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Modelling hydrological diversity: advances in a national scale hydrological modelling framework for probabilistic flow simulation and prediction

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National simulations and predictions of river flows are increasingly demanded for robust environmental management decision making, for water resources planning and for national flood and drought risk assessment. However, producing hydrological simulations for large samples of catchments is challenging. Models will often need to encompass large heterogeneities in hydrological response, be adaptable in their level of spatial/temporal resolution to address different prediction problems and be computationally efficient to assess model and data uncertainties so that they can provide probabilistic simulations.

Here, we present recent advances to the new open source Dynamic TOPMODEL national modelling framework. This is a flexible and computationally efficient modelling framework that can be applied from catchment to national scale and can be adapted for specific hydrologic settings or data availability situations. To benchmark model performance and target model developments, we applied the model across the UK using an initial setup consisting of a uniform model structure, Monte Carlo sampled parameter sets and Hydrological Response Units (HRUs) defined by three equal classes of slope and accumulated area, catchment masks, and a 10 km2 rainfall and PET grid. Daily data from 1961 – 2015 was used for over 1,300 gauged catchments to evaluate the performance against a suite of model performance metrics. The model is found to perform well in the majority of catchments but less well in catchments that were dry, heavily human impacted, snow influenced, or groundwater dominated. To address these challenges, we highlight ongoing advances to the model including the development of spatial parameter fields, the adaptation of the model for human impacted catchments and better characterisation of groundwater dynamics. Finally we discuss how these model developments lead to a better characterisation of hydrological diversity and improved modelling capability across large samples of catchments.