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A physical similarity approach to regionalisation using a global database of catchments

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A common task for hydrologists is modelling runoff at ungauged catchments. Difficulties in transferring information from gauged to ungauged sites (referred to as regionalisation), make the results very uncertain. An attractive method for regionalisation is to transfer rainfall-runoff model parameters directly from a donor catchment; preserving the correlation between the model parameters. However, the scale of most regionalisation studies has limited the number of appropriate donor catchments, with this pool often reduced further if a threshold of model performance is applied. A growing trend in hydrological modelling is the development of large scale, even global, repositories of catchment models often available online. These developments are starting to address the problem of small numbers of appropriate donor catchments available for regionalisation analysis. However, large scale hydrological modelling repositories, potentially using automated methods to calibrate models, may make more catchments available but at the expense of higher variation in fit efficiency. This presentation investigates the question: is it more important to have donor catchments with better performing rainfall-runoff models, or can a shortfall in the performance of the donor catchment models be offset if they are more similar to the target catchment?

To answer this question, we make use of GCD (JBA Risk Management's global database of catchments). All catchments in the database are described by a set of geomorphological and meteorological attributes and a calibrated IHACRES hydrological model. The input to the IHACRES models is formed from the Climate Forecast System Reanalysis (CFSR) gridded temperature and precipitation data set, while the models were calibrated against daily or monthly streamflow data. This resource provides access to around 18,000 catchment models and their selected attributes. The catchment attributes were derived from global datasets for soil type, elevation, land cover, mean annual rainfall and climate zone classification.

Using this database, we applied a leave-one-out cross validation of regionalisation using 3,000 catchments as a sample. The regionalisation involved selecting the ten most similar catchments and using weighted average to obtain the streamflow. The validation tested two distinct methods for assigning weights: 1) weighting according to attribute similarity; and 2) weighting according to KGE (Kling-Gupta Efficiency) score. The results show that the two weighting methods produce similar global performance suggesting that shortcomings in the availability of good model efficiency can be offset by high similarity of donor catchments and vice versa. However, when subset by climate classification, the weighting method based on KGE score performs significantly better in arid regions where the availability of donor models is low. This strongly suggests that when there is a paucity of donor catchments to choose from, it is important to invest most effort in selecting well-fitting models rather than limiting the model pool to more similar catchments. At a transitional period where the demand for, but also the number of options, for global-scale river flow prediction is increasing, these findings are useful to support modelling strategy.