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Modeling of groundwater table depth anomalies using Long Short-Term Memory networks over Europe

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Groundwater is the dominant source of fresh water in many European countries. However, due to a lack of near-real-time water table depth (wtd) observations, monitoring of groundwater resources is not feasible at the continental scale. Thus, an alternative approach is required to produce wtd data from other available observations near-real-time. In this study, we propose Long Short-Term Memory (LSTM) networks to model monthly wtd anomalies over Europe utilizing monthly precipitation anomalies as input. LSTM networks are a special type of artificial neural networks, showing great promise in exploiting long-term dependencies between time series, which is expected in the response of groundwater to precipitation. To establish the methodology, spatially and temporally continuous data from terrestrial simulations at the continental scale were applied with a spatial resolution of 0.11°, ranging from the year 1996 to 2016 (Furusho-Percot et al., 2019). They were divided into a training set (1996 – 2012), a validation set (2012 – 2014) and a testing set (2015 -2016) to construct local models on selected pixels over eight PRUDENCE regions. The outputs of the LSTM networks showed good agreement with the simulation results in locations with a shallow wtd (~3m). It is important to note, the quality of the models was strongly affected by the amount of snow cover. Moreover, with the introduction of monthly evapotranspiration anomalies as additional input, pronounced improvements of the network performances were only obtained in more arid regions (i.e., Iberian Peninsula and Mediterranean). Our results demonstrate the potential of LSTM networks to produce high-quality wtd anomalies from hydrometeorological variables that are monitored at the large scale and part of operational forecasting systems potentially facilitating the implementation of an efficient groundwater monitoring system over Europe.

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).