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Effect of Rainfall Data Quality on Rainfall-Runoff Model Calibration and Regionalisation

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The majority of catchment water balance studies use conceptual rainfall-runoff models to estimate total daily runoff at the catchment outlet. In most applications, the observed runoff used to calibrate these rainfall-runoff models is only available at the catchment outlet and thus represents an aggregated response of spatially variable rainfall across the catchment. In many applications, the input climate data (rainfall and PET) used to calibrate the models is available only at limited locations within the catchment or even somewhere close to the catchment. Only in some applications is spatially variable climate data used to drive the models either as a lumped or distributed model.

Many regionalisation studies over the last decade have focussed on the transfer of rainfall-runoff model parameters from gauged to ungauged catchments with the intention of deriving a rainfall-runoff model for an ungauged catchment (i.e. one with no streamflow records). Sometimes this is done through the transfer of calibrated models from 'similar' or nearby catchments, and sometimes it is done through the transfer of model parameters based on their relationships with measurable catchment attributes. Where the latter technique has been used, it is based on the assumption that rainfall-runoff model parameters are representative of the hydrologic response of the catchment and are thus largely independent of each other and of errors in the rainfall inputs.

1. METHODS

To investigate the implications of input rainfall data and the model calibration and simulation methodology on the model calibration and regionalisation, two widely used daily rainfall-runoff models (SIMHYD and Sacramento) were calibrated using the four methods shown in Table 1 on 238 catchments varying in size from ~ 100 km^2 to 2,000 km^2.

Table 1: Calibration methods investigated

Method	Rainfall input	Models
1	Single raingauge closest to catchment centroid	Lumped
2	Weighted (Thiessen polygon) average of all raingauges	Lumped
3	Arithmetic average of 5 km (SILO) rainfall grid	Lumped
4	5 km (SILO) rainfall grid	Distributed

2. RESULTS

The calibration and simulation results for all 238 catchments clearly show that there is substantial improvement in model efficiencies with improved spatial representation of input rainfall data. The results also suggest that the improvements are generally greater in larger catchments than in smaller catchments. This is to be expected as there is a greater likelihood that rainfall will show greater spatial variability in larger catchments and therefore a single raingauge is unlikely to capture all of the rainfall events adequately.

Results from methods 1-3 indicate that the use of different rainfall inputs to calibrate the rainfall-runoff models can produce vastly different parameter values. This appears to be particularly true for the more highly parameterised Sacramento model compared to the less highly parameterised SIMHYD model. The implication of this result is that it is not possible to relate model parameters directly to catchment attributes and use these relationships to produce rainfall-runoff models in ungauged catchments. Also, models calibrated on less spatially distributed rainfall inputs do not perform as well when regionalised as those calibrated on more spatially distributed rainfall inputs. This implies that although we can transfer entire models from gauged to ungauged catchments, if the rainfall used to calibrate the model was poor, the resultant regionalised model will also be poor even if the rainfall in the ungauged catchment is of high quality.

Comparing results from method 4 with those from method 3, there are minor improvements in the efficiencies for both models when comparing a lumped model with a distributed model. However, in general these improvements are not as large as the improvements seen by using an improved representation of the rainfall.

3. DISCUSSION

These results were achieved using the SIMHYD and Sacramento models and may therefore only be applicable to these specific rainfall-runoff models. However, the authors have seen little evidence that the parameters of other rainfall-runoff models are less cross-correlated than these two and this believe these results to be more widely applicable. Similarly, the quality of rainfall inputs in the current study may be considered to be on the poor side (particularly for larger catchments), however calibrating a model on a handful of raingauges (or even just one) for catchments up to around 2,000 km^2 is common practice, at least in Australia where distances between rainfall gauges are often very large.