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Soil organic carbon mapping using state-of-the-art machine learning algorithms and deep neural networks in different climatic regions of Iran

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Abstract

Soil Organic Carbon (SOC) is a major source of terrestrial carbon and also a key element for soil quality and fertility, as it improves aggregate stability, water retention capacity, and nutrient availability. This study aims to evaluate the performance of eight state-of-the-art machine learning algorithms including: artificial neural network (ANN), random forest (RF), Cubist, support vector regression (SVR), regularized linear regression (lasso), k nearest neighbour (kNN), XGBoost, and deep neural networks (DL) to predict SOC concentration at five standard depth intervals (0-5, 5-15, 15-30, 30-60 and 60-100 cm) using environmental covariates as predictors. Three study areas in Iran from different climatic regions including arid, semi-arid, and humid climate regimes were selected with an overall sample count of 185, 188 and 122, respectively. The SOC content ranges between 0.03 and 12.33%. In all areas, the amount of SOC decreased with increasing soil depths. The same holds true for the performance of all tested prediction techniques, calculated as spatial cross-validation (0.19% to 1.90%). Furthermore, results showed that all machine-learning techniques had better performances in arid region compared to semi-arid and humid climate regimes. Moreover, DL outperformed the commonly used machine learning algorithms in digital soil mapping (0.15% to 1.10%). The superiority of DL-models was most evident for deeper soil increments. We conclude that DL has a high potential in soil organic carbon mapping and could be an alternative to the standard algorithms to predict SOC content especially with regard to larger soil depth.

Keywords: Soil organic carbon mapping, machine learning, climate conditions, deep learning, Iran

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