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The potential of soil organic carbon mapping by combined in-situ spectroscopy and WorldView-2 satellite data

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New very high resolution eight-spectral-band sensor, WorldView-2, was tested as potential source of information for soil organic carbon (SOC) mapping at field scale. The evaluation was focused firstly on the spectral resolution of the sensor and secondly on the practical application of the remotely sensed image in combination with in-situ soil spectroscopy data.

The WorldView-2 sensor provides various technical improvements in the category of so-called "meter" satellites instruments. Most importantly the spectral resolution changed from typical four to eight bands covering visible (VIS) and near-infrared (NIR) wavelengths. On the other hand, the eight bands is very limited in comparison with classical hyper-spectral images to be used for soil mapping. Also the limitation of the spectral range, VIS-NIR, anticipates the potentials of the data for SOC or iron mapping.

The study was conducted on arable field with area of 100 ha located in the South Moravia (Brumovice municipality). The main soil unites are Haplic Chernozem and Regosol (WRB). Field (fresh soil samples) and laboratory (dry soil samples) spectral data were extensively acquired from top soil up to 20 cm by FieldSpec-3 instrument, covering spectral range from 350 to 2500 nm. There were available 217 records with reference laboratory chemical analysis of SOC for the study. The soil spectra were further re-sampled to WorldView-2 spectral characteristics according to Relative Spectral Response Function of the sensor. Standard geometric and simplified relative atmospheric correction of the WorldView-2 image was performed.

The WorlView-2 potential for SOC mapping was assessed initially by reflectance spectroscopy PLS-regression technique. The PLS inference model derived from full spectral data set applied to independent test data (10 %) showed high quality of the model: R2 = 0.92, RMSE = 0.10, and RPD = 3.5. Additionally, the same model was assessed from spectra acquired from the fresh soil samples (average gravimetric soil moisture 27.5 %) from available 100 samples. The model performed even better than the one constructed from dry samples spectra yielding R2 = 0.98, RMSE = 0.04, and RPD = 7.9.

By application of the simulated WorldView-2 spectral data (eight bands) the quality of the prediction model generally decreased, however, provided still very good results highlighting the potentials. The PLSR model applied for the SOC yielded R2 = 0.76, RMSE = 0.178, and RPD = 2.1. Subsequently the WorlView-2 image spectral signatures were assessed by the reference soil sampling. Only part of the field was fully bare at the time of the image acquisition (29th April 2010). The limited data set (31 samples) was firstly tested using simulated spectra providing good model results (R2 = 0.85; RMSE = 0.15; and RPD = 2.6) and then with real WorldView-2 spectra. The PLSR performed low quality. The correlation coefficient was R2 = 0.49, RMSE = 0.29 and RPD = 1.32. Another test with WorldView-2 data was done by calculating simplified index as a slope of spectral signature in visible part of the spectra. However, this technique did not provide any good result.

The initial assessment proved at first spectral potential of the WorldView-2 sensor for SOC mapping, however, the model constructed from the remotely sensed data did not confirm the potential. There exist several hypothetical reasons: the limited reference data set, the simplified pre-processing of the image and the selected modelling technique.