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Development of a Compound Distribution Markov Chain Model for Stochastic Generation of Rainfall with Long Term Persistence

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One of the overriding issues in the rainfall simulation is the underestimation of observed rainfall variability in longer timescales (e.g. monthly, annual and multi-year), which usually results into under-estimation of reservoir reliability in urban water planning. This study has developed a Compound Distribution Markov Chain (CDMC) model for stochastic generation of daily rainfall. We used two parameters of Markov Chain process (transition probabilities of wet-to-wet and dry-to-dry days) for simulating rainfall occurrence and two parameters of gamma distribution (calculated from mean and standard deviation of wet-day rainfall) for simulating wet-day rainfall amounts. While two models with deterministic parameters underestimated long term variability, our investigation found that the long term variability of rainfall in the model is predominantly governed by the long term variability of gamma parameters, rather than the variability of Markov Chain parameters. Therefore, in the third approach, we developed the CDMC model with deterministic parameters of Markov Chain process, but stochastic parameters of gamma distribution by sampling the mean and standard deviation of wet-day rainfall from their log-normal and bivariate-normal distribution. We have found that the CDMC is able to replicate both short term and long term rainfall variability, when we calibrated the model at two sites in east coast of Australia using three types of daily rainfall data – (1) dynamically downscaled, 10 km resolution gridded data produced by NSW/ACT Regional Climate Modelling project, (2) 5 km resolution gridded data by Australian Water Availability Project and (3) point scale raingauge stations data by Bureau of Meteorology, Australia. We also examined the spatial variability of parameters and their link with local orography at our field site. The suitability of the model in runoff generation and urban reservoir-water simulation will be discussed.