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Knowledge transfer from simulation to reality via Long Short-Term Memory networks: Estimating groundwater table depth anomalies over Europe

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Near real-time groundwater table depth measurements are scarce over Europe, leading to challenges in monitoring groundwater resources at the continental scale. In this study, we leveraged knowledge learned from simulation results by Long Short-Term Memory (LSTM) networks to estimate monthly groundwater table depth anomaly (wtd_a) data over Europe. The LSTM networks were trained, validated, and tested at individual pixels on anomaly data derived from daily integrated hydrologic simulation results over Europe from 1996 to 2016, with a spatial resolution of 0.11° (Furusho-Percot et al., 2019), to predict monthly wtd_a based on monthly precipitation anomalies (pr_a) and soil moisture anomalies (θ_a). Without additional training, we directly fed the networks with averaged monthly pr_a and θ_a data from 1996 to 2016 obtained from commonly available observational datasets and reanalysis products, and compared the network outputs with available borehole *in situ* measured wtd_a. The LSTM network estimates show good agreement with the *in situ* observations, resulting in Pearson correlation coefficients of regional averaged wtd_a data in seven PRUDENCE regions ranging from 42% to 76%, which are ~ 10% higher than the original simulation results except for the Iberian Peninsula. Our study demonstrates the potential of LSTM networks to transfer knowledge from simulation to reality for the estimation of wtd_a over Europe. The proposed method can be used to provide spatiotemporally continuous information at large spatial scales in case of sparse ground-based observations, which is common for groundwater table depth measurements. Moreover, the results highlight the advantage of combining physically-based models with machine learning techniques in data processing.

Reference:

Furusho-Percot, C., Goergen, K., Hartick, C., Kulkarni, K., Keune, J. and Kollet, S. (2019). Pan-European groundwater to atmosphere terrestrial systems climatology from a physically consistent simulation. Scientific Data, 6(1).