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Mapping soil organic carbon stocks by robust geostatistical and boosted regression models

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Carbon (C) sequestration in forests offsets greenhouse gas emissions. Therefore, quantifying C stocks and fluxes in forest ecosystems is of interest for greenhouse gas reporting according to the Kyoto protocol. In Switzerland, the National Forest Inventory offers comprehensive data to quantify the aboveground forest biomass and its change in time. Estimating stocks of soil organic C (SOC) in forests is more difficult because the variables needed to quantify stocks vary strongly in space and precise quantification of some of them is very costly.

Based on data from 1'033 plots we modeled SOC stocks of the organic layer and the mineral soil to depths of 30 cm and 100 cm for the Swiss forested area. For the statistical modeling a broad range of covariates were available: Climate data (e. g. precipitation, temperature), two elevation models (resolutions 25 and 2 m) with respective terrain attributes and spectral reflectance data representing vegetation. Furthermore, the main mapping units of an overview soil map and a coarse scale geological map were used to coarsely represent the parent material of the soils.

The selection of important covariates for SOC stocks modeling out of a large set was a major challenge for the statistical modeling. We used two approaches to deal with this problem: 1) A robust restricted maximum likelihood method to fit linear regression model with spatially correlated errors. The large number of covariates was first reduced by LASSO (Least Absolute Shrinkage and Selection Operator) and then further narrowed down to a parsimonious set of important covariates by cross-validation of the robustly fitted model. To account for nonlinear dependencies of the response on the covariates interaction terms of the latter were included in model if this improved the fit. 2) A boosted structured regression model with componentwise linear least squares or componentwise smoothing splines as base procedures. The selection of important covariates was done by the modeling procedure directly. In our presentation, we shall summarize the main results of these analyses and present a validation of the two approaches with independent data.