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Mapping SOC content and bulk density of a disturbed peatland relict with electromagnetic induction and DEM data

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Peatlands represent a huge storage of soil organic carbon (SOC), and there is considerable interest to assess the total amount of carbon stored in these ecosystems. However, reliable field-scale information about peat properties, particularly SOC content and bulk density (BD) necessary to estimate C stocks, remains difficult to obtain. A potential way to acquire information on these properties and its spatial variation is the non-invasive mapping of easily recordable physical variables that correlate with peat properties, such as bulk electrical conductivity (ECa) measured with electromagnetic induction (EMI). However, ECa depends on a range of soil properties, including BD, soil and water chemistry, and water content, and thus results often show complex and site-specific relationships. Therefore, a reliable prediction of SOC and BD from ECa data is not necessarily given. In this study, we aim to explore the usefulness of Multiple Linear Regression (MLR) models to predict the peat soil properties SOC and BD from multi-offset EMI and high-resolution DEM data. The quality of the MLR models is assessed by cross-validation. We use data from a medium-scale disturbed peat relict (approximately 35ha) in Northern Germany. The potential explanatory variables considered in MLR were: EMI data of six different integral depths (approximately 0.25, 0.5, 0.6, 0.9, 1, and 1.80 m), their vertical heterogeneity, as well as several topographical variables extracted from the DEM. Ground truth information for SOC, BD content and peat layer thickness was obtained from 34 soil cores of 1 m depth. Each core was divided into several 5 to 20 cm thick layers so that integral information of the upper 0.25, 0.5, and 1 m as well as from the total peat layer was obtained. For cross-validation of results, we clustered the 34 soil cores into 4 classes using K-means clustering and selected 8 cores for validation from the clusters with a probability that depended on the size of the cluster. With the remaining 26 samples, we performed a stepwise MLR and generated separate models for each depth and soil property. Preliminary results indicate reliable model predictions for SOC and BD (R^2 = 0.83- 0.95). The RMSE values of the validation ranged between 3.5 and 7.2 vol. % for SOC and 0.13 and 0.37 g/cm^3 for BD for the independent samples. This equates roughly the quality of SOC predictions obtained by field application of vis-NIR (visible-near infrared) presented in literature for a similar peatland setting. However, the EMI approach offers the potential to derive information from deeper depths and allows non-invasive mapping of BD variability, which is not possible with vis-NIR. Therefore, this new approach potentially provides a more useful tool for total carbon stock assessment in peatlands.