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Mapping organic carbon stocks of Swiss forest soil

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Carbon (C) sequestration into forest sinks offsets greenhouse gas emissions under the Kyoto protocol. Therefore, quantifying C stocks and fluxes in forest ecosystems is of interest for reporting greenhouse gas emissions. In Switzerland, the National Forest Inventory offers comprehensive data to quantify the above ground forest biomass and its change in time. Estimating stocks of soil organic C (SOC) in forests is more difficult because of its high spatial variability. To date the greenhouse gas inventory relies only on sparse data and regionally differentiated predictions of SOC stocks in forest soils are currently not possible. Recently, more soil data and new explanatory variables for statistical modeling like high resolution elevation data and satellite images became available.

Based on data from 1'033 sites, we modeled SOC stocks to a depth of 1 m including the organic layer for the Swiss forested area. We used a novel robust restricted maximum likelihood method to fit a linear regression model with spatially correlated errors to the C stock data. For the regression analysis we used a broad range of covariates derived from climate data (precipitation, temperature, radiation), two elevation models (resolutions 25 and 2 m) and spectral variables representing vegetation. Furthermore, the main cartographic categories of an overview soil map were used to broadly represent the parent material.

The numerous covariates, that partly correlated strongly, were reduced to a first subset using LASSO (Least Absolute Shrinkage and Selection Operator). This subset of covariates was then further reduced based on cross validation of the robustly fitted spatial model. The levels of categorical covariates were partly aggregated during this process and interactions between covariates were explored to account for nonlinear dependence of C stocks on the covariates. Using the final model, robust kriging prediction and error maps were computed with a resolution of one hectare.