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Forecasting reservoir inflows with Long Short-Term Memory models

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The increased variability of water resources and the escalating water consumption contribute to the risk of stress and water scarcity in reservoirs that are typically designed based on historical conditions. Therefore, it is relevant to provide accurate forecasts of reservoir inflow to optimize sustainable water management as conditions change, especially during extreme events, such as flooding and drought. However, accurate forecasting the inflow is not straightforward, due the uncertainty of the hydrological inputs and the strong non-linearity of the system. Numerous recent studies have employed approaches based on Machine Learning (ML) techniques, such as Artificial Neural Networks (ANN), Long Short-Term Memory (LSTM), and Random Forest (RF), with successful examples of providing skilful site-specific predictions. In particular, LSTM have emerged among the pool of ML models for their performance in simulating rainfall-runoff processes, thanks to their ability to learn long-term dependencies from time series.
Here we propose an LSTM-based approach for inflow prediction in the Barrios de Luna reservoir, located in the Spanish part of the Douro River Basin. The reservoir has a dual role, as its water is used for irrigation during dry summer periods, and its storage volume is used to mitigate floods. Therefore, in order to operate the reservoir in the short-term, Barrios de Luna reservoir operators need accurate forecast to support water management decisions in the daily and weekly time horizons. In our work, we explore the potential of a LSTM model to predict inflow in the reservoir at varying lead times, ranging from 1 day up to 4 weeks. Initially, we use as inputs past inflow, precipitation and temperature observations, and then we include meteorological forecasts of precipitation and temperature from ECMWF Extended Range. For the latter experiments, different configurations of the LSTM are tested, i.e. training the model with observations and forecasts together and training the model with observations only and fine tune it with forecasts.
Our preliminary results show that precipitation, temperature and inflow observations are all crucial inputs to the LSTM for predicting inflow, and meteorological forecast inputs seem to improve performance for the longer lead-times of one week up to a month.
Predictions developed will contribute to the Douro case study of the CLImate INTelligence (CLINT) H2020 project.