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Flood forecasting in small catchments using deep learning LSTM networks

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Long short-term memory (LSTM) networks are able to learn and replicate the relationships of multiple climate and hydrological temporal variables, and therefore are theoretically suitable for data driven modelling and forecasting of rainfall-runoff behavior. However, they inherit some prediction errors occasionally found in data-driven models: phase shift errors, oscillations and total failures. The phase shift error is a particularly significant challenge due to its occurrence when using hourly precipitation and runoff data for catchments with short response times.

In order to detect and eliminate these errors, we investigated four approaches, of which the first two are of structural nature, while the last two modify the input time series by certain transformations:
1. The use of encoder-decoder architectures for LSTM networks.
2. Offsetting the start of the flood forecast to the forecast time step of interest.
3. The inversion of the input time series.
4. Including subsequently observed precipitation data as a “best precipitation forecast”.

We tested the four approaches on five different pilot catchments located in Saxony, Germany with relatively short response times. The results show no advantage of the structural approaches. In contrast, the modification of the input time series shows potential for improving the predictive quality of flood forecasting in a potential operational application.