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Flood Forecasting with Deep Learning LSTM-Networks: Relevance of Catchment Attributes in Regional Network Training

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Floods present one of the most frequent natural hazards in Germany. In order to efficiently and successfully deal with instances of floods we need timely and reliable forecasts of the expected runoff. During the last decades, several deep learning methods proved to be valuable for rainfall-runoff modelling in many larger catchments, especially Long Short-Term Memory (LSTM) networks. One of the core challenges of data-driven models is the provision of an extensive and informative training database, implicitly describing the cause-effect relationships for different catchment conditions. However, the data basis of individual catchments regarding flood events may be limited due to short observation time series as well as a general lack in flood events during the observation period, which may cause flawed data-driven models for flood forecasting. These problems become even more pronounced in hourly flood forecasts for small-scale, fast responding catchments.

In this study with the purpose of hourly forecasting runoff events in small-scale Saxon catchments, we solved aforementioned dilemma through an extension of the training database from single-catchment datasets (“local network training”) to one dataset containing multiple catchments from one bigger region (“regional network training”). In consequence, we trained our LSTM networks on hourly rainfall and runoff time series of preselected rainfall-runoff-events from 52 Saxon catchments. Alongside these time series, we included a selection of attributes regarding the catchment’s characteristics and its climate, which allows the model to differentiate between catchments and to condition the runoff generation according to the catchment characteristics. In this contribution, we show that our regional network training facilitates rainfall-runoff simulations even at gauging sites with short observation periods – too short to enable local network training – and in in extreme cases even at ungauged catchments during flood events. We further discuss the following questions:

- Which catchment attributes have the highest influence on the quality of hourly flood forecasting in regional network training? The selection of attributes contains topography (e.g. area, catchment shape, elevation, slope & river length), land use (e.g. sealing of the ground & vegetation) as well as climatic conditions (e.g. aridity, yearly potential evapotranspiration and rainfall).
- In which case may the catchment attributes be omitted in regional network training?

- When do local and regional network trainings result in flood forecasts of similar quality?