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Stochastic centring of BARRA rainfall space-time patterns in a hydrological model

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Abstract: When using hydrological models to estimate flood characteristics for infrastructure design, a key consideration is how the potential variability in rainfall over the catchment is represented. The most recent iteration of Australian Rainfall and Runoff (Nathan and Ball 2019) encourages representing this rainfall variability in a Monte Carlo framework. For most applications, these design storms are constructed through combination of design depths with temporal patterns and spatial patterns. However, for larger catchments it can be more appropriate to use space-time patterns rather than distinct spatial and temporal patterns, to ensure that the combined spatiotemporal characteristics are physically reasonable.

In both approaches, it is often assumed that the storm is centred over the catchment. However, floods can occur even when storms only partially cover a catchment. Representing variability in storm position can result in a greater variety of modelled flood hydrographs. In Scorah et al. (2021), a technique was developed to incorporate stochastic centring of storm space-time patterns within a catchment. This method involved development of rainfall frequency curves through transposition of regional storm space-time patterns. From this transposition process the probability of a particular storm at a particular location resulting in a given catchment average depth being exceeded could be estimated.

A limitation of the analysis in Scorah et al. (2021) is that the space-time patterns were constructed by disaggregating AWAP gridded rainfall (Jones et al. 2009) using the nearest sub-daily gauged information. This means that the sample of regional storm space-time patterns is constrained by gauge density. To overcome this limitation, the Scorah et al. (2021) analysis was repeated using the BARRA sub-daily rainfall dataset (Su, C. H. et al. 2018). Because the BARRA data is a reanalysis dataset, gauged rainfall observations are not used directly; consequently, the resulting space-time patterns are not sensitive to rainfall gauge density.

Hydrology modelling based on the stochastic centring of space-time patterns derived using BARRA was then conducted for a large catchment in NSW and the results were compared to a more conventional application of catchment-centred space-time patterns. It was found that catchment-centred space-time patterns resulted in similar flood peaks at the outlet when compared to the stochastic space-time pattern centring approach. However, for downstream areas outside the study catchment the variability in rainfall was far greater in the stochastic centring approach compared with the catchment-centred approach. This highlights a challenge, as hydrology modelling for downstream catchments is often an important input when using hydraulic models to estimate the consequences associated with dam failures. Further research should therefore consider how this rainfall space-time variability can best be represented in hydraulic models, particularly given the typically larger run times compared to hydrologic models.

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