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Regionalisation of rainfall-runoff models in southern and northern Australian catchments

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Abstract: With computational advances it has become increasingly possible to incorporate complex process in numerical hydrological models. However, these 'process-based' models require a considerable amount of data as inputs and for parameterization. For this reason, conceptual rainfall-runoff models are widely used for estimating runoff and streamflow, because they only require rainfall, evapotranspiration and streamflow observations for the parameterization process. However, without sufficient length of data, runoff estimates can be highly uncertain, and model error cannot be estimated. There have been numerous studies that have examined different methods for applying these models where no streamflow data exist, which often involves a process of transferring parameters from gauged catchments to ungauged catchments, termed "Regionalisation" (Young 2006).

This study compared how the performance of different regionalization methods compared to calibrating a rainfall-runoff model with increasing length of streamflow data made available. To achieve this, we calibrated and verified the Sacramento Soil Moisture Accounting (SAC-SMA) model using daily rainfall and streamflow data for 290 Australian gauged unregulated catchments. The calibration and verification were conducted over a non-overlapping period with shifting windows, testing various parameter sets from different methods, including i) local window – model parameters were optimized against a limited length of streamflow data (i.e. 1 to 10 years) , ii) nearest neighbour – model parameters were transposed from the nearest neighbour catchment/s, iii) flow similarity –adopted the parameter set from the parameter library for the catchment with the most similar flow over limited length of streamflow data, and iv) combined methods – a weighted combination of the nearest neighbour and the flow similarity. All the methods were validated against the entire streamflow record for each of the 290 catchments. This study tested these methods for three objective functions (OF) based on Nash and Sutcliffe Efficiency and Multi-Bin Efficiency and moving windows with various record lengths to determine the most effective approach for simulating streamflow in ungauged catchments.

The study experimented the regionalisation methods for about 6,000 different periods across 290 catchments. In terms of variability across all the test we have taken, the combined method produces the most reliable results as its confidence bound in the box-whisker plot appears to be smaller than others and this get more notable in northern Australian catchments. All the test results show the similar outcome from three different OFs. In shorter record periods, the local window method seemed to produce more scattered results compared to the flow similarity or combined methods. However, as the record period lengthens, the combined method yielded higher estimated values for both the minimum and 25th percentile model efficiency.

This study grouped all catchments into three levels of humidity using annual mean rainfall and found that, in terms of catchment humidity, the local window method had the highest chance of outperforming other methods in all test cases, particularly in drier catchments. Additionally, when considering catchment area, local window was the most effective method for most catchment areas.

REFERENCES

Young, A.R. 2006. Stream flow simulation within UK ungauged catchments using a daily rainfall-runoff model. Journal of Hydrology 320(1–2), 155–172.

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