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Parameterisation of the Dynamic TOPMODEL national-scale hydrological model using uncertain Multiscale Parameter Regionalisation.

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A key challenge for the implementation of hyper-resolution hydrologic models is the generation of realistic spatial parameter fields from catchment characteristics. We tackle this challenge in the context of our new flexible national-scale hydrological modelling framework, Dynamic TOPMODEL. Dynamic TOPMODEL splits each catchment into spatially connected hydrological response units that can be assigned a different set of model parameters and structures to represent different hydrological processes (Beven and Freer, 2001). The model therefore requires methods to generate plausible spatial fields of parameters that represent the heterogeneity of catchment characteristics, which can then be sampled within an uncertainty analysis framework. Such an approach would reduce computational spatial sampling challenges and avoid an unrealistic 'patchwork quilt' of parameters with discontinuities in the spatial field of parameter values (Mizukami et al. 2017).

In this study, we apply Dynamic TOPMODEL to the River Severn catchment in the UK and utilise Multi-scale Parameter Regionalisation (MPR) to generate plausible spatial fields of parameters and evaluate the results against a more simplistic Monte-Carlo parameterisation technique. MPR has previously been used to solve such parameterisation problems in other models, by using catchment descriptors such as soil characteristics to infer the spatial field of model parameters and pedo-transfer functions to link parameters to catchment descriptors (Samaniego et al. 2010). Parameters are derived from catchment descriptors at the highest possible spatial resolution, and then upscaled to the modelling scale. This results in the transferability of calibrated MPR parameters across spatial scales, which is useful in a flexible modelling framework such as Dynamic TOPMODEL. However, little has been done to explore uncertainties in the parameter fields created using MPR and the method has not before been applied to a flexible framework such as Dynamic TOPMODEL or for the UK. Consequently, this study aims to answer the following research questions. First, is MPR a suitable parameterisation strategy for the Dynamic TOPMODEL modelling framework, and does the performance of Dynamic TOPMODEL calibrated with MPR spatial fields outperform more homogeneous Monte-Carlo calibration for multiple gauges? Secondly, which basin predictors are useful in representing our parameters and thereby improving predictions for the UK? Thirdly, how can parameter uncertainty be considered and evaluated within the MPR framework?