# 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.

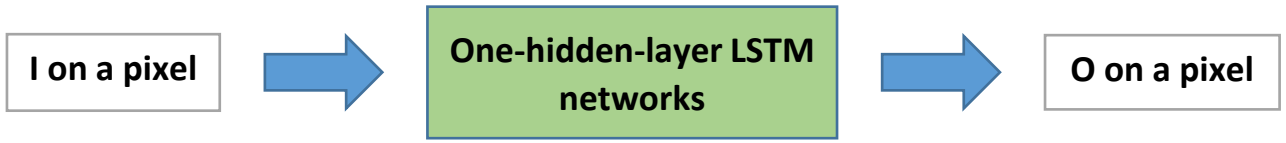
⬇ objective

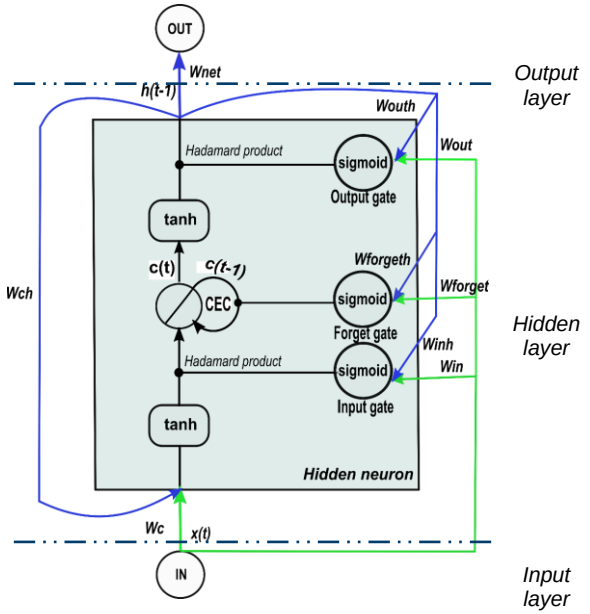
Identify an appropriate **ML** technique as an **alternative** approach to **produce wtd anomalies from other available hydrometeorological observations near-real-time**.

## 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:**

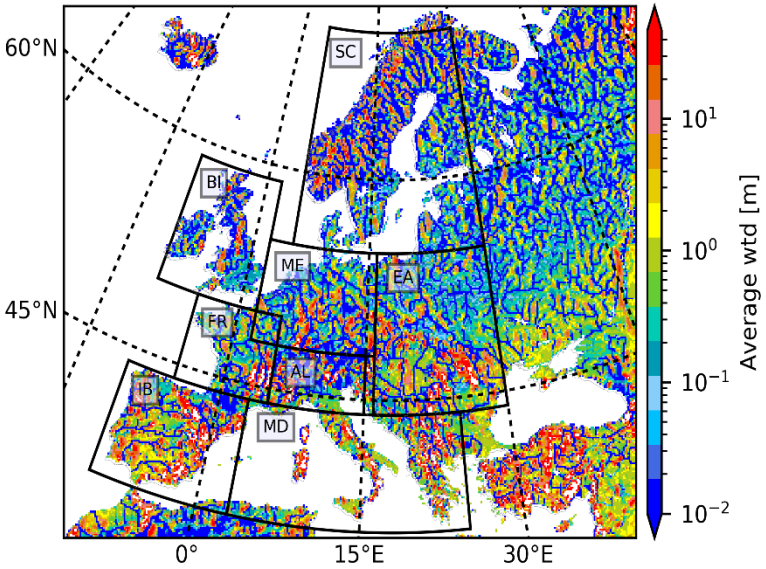


# STUDY AREA & DATA

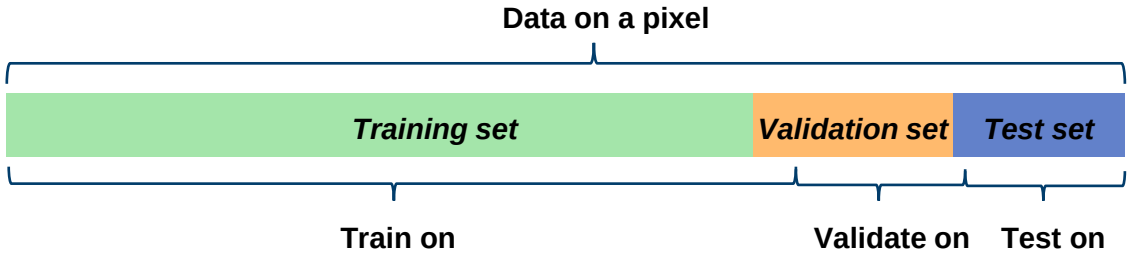
## Study area:

**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)”



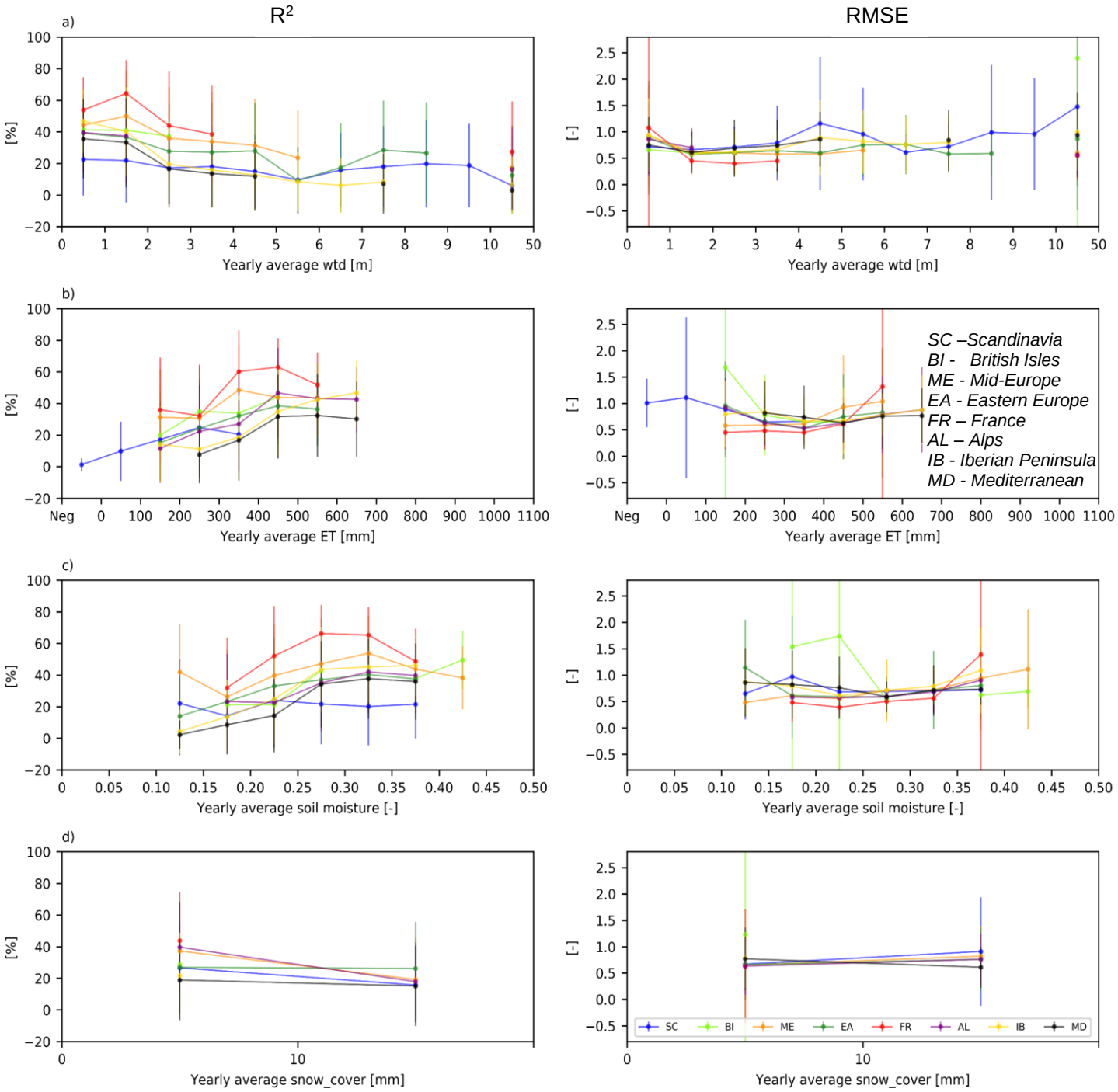

## Data:

- 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



# RESULTS

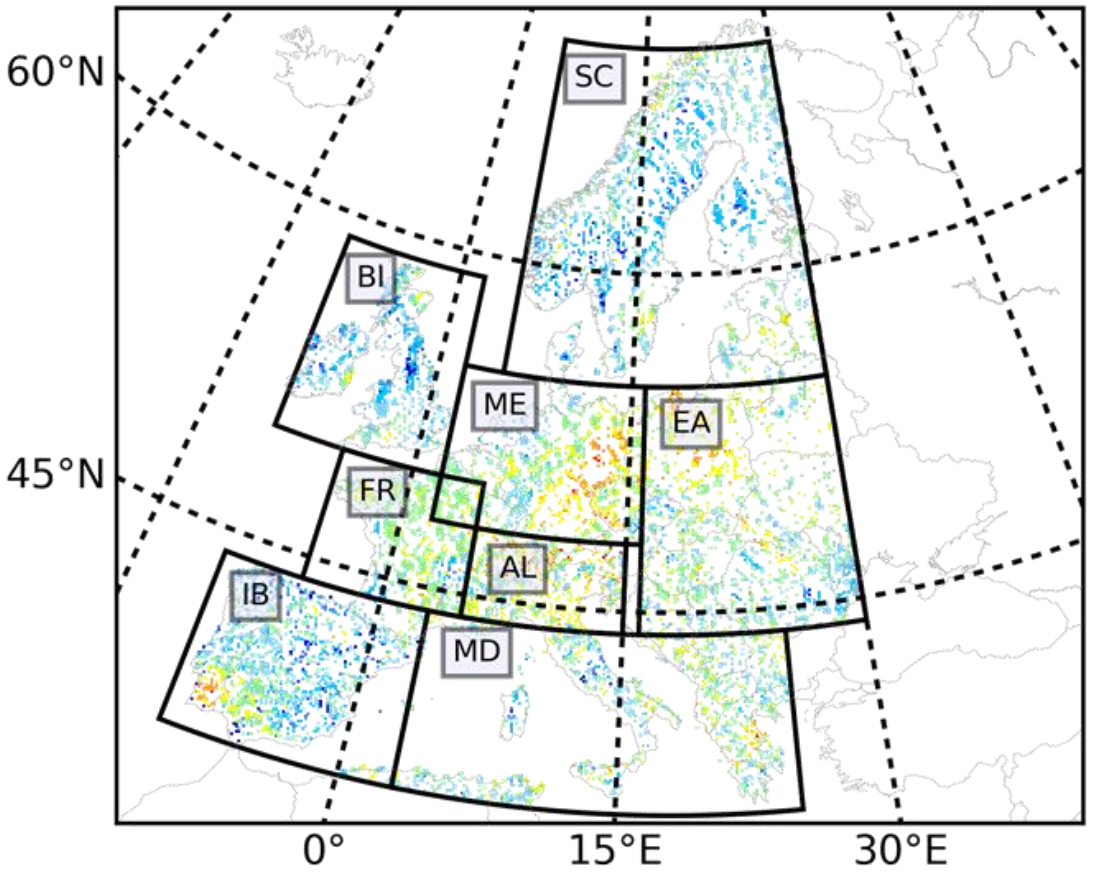
- Classification of network test performance based on yearly averaged **a) wtd**, **b) ET**, **c) soil moisture** and **d) snow cover.**
- Performance metrics: coefficient of determination (**$R^2$**) & root mean square error (**RMSE**)
- Finding:
  - ➢ Good performance in locations with a shallow wtd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



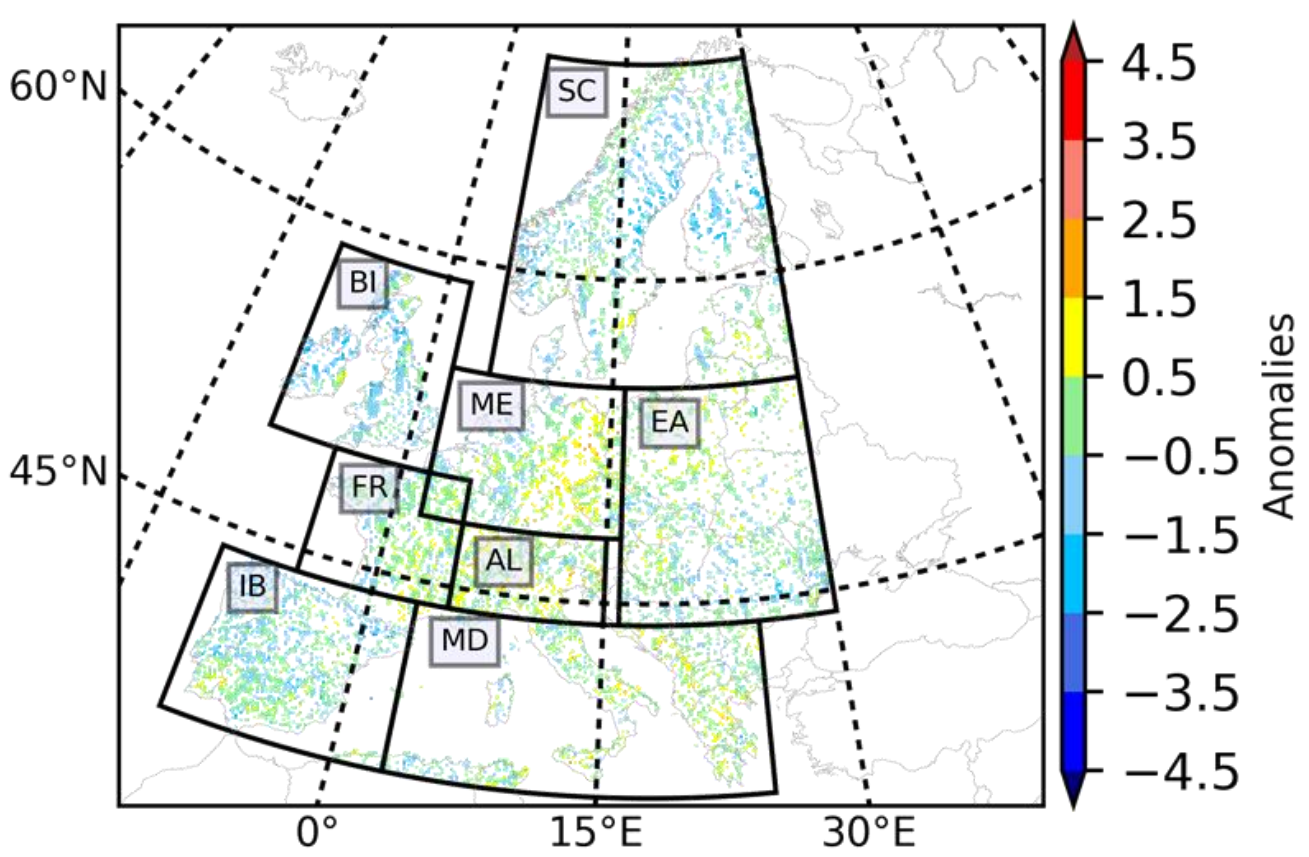
# RESULTS

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

TSMP simulation results




LSTM results



# 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.