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Explainable deep neural networks for exploring spatial variability of soil properties in Germany

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Digital soil mapping approaches predict soil properties based on the relationship between soil observations and related environmental covariates using machine learning models. In this research, we applied deep neural networks to predict the spatial distribution of soil properties in Germany using 1976 soil observations and 170 environmental covariates which are derived from several sources (e.g., remote sensing data). However, a major problem with using deep neural networks is that the exact contribution of environmental covariates in the overall result is unknown. To address this issue and improve the interpretability of deep neural networks, several model-agnostic interpretation tools (i.e., post hoc analyses and techniques) are used to understand previously trained "black-box models" or their predictions. For example, a permutation feature importance technique ranked remote sensing images as the most important predictors to explain the spatial variability of soil organic carbon in the study area. This is the first study to use deep neural networks with explainable algorithms to explore and visualize the spatial distribution of soil properties in Germany.

Keywords: explainable machine learning; deep neural networks; soil properties; Germany