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Using large hydrological datasets to create a robust, physically based, spatially distributed model for Great Britain

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The impact of climate change on hydrological systems requires further quantification in order to inform water management. This study intends to conduct such analysis using hydrological models. Such models are of varying forms, of which conceptual, lumped parameter models and physically-based models are two important types. The majority of hydrological studies use conceptual models calibrated against measured river flow time series in order to represent catchment behaviour. This method often shows impressive results for specific problems in gauged catchments. However, the results may not be robust under non-stationary conditions such as climate change, as physical processes and relationships amenable to change are not accounted for explicitly. Moreover, conceptual models are less readily applicable to ungauged catchments, in which hydrological predictions are also required.
As such, the physically based, spatially distributed model SHETRAN is used in this study to develop a robust and reliable framework for modelling historic and future behaviour of gauged and ungauged catchments across the whole of Great Britain. In order to achieve this, a large array of data completely covering Great Britain for the period 1960-2006 has been collated and efficiently stored ready for model input. The data processed include a DEM, rainfall, PE and maps of geology, soil and land cover. A desire to make the modelling system easy for others to work with led to the development of a user-friendly graphical interface. This allows non-experts to set up and run a catchment model in a few seconds, a process that can normally take weeks or months.

The quality and reliability of the extensive dataset for modelling hydrological processes has also been evaluated. One aspect of this has been an assessment of error and uncertainty in rainfall input data, as well as the effects of temporal resolution in precipitation inputs on model calibration. SHETRAN has been updated to accept gridded rainfall inputs, and UKCP09 gridded daily rainfall data has been disaggregated using hourly records to analyse the implications of using realistic sub-daily variability.

Furthermore, the development of a comprehensive dataset and computationally efficient means of setting up and running catchment models has allowed for examination of how a robust parameter scheme may be derived. This analysis has been based on collective parameterisation of multiple catchments in contrasting hydrological settings and subject to varied processes. 350 gauged catchments all over the UK have been simulated, and a robust set of parameters is being sought by examining the full range of hydrological processes and calibrating to a highly diverse flow data series.

The modelling system will be used to generate flow time series based on historical input data and also downscaled Regional Climate Model (RCM) forecasts using the UKCP09 Weather Generator. This will allow for analysis of flow frequency and associated future changes, which cannot be determined from the instrumental record or from lumped parameter model outputs calibrated only to historical catchment behaviour. This work will be based on the existing and functional modelling system described following some further improvements to calibration, particularly regarding simulation of groundwater-dominated catchments.