration tools such as Multiple Linear Regression, Partial Least Square Regression, Multivariate Adaptive Regression Spline, etc. The derived calibration model is then used to predict the values of unknown locations using the reflectance. A test set is often extracted from the soil sample database to validate the model. Multivariate calibration methods can perform very well for laboratory spectral data. However, such methods are very sensitive to small difference in the predictors arising e.g. from variation in measuring conditions. As a consequence, statistical methods are often considered as site- and sensor-specific due to spatio-temporal variation in soil characteristics not related to the studied property. Under field conditions, soil reflectance is indeed the result of complex interactions between incoming solar radiations, surface characteristics (roughness, vegetation residues) and soil physical/chemical properties (soil organic carbon, moisture, clay, iron oxides, etc…). Accuracy of the predictions will therefore depend on the representativeness of the calibration model in comparison with the entire spectral data cube. While this is not a fundamental problem at small scales, this can strongly degrade predictions in large study areas and hence reduce the potential of imaging spectroscopy.

The purpose of this study is to validate predictions of Soil Organic Carbon (SOC) obtained in a previous study. The study area (Grand-Duchy of Luxembourg; ∼420 km2) was over flown by the AHS-160 imaging spectrometer (63 spectral bands; 2.6 m pixel size; 430-2540 nm). The dataset collected during the flight campaign consisted in 325 soil samples distributed in 47 fields. This dataset was randomly split into a calibration and a test set. Reflectance data were related to surface SOC contents by means of Partial Least Square Regression and Penalized-spline Signal Regression. Calibration and test sets were not independent of each other since they covered the same set of fields. In order to evaluate the actual predictive ability of our model, a second field campaign was organized to collect samples over fields that were not included in the existing calibration/test sets and hence that may represent different part of the spectral data cube. This second field campaign added 114 samples coming from 45 randomly selected fields. Predictive errors of both field campaigns are compared. Cluster analysis and Mahalanobis distance are also used to estimate their representativeness within the entire spectral data cube. Based on these result, a part of the available soil pixels was excluded from further predictions and considered as outliers in relation to the calibration model. A SOC map was then produced with meaningful estimates of uncertainties.