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Identifying the properties of behavioural parameter sets for rainfall-runoff models through optimisation and clustering analysis

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One approach to addressing the equifinality issue for catchment hydrological models is to embed the various response modes of a catchment in behavioural sets of model parameters. Subsequent optimisation with different optimisation criteria associates suitable model structures and parameters with performance for different flow regimes (high or low flows) or desirable combinations of them (notion of catchment signature), e.g. the entire range of a flow curation curve. Assuming that a parsimonious model structure has been identified, the resulting set of models represented by the behavioural set of parameters may result in a set of parameters regrouped in the same, constrained, region of the parameter space. Alternatively, however, clusters of sets of parameters in the parameters space, each performing distinctively better on different aspects of the hydrograph (e.g. sustained low flows) could remain. This could be interpreted as the model structure needing revision, but the predictive capabilities of the existing structure might be sufficient for many applications in water resources management, so that the quest for a "super" one-model-fits-all solution could be relaxed in practice. In particular, the provision of freshwater ecosystem services is currently modelled by using hydrological models. Each freshwater ecosystem service can be provided by some aspect of the hydrograph, e.g. capacity to dilute water contaminants in periods of high flows, or conversely when sustained low flows threaten the survival of the aquatic fauna and flora. This study explores how best an existing, assumed suitable, model structure can be used to elicit several sets of behavioural models, each customised for the modelling of a specific purpose (i.e. freshwater ecosystem service). An initial model optimisation is followed by a clustering analysis to explore the parameters space on behavioural models and identify whether significant differences in hydrological predictions exist.