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Comparison of Two Stochastic Daily Rainfall Models and their Ability to Preserve Multi-year Rainfall Variability

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Stochastic simulation of rainfall is often required in the simulation of streamflow and reservoir levels for water security assessment. As reservoir water levels generally vary on monthly to multi-year timescales, it is important that these rainfall series accurately simulate the multi-year variability. However, the underestimation of multi-year variability is a well-known issue in daily rainfall simulation.

Focusing on this issue, we developed a hierarchical Markov Chain (MC) model in a traditional two-part MC-Gamma Distribution modelling structure, but with a new parameterization technique. We used two parameters of first-order MC process (transition probabilities of wet-to-wet and dry-to-dry days) to simulate the wet and dry days, and two parameters of Gamma distribution (mean and standard deviation of wet day rainfall) to simulate wet day rainfall depths. We found that use of deterministic Gamma parameter values results in underestimation of multi-year variability of rainfall depths. Therefore, we calculated the Gamma parameters for each month of each year from the observed data. Then, for each month, we fitted a multi-variate normal distribution to the calculated Gamma parameter values. In the model, we stochastically sampled these two Gamma parameters from the multi-variate normal distribution for each month of each year and used them to generate rainfall depth in wet days using the Gamma distribution.

In another study, Mehrotra and Sharma (2007) proposed a semi-parametric Markov model. They also used a first-order MC process for rainfall occurrence simulation. But, the MC parameters were modified by using an additional factor to incorporate the multi-year variability. Generally, the additional factor is analytically derived from the rainfall over a pre-specified past periods (e.g. last 30, 180, or 360 days). They used a non-parametric kernel density process to simulate the wet day rainfall depths. In this study, we have compared the performance of our hierarchical MC model with the semi-parametric model in preserving rainfall variability in daily, monthly, and multi-year scales.

To calibrate the parameters of both models and assess their ability to preserve observed statistics, we have used ground based data from 15 raingauge stations around Australia, which consist a wide range of climate zones including coastal, monsoonal, and arid climate characteristics. In preliminary results, both models show comparative performances in preserving the multi-year variability of rainfall depth and occurrence. However, the semi-parametric model shows a tendency of overestimating the mean rainfall depth, while our model shows a tendency of overestimating the number of wet days. We will discuss further the relative merits of the both models for hydrology simulation in the presentation.