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## Sentinel-2 Multitemporal Bare Soil Composites for predicting soil properties using machine learning methods

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Previous studies have shown that remote sensing data can be very useful input into soil prediction models. This input usually represents reflectance from bare soils, which, however, make up only a small part of the total area in a given part of the year. For eliminating masking effect of vegetation time series of individual images (Žížala et al. 2019; Shabou et al. 2015; Demattê et al. 2016; Blasch et al. 2015a) or multitemporal composites of spectral data can be used. Exposed Soil Composite Mapping Processor (SCMaP) (Rogge et al. 2018), Geospatial Soil Sensing System (GEOS3) (Demattê et al. 2018), Bare Soil Composite Image (Gallo et al. 2018), and Barest Pixel Composite for Agricultural Areas (Diek et al. 2017), all developed from Landsat time series, multitemporal bare soil image developed from RapidEye time series (Blasch et al. 2015b), or bare soil mosaic (Loiseau et al. 2019) derived from Sentinel-2 data can serve as examples of such composites. However, only some of the composite products have been used yet to predict soil properties. Promising results were achieved; however, the potential of these spectral composites has not yet been tested in a relevant number of studies. Further research is needed for its evaluation.

Aims of this study are to analyze and to compare the prediction ability of models using different types of multitemporal bare soil composites derived from Sentinel-2 images and their applicability for mapping soil properties in large areas. The study was conducted on a regional scale in the soil heterogeneous region of central Czechia with dissected relief and variable soil properties, where data from 100 soil profiles with soil analytics were available. Sentinel-2 images from 2016-2019 were used for composite formation in the python numpy environment. Different methods of cloud masking, bare soil identification and data aggregation (both already used in previous studies and newly derived) have been tested to compare which is the most suitable for prediction of soil properties. The principles of digital soil mapping and machine learning algorithms (random forest and support vector machine multivariate methods) were used for prediction.

Results reveal that Sentinel-2 multitemporal bare soil composites can be successfully applied in the prediction of soil properties. The setting of basic parameters of composite creation is very complex and challenging and it requires to use exact algorithms for masking clouds and bare soil. Soil moisture and surface roughness also greatly affect spectral characteristics of bare soil and thus a very important aspect of compositing is finding appropriate statistics to derive final pixel values of reflectance (minimum, mean, median, ...). One possible way to minimize the effect of moisture and surface roughness may be incorporation radar backscatter information from

Sentinel-1. However, it further complicates the processing of data and makes the composite creation more complex.

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