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Predicting regional soil moisture dynamics using machine learning techniques and a dense observational network

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Soil moisture has a direct impact on ecosystem functioning, vegetation and crop production, environmental health and affects the stability of rural communities. Soil moisture plays a crucial role in all aspects of land-atmosphere interactions including extreme events such as heatwaves, droughts and floods. The highly localized and complex nature of soil moisture present a major challenge to its accurate estimation. Notwithstanding recent advances in satellite-based monitoring, the temporal and spatial resolution and shallow observation impede their application to mechanistic modeling and to highly resolved applications. Motivated by the importance of soil moisture on many hydrologic processes, the objective of the present study is to develop a predictive tool capable of describing the relationship between soil moisture and a wide range of climatic and soil related parameters. Within this context, we report a dense in-situ measurement networks that offer valuable ground truthing supplemented by physics informed machine learning (ML) techniques. We conducted a detailed observational campaign covering 100,000 m^2 in Falkenberg in Germany by deploying a dense network of sensors to measure soil moisture (at 29 locations), ambient temperature and relative humidity, wind speed, near-surface radiation fluxes and soil temperature. We also determined soil characteristics and important properties (e.g., particle size distribution). We used static and dynamic climatic and soil-related predictors (covariates) for training the ML models to capture the complex relationship between the soil moisture and predictor covariates. Following Hassani et al. [2020], we employ different ML algorithms for model training to evaluate their performance in forecasting soil moisture dynamics in space and time using rigorous cross-validation. This work will shed new lights on the interaction and relationship between soil moisture dynamics and a variety of climatic and soil parameters.

Reference

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