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Layer specific geostatistical coregionalisation of soil organic carbon utilising terrain attributes and spatial patterns of soil redistribution

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High-resolution soil organic carbon (SOC) maps are a major prerequisite for many environmental studies dealing with carbon stocks and fluxes as well as for biogeochemical modelling. Hence, the development of time and cost effective mapping methods is an important issue. In most cases these maps are interpolated based on measured point SOC data with different horizontal resolution, whereas additional secondary (terrain) information is often utilised.

In this study the potential of external drift kriging (EDK) to improve the soil layer specific (I: 0-0.25 m, II: 0.25-0.5 m and III: 0.5-0.9 m) interpolation of SOC concentrations in a hilly 4.2 ha agriculturally used catchment was tested using three different input data densities (6, 16.9, and 37.9 soil samples/ha). A number of covariables were used in EDK with a special focus on those representing processes of soil moisture distribution and soil redistribution. The later was, among others, represented by the results of a relatively simple and robust water and tillage erosion model (WaTEM/SEDEM).

With the EDK method a significant improvement of the precision of SOC maps derived from different input data densities was observed particularly for deeper soil layers. While in the plough layer only slight improvements could be found, covariables representing soil moisture distribution and especially soil redistribution substantially improved predictions in the two subsoil layers. A maximum relative improvement of 15.5% was found for soil layer III (16.9 soil samples/ha; Root Mean Square Error 0.153% kg kg-1). Comparing EDK results of medium and low resolution SOC input data (16.9 and 6 samples/ha) with OK results of high resolution inputs (37.9 samples/ha) shows a similar or even improved precision for soil layers I and III, while the reduction of input data density could not be fully compensated utilising covariables in soil layer II.

In general, the results indicate the potential of EDK to improve SOC maps and to reduce sampling density without substantial precision loss, especially when using more complex process-oriented covariables such as spatial patterns of soil redistribution. Especially, patterns of tillage erosion show a significant influence upon the spatial distribution of SOC and hence show some potential to improve SOC maps of agriculturally used land also on larger scales. However, it has to be recognised that the optimal covariables vary between different soil layers indicating different processes responsible for the soil layer specific SOC distribution. Hence, no general covariable is successfully applicable for bulk samples.