MODELING OF GROUNDWATER TABLE DEPTH ANOMALIES USING LONG SHORT-TERM MEMORY NETWORKS OVER EUROPE

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OBJECTIVE

Due to a lack of near-real-time water table depth (wtd) observations over Europe, monitoring of groundwater resources is a challenge at the continental scale.

Identify an appropriate ML technique as an alternative approach to produce wtd anomalies from other available hydrometeorological observations near-real-time.

Experiment design:

- Input variable \( (I) \): monthly precipitation (pr) anomaly
- Output variable \( (O) \): monthly water table depth (wtd) anomaly
- Applied ML technique: Long Short-Term Memory (LSTM) network, known for its good performance in exploiting long-term dependencies between time series.

Construct one-hidden-layer LSTM networks locally on selected pixels:
STUDY AREA & DATA

**Study area:**

PRUDENCE regions - hydrometeorologically different regions within Europe, defined in the project “Prediction of Regional Scenarios and Uncertainties for Defining European Climate Risks and Effects (PRUDENCE)”

**Data:**

- Calculated from *simulation results* from the Terrestrial System Modeling Platform (TSMP) over Europe (termed as “the TSMP-G2A data set”, Furusho-Percot et al., 2019)

- **Spatially and temporally continuous** data from 01/1996 – 12/2016 (totally 252 time steps, 412*424 pixels), with a resolution of 0.11° (12.5 km, EUR-11)

- **Data segmentation:**
  - **Training set:** 01/1996 – 12/2012, totally 204 time steps
  - **Validation set:** 01/2013 – 12/2014, totally 24 time steps
  - **Test set:** 01/2015 – 12/2016, totally 24 time steps

Data on a pixel
RESULTS

- Classification of network test performance based on yearly averaged a) wtd, b) ET, c) soil moisture and d) snow cover.
- Performance metrics: coefficient of determination ($R^2$) & root mean square error (RMSE)
- Finding:
  - Good performance in locations with a shallow wtd ($< 3$ m), large ET ($> 200$ mm) or large soil moisture ($> 0.15$);
  - The quality of the models was significantly affected by the amount of snow cover.
RESULTS

Reproduced European groundwater anomaly maps in the **August of 2015** (in the **test** period)
CONCLUSION

- Local climatology (yearly averaged wtd, ET, soil moisture and snow cover) had a **strong impact** on the network performance of the proposed LSTM networks during testing.

- The modeled wtd anomalies from the LSTM networks **successfully reproduced** simulated wtd anomalies also in the test period.

- The 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.