EGU22-9771
https://doi.org/10.5194/egusphere-egu22-9771
EGU General Assembly 2022

Simulating and multi-step reforecasting real-time reservoir operation using combined neural network and distributed hydrological model

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Reservoirs and dams are essential infrastructures for human utilization and management of water resources; yet modelling real-time reservoir operation and controlled reservoir outflow remains a challenge. Artificial intelligence techniques, especially machine learning and deep learning, have become increasingly popular in hydrological forecasting, including reservoir operation. In this study, we applied a recurrent neural network (RNN) and a long short-term memory (LSTM) to model the reservoir operation and outflow of a large-scale multi-purpose reservoir at the real-time (daily) timescale. This study aims to investigate the capabilities of RNN and LSTM models in simulating and reforecasting the real-time reservoir outflow, considering the uncertainties in model inputs, model training-testing periods, and different model algorithms. The Sirikit reservoir in Thailand was selected as a case study. The main inputs for the RNN and LSTM models were daily reservoir inflow, daily storage, and the month of the year. We applied the distributed wflow_sbm model for reservoir inflow simulation (using MSWEP precipitation data) and ensemble inflow reforecasting (using ECMWF precipitation data). Daily reservoir storage was obtained from observations and real-time recalculation based on the reservoir water balance. The models were trained and tested with 10-fold cross-validation. Results show that both RNN and LSTM models have high accuracies for real-time simulations and reasonable accuracies for multi-step reforecasts, and that LSTM exhibits better model performance in forecasting mode. The performance varied between each cross-validation, being highly related to the extreme events included in either training or test period. With further understanding of the reservoir inflow uncertainty influences on reservoir operation, we conclude that the models can be potentially applicable in real-time reservoir operation and decision-making for operational water management.