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Defining prior probabilities for hydrologic model structures in UK catchments

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The selection of a model structure is an essential part of the hydrological modelling process. Recently flexible modeling frameworks have been proposed where hybrid model structures can be obtained by mixing together components from a suite of existing hydrological models. When sufficient and reliable data are available, this framework can be successfully utilised to identify the most appropriate structure, and associated optimal parameters, for a given catchment by maximizing the different models ability to reproduce the desired range of flow behaviour. In this study, we use a flexible modelling framework to address a rather different question: can the most appropriate model structure be inferred a priori (i.e without using flow observations) from catchment characteristics like topography, geology, land use, and climate? Furthermore and more generally, can we define priori probabilities of different model structures as a function of catchment characteristics?

To address these questions we propose a two-step methodology and demonstrate it by application to a national database of meteo-hydrological data and catchment characteristics for 89 catchments across the UK. In the first step, each catchment is associated with its most appropriate model structure. We consider six possible structures obtained by combining two soil moisture accounting components widely used in the UK (Penman and PDM) and three different flow routing modules (linear, parallel, leaky). We measure the suitability of a model structure by the probability of finding behavioural parameterizations for that model structure when applied to the catchment under study. In the second step, we use regression analysis to establish a relation between selected model structures and the catchment characteristics. Specifically, we apply Classification And Regression Trees (CART) and show that three catchment characteristics, the Base Flow Index, the Runoff Coefficient and the mean Drainage Path Slope, can be used to predict which model structure is more appropriate.

The study constitutes a first step to enhance the choice of model structures in hydrological modeling across regions, with potentially interesting applications for predictions in ungauged basins, that was made possible by the analyses of large datasets.