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Mapping soil organic carbon based on simulated EnMAP images and the LUCAS soil spectral library

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The degradation of European soils is a cause for concern. Examples are the reduction of carbon content and soil fertility. The European Commission therefore recommends further research on how to better monitor soils and their changes over time and space. Digital soil mapping (DSM) is already an established method for the use of hyperspectral information from soil samples for quantifying soil properties under laboratory conditions based on soil spectral libraries. At the remote sensing level, imaging spectroscopy has already achieved good results for the prediction of soil properties on a local scale. Major advantages of this method are that topsoil maps can be updated more frequently, spatially more accurately and with less costs.

In this study we bring together pedometric and remote sensing approaches to achieve the development of soil spectral models applicable to upcoming global hyperspectral imagery, combining DSM methods and data with Earth Observation expertise. In a first step at laboratory level, we used the EU-wide topsoil database LUCAS. We investigated whether using solely spectral data (without any covariates) and selected classification algorithms combined with PLSR could allow and improve the quantification of soil organic carbon (SOC) content. The best results were obtained for the local PLSR approach with RMSE=5.16 g kg-1, RPD=1.74 and R^2=0.67. In addition, the local PLSR approach was tested with LUCAS spectral data resampled to EnMAP satellite spectral resolution, resulting in a very similar SOC prediction model accuracy.

In the next step, the local PLSR approach was applied to airborne HySpex image data and simulated satellite EnMAP data from a test area in north-eastern Germany where local soil data are available for model validation. This area is associated with one LUCAS point. A direct application of the laboratory-based SOC model to the spectra of the airborne image was not possible due to higher variability in the image data caused by different environmental conditions (solar illumination, mixed soil-vegetation pixels, surface state -roughness, wetness-) and sensor performances different from the laboratory data resulting in an overall lower signal-to-noise ratio in the airborne image. Therefore, after reducing the effect of soil moisture, green vegetation cover, residues coverage, we used a two-step approach where (i) wet chemistry SOC analyses for a set of soil samples from the test area were replaced by the local PLSR approach using the LUCAS

database. Then (ii) an airborne model was calibrated using the SOC content from (i) and the corresponding image spectra to calibrate an airborne PLSR. Preliminary results show a good airborne model accuracy for HySpex imagery with RMSE=3.33 g kg-1, RPD=1.59, R^2=0.63 and slightly lower but still good accuracy for simulated EnMAP imagery with RMSE=3.72 g kg-1, RPD=1.45, R^2=0.55. Both models were then applied to the images to produce SOC maps for bare soils and validated with existing data and previous SOC mapping works in the area based on local datasets. This approach demonstrates the possibility to replace wet chemistry by the local PLSR approach based on large scale soil spectral libraries for SOC mapping.