

Wavelet Neural Network and Long Short-Term Memory Recurrent Neural Network for Rainfall and Runoff Prediction with Satellite-Derived Meteorological Data

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Abstract

At the catchment scales, the use of coupled, physically based and spatially explicit modelling of hydrological processes continue to be expensive due to the high computational costs and the demand for the necessary meteorological input data. As such, physically based models are still rarely used in operational rainfall–runoff forecasting. In addition, for most regions, the required parameterization datasets for the physical models, for example the 3D information on the physical characteristics of the sub-surface, are not available. For operational reasons therefore only simplified physical and conceptual models are routinely used. To improve on the physical and conceptual models, data-based mechanistic modelling concepts or fully data-driven approaches including regression, fuzzy-based or artificial neural networks (ANNs) have been developed and explored. This study evaluates the performance of long short-term memory (LSTM) recurrent neural networks (RNN) and the wavelet neural networks (WNN) for the prediction of rainfall and runoff in data scarce basins. Both models were trained and validated using 31-years (1979-2009) of observed data from three (3) discharge stations, ten (10) rainfall stations with corresponding satellite-derived meteorological data comprising of wind velocity, relative humidity, average temperature and solar radiation. With four (4) optimal hidden layers comprising of thirty (30) neurons each, the best results for the runoff prediction using LSTM-RNN and WNN models were determined with respective R2 of 0.8967 and 0.8820, with rainfall as the most significant predictor variable. For rainfall prediction, the LSTM-RNN outperformed WNN by 11% as measured in terms of R2 and through spatial distribution comparison with observed precipitation, showing that the integration of satellite-observed meteorological data, in the prediction of rainfall and runoff yields good results.

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