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Drivers for spatial variability in agricultural soil organic carbon stocks in Germany

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Soil organic carbon is one of the largest components of the global carbon cycle. It has recently gained importance in global efforts to mitigate climate change through carbon sequestration. In order to find locations suitable for carbon sequestration, and estimate the sequestration potential, however, it is necessary to understand the factors influencing the high spatial variability of soil organic carbon stocks. Due to numerous interacting factors that influence its dynamics, soil organic carbon stocks are difficult to predict. In the course of the German Agricultural Soil Inventory over 2500 agricultural sites were sampled and their soil organic carbon stocks determined. Data relating to more than 200 potential drivers of SOC stocks were compiled from laboratory measurements, farmer questionnaires and climate stations. The aims of this study were to 1) give an overview of soil organic carbon stocks in Germany's agricultural soils, 2) to quantify and explain the influence of explanatory variables on soil organic carbon stocks. Two different machine learning algorithms were used to identify the most important variables and multiple regression models were used to explore the influence of those variables. Models for predicting carbon stocks in different depth increments between 0-100 cm were developed, explaining up to 62% (validation, 98% calibration) of total variance. Land-use, land-use history, clay content and electrical conductivity were main predictors in the topsoil, while bedrock material, relief and electrical conductivity governed the variability of subsoil carbon stocks. We found 32% of all soils to be deeply anthropogenically transformed. The influence of climate related variables was surprisingly small ($\leq$5% of explained variance), while site variables explained a large share of soil carbon variability (46-100% of explained variance), in particular in the subsoil. Thus, the understanding of SOC dynamics at regional scale requires a thorough description of the variability in soil physical parameters. Agronomic management impact on SOC stocks is important near the soil surface, but is mainly attributable to land-use and not to other management factors on this large regional scale. The importance of historical land-use practices as well as anthropogenic soil transformations to SOC stocks highlights the need for prudent soil management and conservation policies.