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How to map soil carbon stocks in highly urbanized regions?

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Soil organic carbon (SOC) is the largest carbon stock in terrestrial ecosystems and the capacity for carbon sequestration is a widely accepted soil function. For land-use planning and decision making the regional analysis of SOC stocks and their spatial variability is an important and challenging task that receives increasing attention. Quite a few studies focus on mapping the carbon stocks in natural and agricultural areas using digital soil mapping (DSM) techniques. Although urban areas remain almost neglected.

The urban environment provides a number of specific features and processes that influence soil formation and functioning: soil sealing, functional zoning and settlement history. This not only results in a considerable urban SOC (especially in the subsoil), but also results in a unique spatial variability of SOC stocks at short distance. In contrast to the often gradual changes in natural areas, urban soils may exhibit abrupt changes due to the anthropogenic influence. Thus implementation of standard DSM methodology will result in extremely high nuggets and correspondingly low prediction accuracy. Besides, traditional regression kriging, widely-used for the case when legacy data is lacking, is often based on the correlation between SOC and dominating soil forming factors (climate, relief, parent material and vegetation). Although in urban conditions, anthropogenic influence itself turns out to be a predominant soil-forming factor. The spatial heterogeneity of urban soil carbon stocks is further complicated by a specific profile distribution with possible second SOC maximum, referred to cultural layer. Importance of urban SOC as well as specifics of urban environment requires for a specific approach to map urban SOC as part of regional analysis.

Moscow region with its variability of bioclimatic conditions and high urbanization level (10 % from the total area) was chosen as an interesting case study. Random soil sampling in different soil zones (4) and land-use types (3 non-urban and 3 urban) was organized in Moscow region in 2010-2011 (n=242). Both topsoil (0-10 cm) and subsoil (10-150 cm) were included.SOC content for each point was analyzed and this data was incorporated with the information on climatic (annual temperature and precipitation), elevation, land-use, soil (dominating type and soil complexes) factors.

The validation of the SOC map, created using regression kriging, demonstrated low accuracy, caused by principal differences in SOC spatial distribution between non-urban and urban areas. Extremely high variability in very short distances (30-50 m) shown for the latter was obviously not possible to interpolate for the whole region territory. In order to consider this internal variability urban areas was described from the total dataset and the heterogeneity index, based on the ratio of functional zones, sealed and open areas and cut-off profiles, was estimated per settlement and district. Thus, the regional SOC map was combined from traditional regression kriging outcome for agricultural areas and aggregated internal variability estimation results for urban ones.