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Experiments with encapsulation of Monte Carlo simulation results in machine learning models

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Uncertainty analysis techniques based on Monte Carlo (MC) simulation have been applied in hydrological sciences successfully in the last decades. They allow for quantification of the model output uncertainty resulting from uncertain model parameters, input data or model structure. They are very flexible, conceptually simple and straightforward, but become impractical in real time applications for complex models when there is little time to perform the uncertainty analysis because of the large number of model runs required. A number of new methods were developed to improve the efficiency of Monte Carlo methods and still these methods require considerable number of model runs in both offline and operational mode to produce reliable and meaningful uncertainty estimation.

This paper presents experiments with machine learning techniques used to encapsulate the results of MC runs. A version of MC simulation method, the generalised likelihood uncertain estimation (GLUE) method, is first used to assess the parameter uncertainty of the conceptual rainfall-runoff model HBV. Then the three machines learning methods, namely artificial neural networks, M5 model trees and locally weighted regression methods are trained to encapsulate the uncertainty estimated by the GLUE method using the historical input data. The trained machine learning models are then employed to predict the uncertainty of the model output for the new input data.

This method has been applied to two contrasting catchments: the Brue catchment (United Kingdom) and the Bagamati catchment (Nepal). The experimental results demonstrate that the machine learning methods are reasonably accurate in approximating the uncertainty estimated by GLUE. The great advantage of the proposed method is its efficiency to reproduce the MC based simulation results; it can thus be an effective tool to assess the uncertainty of flood forecasting in real time.