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Soil process-oriented modelling of within-field variability based on high-resolution 3D soil type distribution maps.

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Today, the knowledge of within-field variability is essential for numerous purposes, including practical issues, such as precision and sustainable soil management. Therefore, process-oriented soil models have been applied for a considerable time to answer question of spatial soil nutrient and water dynamics, although, they can only be as consistent as their variation and resolution of soil input data. Traditional approaches, describe distribution of soil types, soil texture or other soil properties for greater soil units through generalised point information, e.g. from classical soil survey maps. Those simplifications are known to be afflicted with large uncertainties. Varying soil, crop or yield conditions are detected even within such homogenised soil units. However, recent advances of non-invasive soil survey and on-the-go monitoring techniques, made it possible to obtain vertical and horizontal dense information (3D) about various soil properties, particularly soil texture distribution which serves as an essential soil key variable affecting various other soil properties.

Thus, in this study we based our simulations on detailed 3D soil type distribution (STD) maps (4x4 m) to adjacently built-up sufficient informative soil profiles including various soil physical and chemical properties. Our estimates of spatial STD are based on high-resolution lateral and vertical changes of electrical resistivity (ER), detected by a relatively new multi-sensor on-the-go ER monitoring device. We performed an algorithm including fuzzy-c-mean (FCM) logic and traditional soil classification to estimate STD from those inverted and layer-wise available ER data. STD is then used as key input parameter for our carbon, nitrogen and water transport model. We identified Pedological horizon depths and inferred hydrological soil variables (field capacity, permanent wilting point) from pedotransferfunctions (PTF) for each horizon. Furthermore, the spatial distribution of soil organic carbon (SOC), as essential input variable, was predicted by measured soil samples and associated to STD of the upper 30 cm. The comprehensive and high-resolution (4x4 m) soil profile information (up to 2 m soil depth) were then used to initialise a soil process model (Carbon and Nitrogen Dynamics - CANDY) for soil functional modelling (daily steps of matter fluxes, soil temperature and water balances). Our study was conducted on a practical field ($\sim$32,000 m^2) of an agricultural farm in Central Germany with Chernozem soils under arid conditions (average rainfall < 550 mm). This soil region is known to have differences in soil structure mainly occurring within the subsoil, since topsoil conditions are described as homogenous. The modelled soil functions considered local climate information and practical farming activities. Results show, as expected, distinguished functional variability, both on spatial and temporal resolution for subsoil evident structures, e.g. visible differences for available water capacity within 0-100 cm but homogenous conditions for the topsoil.