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Modelling of soil organic matter of arable soils with optical remote sensing data: the impact of soil surface state

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The study presents the analysis of effect of changes of the open surface of arable soils occurring due to the influence of agricultural practices or natural factors (mainly, precipitation) on the possibility of assessment of organic matter content in the arable layer with optical remote sensing data.

The object of the research was gray forest arable soil of a test field located in the Yasnogorsky district of the Tula region. In 2019, the field was complete fallow.

During field work conducted on the test field on 15.08.2019, the spectral reflectance of the surface of arable soils and a wetter subsurface horizon was measured at 30 points. At the same points, 30 mixed samples of the arable horizon were collected for laboratory estimation of organic matter content.

Spectral reflectance was measured using a HandHeld-2 field spectroradiometer, which operates in the range 325–1050 nm with a step of 1 nm.

Proximal sensing data were smoothed with Savitzky-Golley function and recalculated into Sentinel-2 bands using Gaussian function.

We also chose seven Sentinel-2 scenes for 2019 for the studied region: 2.04.2019, 17.04.2019, 20.04.2019, 5.05.2019; 6.06.2019, 19.06.2019, 28.08.2019. Atmospheric correction for chosen scenes was performed with Sen2Cor model in SNAP. Afterwards we extracted reflectance values at points, where we collected spectral data and soil samples in the field.

Then we calculated a number of spectral indices and ratios for both proximal and Sentinel-2 data which were further used in regression modelling. Models were cross-validated by bootstrapping.

At field scale, difference in moisture content did not significantly affect the accuracy and quality of the models. R^2_{adjcv} of model for dry surface layer was a bit higher than in case of model for wet subsurface layer (0.77 vs. 0.72). RMSE_{Pcv} and RPIQ for both cases were very close (0.71 and 0.71; 2.09 and 2.12).

When we used models developed based on proximal sensing data to calculate OM content with Sentinel-2 data at different acquisition dates, we found that the accuracy of OM prediction varied.

In some cases RMSE was higher than 7 % and predicted OM content was two times higher than actual.

Models developed based only on Sentinel-2 data for different acquisition dates, varied in accuracy, quality and informative bands. R^2_{adjcv} of most models was about 0.72-0.83, RPIQ was 2.09-2.07, and RMSE_{Pcv} was in the range of 0.56-0.77 %.

Therefore changes in surface state of arable soils result in a situation when for each state we have different model. That imposes restrictions on further use of such models for remote evaluation and monitoring of organic matter content in arable soils. To deal with this problem, it is necessary to account for soil surface state when developing models for properties of arable soils based on optical remote sensing data.

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