Runoff predictive capability of a simple LSTM model versus a proven conceptual model between diverse hydrological regimes

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In the field of deep learning, LSTM lies in the category of recurrent neural network architectures. The distinctive capability of LSTM is learning non-linear long-term dependency structures. This makes LSTM a promising candidate for prediction tasks in non-linear time dependent systems such as prediction of runoff in a catchment. This work presents a comparative framework between an LSTM model and a proven conceptual model, namely GR4J. Performance of the two models is studied with respect to length of study period, surface area, and hydrological regime of 491 gauged French catchments covering a wide range of geographical and hydroclimatic conditions.

Meteorological forcing data (features) include daily time series of catchment-averaged total precipitation, potential evapotranspiration, and air temperature. The hydrometric data consists of daily time series of discharge (target variable). The length of study period varies within the sample depending on the availability of full-record of discharge and, on average, is 15 [years].

In equivalent experimental scenarios, features are kept same in both models and the target variable is predicted for each catchment by both models. Their performance is then evaluated and compared. To do this, the available time series are split into three independent subsequent subsets, namely, training set, validation set, and evaluation set, constituting, respectively, 50%, 20%, and 30% of the study period. The LSTM model is trained based on the training and validation sets and predicts the target on the evaluation set. The four parameters of GR4J model are calibrated using the training set and the calibrated model is then used to estimate discharges corresponding to the evaluation set.

The results suggest that the hydrological regime of catchment is the main factor behind the performance pattern of the LSTM model. According to the results, in the hydrological regimes Uniform and Nival, involving flow regimes with dominant long-term processes, the LSTM model outperforms GR4J model. However, in Pluvial-Mediterranean and Pluvial-Nival regimes characterised with pluri-season peaks, the LSTM model underperforms GR4J model.