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Performance degradation in predicting topsoil organic carbon contents using reflectance spectra from lab, field to SPOT scales over a periurban region

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Within the framework of the French Gessol3 Programme (Prostock project), this study aims at comparing various observation scales for predicting topsoil organic carbon (SOC) content using Vis-NIR-SWIR reflectance spectra successively collected at the lab, in bare agricultural fields or extracted from atmospherically corrected multispectral SPOT images of very high (2.5 m) and medium low (20 m) spatial resolutions. The spatial coverage is that of a large periurban area (221 km^2) characterized by cereal cropping systems and contrasting soil types. Considering either regional (entire periurban area) or local (a 6 ha-experimental field) scales, SOC contents were estimated from Partial Least Squares Regression (PLSR) modelling of lab and field spectra, for a number of latent variables comprised between 1 and 20. Regression robustness was evaluated through a series of 500-1000 bootstrapped datasets of calibration/validation samples generated amongst a total of 165 sampled sites. The optimal number of latent variables (BestComp) was chosen considering the lowest median validation Root Mean Square Error (RMSE) and for this BestComp, calibration/validation sets leading to minimum, median and maximum validation RMSE were considered. For satellite images, SOC contents were estimated from multiple linear (ML) modelling and the calibration/validation set leading to lowest calibration RMSE was selected for applying regression equation to the image pixels with bare soils. RMSE, bias and uncertainty were compared between the different models.

At the regional scale, PLSR lab and field-based SOC models resulted in median validation RMSE values of $\sim$3 $g.kg^{-1}$and $\sim$4 $g.kg^{-1}$ respectively ($\leq$0.95 $g.kg^{-1}$ locally for lab-based models), while ML image-based SOC models resulted in median validation RMSE values between $\sim$4-6.6 $g.kg^{-1}$. Using an additional independent set of pixels with bare soils, ML models applied to the SPOT images were 'post-validated' resulting in validation RMSE values of $\sim$4-5 $g.kg^{-1}$at the regional scale and $\sim$3 $g.kg^{-1}$ locally. Image-based models thus resulted in acceptable validation errors, in possible agreement with the need to spatially monitor SOC contents of regional territories. However, having higher validation bias and error uncertainty than lab or field-based models, they should be considered with caution.