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Prediction of soil texture using optical and microwave earth observation data in a random forest approach

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Precision Agriculture (PA) applied on a widespread basis can be a building block for reduced ecosystem degradation without compromising food security. One problem of farmers in the implementation of PA applications is the lack of high spatial resolution soil information.

The EU-funded research project 'pH-BB: Precision liming in Brandenburg' aims at developing innovative nutrient management strategies based on proximal soil sensing data. For this study, the pH-BB project provided us the data of the 361 soil samples, which were taken at an 800-hectare farm in Brandenburg close to Frankfurt (Oder) and analyzed in the laboratory for the texture fractions clay, silt, and sand. We used the Google Earth Engine to process remote sensing earth observation (EO) data of 1474 Sentinel-1 (S1) SAR and 85 cloud free Sentinel-2 (S2) scenes available at the study site during the period 2016-03-01 - 2021-11-09. Vegetation and soil indices were computed with optical S2 data and backscatter in VV and VH polarization were extracted from the S1 datasets. To derive long-term persistent patterns in the EO data, simple statistical parameters such as coefficient of variation, standard deviation, maximum pixel value, etc. were calculated along the temporal domain of the EO data. Together with calculated terrain attributes, 24 covariate grids were finally available for model building. Reference samples (rs) were randomly divided into a training dataset (70% of rs) and a validation dataset (30% of rs). Pixel values of the covariate datasets at the sampling locations were added to the rs datasets.

A random forest machine learning algorithm was applied to the training dataset to train two individual models for the alr-transformed target variables silt and sand using the covariates. The developed models were then applied to the gridded datasets to predict maps for the alr-transformed target variables silt and sand. The final maps of all 3 texture fractions clay, silt, and sand were computed by back-transforming the predicted alr silt and sand grids.

In the derived models EO covariates showed the highest level of importance. Comparison of the prediction results with the validation data set showed that the spatial distribution, of the clay, silt, and sand fractions was predicted, with a root mean square error (rmse) of 6.2, 5.3, and 9.7 mass-%, respectively. A classification of the predicted maps according to the German KA5 scheme

showed that especially in the sand dominated soil classes the prediction errors were lower, whereas they increased in the loamy soil classes (dependent on the clay content).

With a rmse of 5.3 - 9.7 mass-%, the performance of the approach shows good potential for surface soil texture assessments even at high resolution or for global applications or as an initial guess for soil mapping with high resolution proximal soil sensing devices.