Streamflow-based evaluation highlights discrepancies in stochastic rainfall model performance

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Abstract: Stochastic rainfall models (SRMs) are widely used to assess hydrological risks such as flooding and drought by generating alternative plausible climatic timeseries. However, these models are typically evaluated in a stand-alone manner using metrics related to the stochastic generator, without considering their end-of-system impact on water-related infrastructure within a catchment. A framework is presented for quantitatively evaluating stochastic rainfall models in terms of their catchment-based performance using streamflow-based metrics. The framework is used to evaluate two stochastic rainfall models, a Markov-based model (WGEN), and a latent-variable model (LV), across 383 sites in two countries, Australia, and the United States. While both models showed overall good performance in terms of rainfall metrics, their performance differed significantly when evaluated based on streamflow-based metrics when coupled with the GR4J conceptual rainfall-runoff model. Figure 1 illustrates an instance where 'good-modelled' rainfall can translate to 'poor-modelled' streamflow.

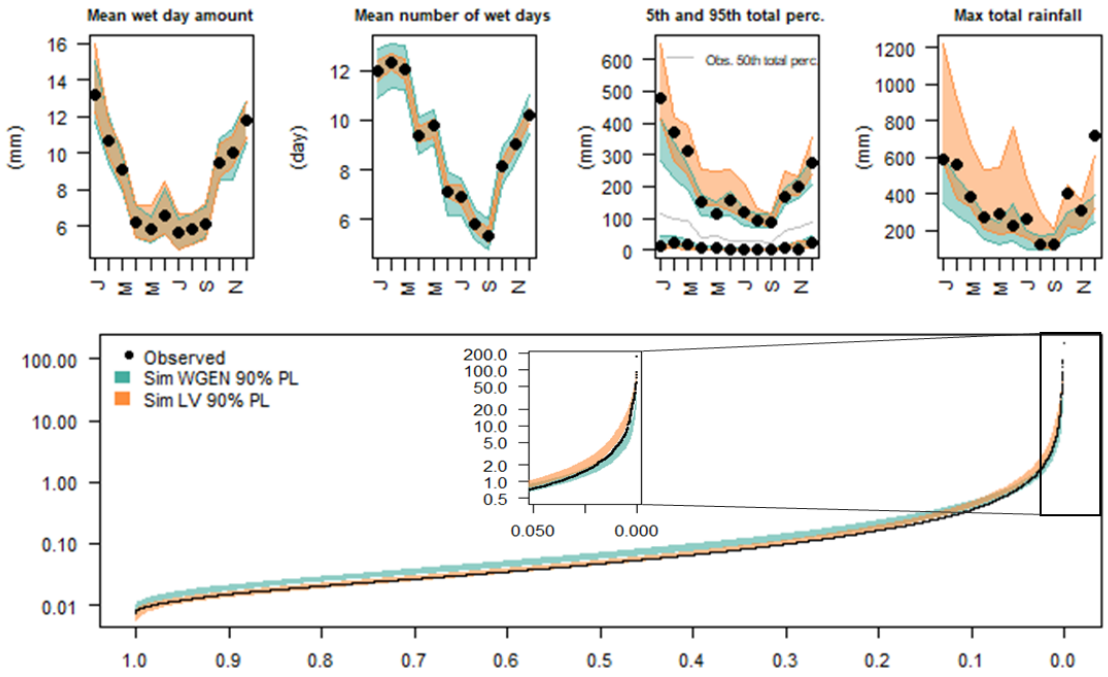

Figure 1. WGEN and LV model performance in simulating 4 rainfall statistics and the flow duration curve for catchment 136101A, Queensland, Australia. PL is denoted as the probability limit

Figure 1 shows that both WGEN and LV model effectively preserved the rainfall extremes (the 5th and the 95th percentiles) and the rainfall seasonal characteristics (the mean wet day amounts and the mean number of wet days). However, when the simulated rainfall translated to simulated streamflow, the WGEN model shows to consistently overestimate the streamflow lower-tail and underestimate the upper-tail. In contrast, the LV model preserves the streamflow lower-tail but overestimates the upper-tail. Hence, component-wise evaluation, such as focusing on rainfall metrics, can misrepresent the ultimate model performance. The results highlight that streamflow-based evaluation is more informative than rainfall-based evaluation, as it captures the effects of rainfall transformation within a catchment.

Keywords: *Stochastic rainfall, rainfall runoff, continuous simulation, rainfall generation*