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Nowcasting and forecasting soil moisture using meteorological parameters

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Real-time, high-resolution estimates and predictions of soil moisture (SM) data could significantly enhance the forecasting of SM- and precipitation-related extreme events, such as floods, droughts, and wildfires. Current estimates and short-term predictions of SM data can serve as leading indicators for upcoming anomalies in vegetative growth and productivity, improve irrigation scheduling, and enhance streamflow forecasting. However, existing SM data products—including in-situ measurements, satellite-derived data, and model-derived simulated reanalysis data—are valuable but fall short of simultaneously providing real-time, high-resolution, broad spatial coverage, and near-future estimates of soil moisture.

In this study, we propose a deep learning (DL) framework that integrates historical satellite-derived SM data, in-situ measurements, and meteorological data to address these limitations. The framework is designed to reduce the latency between satellite-derived SM data release and the current time, thereby offering more up-to-date SM estimates. Furthermore, we forecast SM for the next 11 days using meteorological inputs such as precipitation, air temperature, humidity, wind speed and direction, and solar radiation.

Our framework aims to deliver more timely SM estimates by minimizing data latency while also providing short-term forecasts of SM. The primary objective is to generate real-time, high-resolution SM estimates for the entire state of Texas. Currently, real-time, up-to-date SM data and predictions are not available at this resolution or scale. To address this gap, we employ meteorological data to guide a DL model that estimates and predicts NASA's SMAP Level 4 SM data product, which currently has a latency of 2–5 days.

Our DL model is specifically designed to account for both the temporal and spatial heterogeneity of SM. It is deployed in an "on-line"fashion, meaning the model is trained continuously as new data becomes available. This iterative updating process allows the model to adapt dynamically to changing patterns over time, ensuring that predictions remain accurate and relevant in real-time.

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References

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