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Characterizing Drought Events from a Hydrological Model Ensemble

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Hydrological droughts are a slow onset natural hazard that can affect large areas. Within the United Kingdom there have been eight major drought events over the last 50 years, with several events acting at the continental scale, and covering the entire nation. Many of these events have lasted several years and had significant impacts on agriculture, the environment and the economy. Generally in the UK, due to a northwest-southeast gradient in rainfall and relief, as well as varying underlying geology, droughts tend to be most severe in the southeast, which can threaten water supplies to the capital in London.

With the impacts of climate change likely to increase the severity and duration of drought events worldwide, it is crucial that we gain an understanding of the characteristics of some of the longer and more extreme droughts of the 19th and 20th centuries, so we may utilize this information in planning for the future. Hydrological models are essential both for reconstructing such events that predate streamflow records, and for use in drought forecasting. However, whilst the uncertainties involved in modelling hydrological extremes on the flooding end of the flow regime have been studied in depth over the past few decades, the uncertainties in simulating droughts and low flow events have not yet received such rigorous academic attention.

The “Cascade of Uncertainty” approach has been applied to explore uncertainty and coherence across simulations of notable drought events from the past 50 years using the airGR family of daily lumped catchment models. Parameter uncertainty has been addressed using a Latin Hypercube sampled experiment of 500,000 parameter sets per model (GR4J, GR5J and GR6J), over more than 200 catchments across the UK. The best performing model parameterisations, determined using a multi-objective function approach, have then been taken forward for use in the assessment of the impact of model parameters and model structure on drought event detection and characterization. This ensemble approach allows for uncertainty estimates and confidence intervals to be explored in simulations of drought event characteristics, such as duration and severity, which would not otherwise be available from a deterministic approach. The acquired understanding of uncertainty in drought events may then be applied to historic drought reconstructions, supplying evidence which could prove vital in decision making scenarios.