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Mapping within-field variations of soil organic carbon content using UAV multispectral visible near-infrared images

Jean-Marc Gilliot, Emmanuelle Vaudour, and Joël Michelin
UMR ECOSYS, AgroParisTech, INRA, Université Paris-Saclay, 78850, Thiverval-Grignon, France

This study was carried out in the framework of the PROSTOCK-Gessol3 project supported by the French Environment and Energy Management Agency (ADEME), the TOSCA-PLEIADES-CO project of the French Space Agency (CNES) and the SOERE PRO network working on environmental impacts of Organic Waste Products recycling on field crops at long time scale. The organic matter is an important soil fertility parameter and previous studies have shown the potential of spectral information measured in the laboratory or directly in the field using field spectro-radiometer or satellite imagery to predict the soil organic carbon (SOC) content. This work proposes a method for a spatial prediction of bare cultivated topsoil SOC content, from Unmanned Aerial Vehicle (UAV) multispectral imagery.

An agricultural plot of 13 ha, located in the western region of Paris France, was analysed in April 2013, shortly before sowing while it was still bare soil. Soils comprised haplic luvisols, rendzic cambisols and calcaric or colluvic cambisols. The UAV platform used was a fixed wing provided by Airinov® flying at an altitude of 150m and was equipped with a four channels multispectral visible near-infrared camera MultiSPEC 4C® (550nm, 660nm, 735 nm and 790 nm). Twenty three ground control points (GCP) were sampled within the plot according to soils descriptions. GCP positions were determined with a centimetric DGPS. Different observations and measurements were made synchronously with the drone flight: soil surface description, spectral measurements (with ASD FieldSpec 3® spectroradiometer), roughness measurements by a photogrammetric method. Each of these locations was sampled for both soil standard physico-chemical analysis and soil water content. A Structure From Motion (SFM) processing was done from the UAV imagery to produce a 15 cm resolution multispectral mosaic using the Agisoft Photoscan® software.

The SOC content was modelled by partial least squares regression (PLSR) between the laboratory analyses and the multispectral information for the 23 plots. The mean squared error of cross validation (RMSECV) by LOO (Leave One Out) method was 1.97 g of OC per kg of soil. A second correction of the model incorporating the effects of moisture and roughness on reflectance, has improved the quality of the prediction by 18% and a RMSECV of 1.61 g / kg. The model was finally spatialized on the whole plot using ArcGIS® by applying the regression formula on all mosaic pixels. Results are discussed in the light of an additional sampling campaign carried out in October 2015, providing 34 independent samples.