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Using multi-temporal Sentinel-2 data to predict chemical properties of the organic surface layer of forest soils

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Area-wide high resolution information of organic layer properties is required for assessing the current nutrient availability in forest stands. Together with climate, location, parent material and terrain predictors, vegetation is known to have a direct impact on the characteristics of the organic surface layer of forest soils and therefore plays an important role in predicting its chemical properties.

Here, we use multi-temporal Sentinel-2 (S2) Earth Observation (EO) data as a proxy for various vegetation characteristics to spatially predict forest organic layer properties at 10 m spatial resolution in Saxony/Germany. To ensure full data coverage of the study area, we used multi-temporal statistical measures of S2 data generated by the FORCE algorithm. Complementary to ancillary predictors (climate, location, parent material, terrain), we compared three different sets of vegetation related data as predictors: (1) categorical tree species groups from a field survey, (2) multi-temporal statistical measures derived from S2 data and (3) S2 multi-temporal statistical measures and additional S2 multi-temporal spectral indices.

We used random forest regression models to estimate pH value, base saturation, C/N ratio and effective cation exchange capacity of the organic surface layer and the upper 0-5 cm of the first mineral soil horizon. For model evaluation 5-times 10-fold cross-validation was applied. For predictor evaluation and selection, we used recursive feature elimination.

The results indicate that S2 data can serve as a vegetation proxy when predicting forest organic layer properties. For example, the cross-validation estimate of the prediction error in scenario (3) for C/N ratio (organic surface layer) is about 7.3 % lower than in scenario (1). In some cases the explanatory power is higher compared to the field survey data of the tree species groups, probably due to the high local variability of EO based data. This may help to reveal short range variability of chemical properties. We conclude that the three scenarios show comparable results

and thus multi-temporal S2 data can be used as a vegetation proxy to spatially predict chemical properties of the organic surface layer of forest soils.