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Development of new regional flood estimation methods for New South Wales

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ABSTRACT

Design flood estimation is a major task in hydrologic design and often carried out using recorded flood data by at-site flood frequency analysis. Due to presence of numerous ungauged catchments, regional flood frequency analysis (RFFA) is widely adopted in practice. There are a number of RFFA methods such as index flood method (IFM), which requires formation of homogeneous regions. However, in Australia, it is difficult to form homogeneous regions.

In this study, advanced statistical techniques are adopted to develop new RFFA methods using data from 88 catchments in New South Wales. Eight catchment characteristics are selected as predictor variables. The RFFA methods are evaluated by a leave-one-out (LOO) validation. The homogeneity test proposed by Hosking and Wallis (1993) is adopted to identify homogeneous regions, however none are found. Hence, firstly, an approximate index flood method (AIFM) is proposed in both fixed region and region of influence (ROI) frameworks.

In the proposed AIFM, the 10% AEP flood (Q10) is considered as the index variable. The prediction equation to estimate Q10 is developed by multiple linear regression (MLR) analysis and catchment area, rainfall intensity, shape factor and stream density are found to be the most significant predictors. It is also found that the AIFM with ROI performs better than the fixed region approach. Thereafter, principal component analysis (PCA) is employed to derive uncorrelated principal components (PC), since many of the selected predictor variables are highly correlated. The first five PCs are selected in a MLR analysis and it is named as the principal component regression (PCR), which is applied in both the fixed region and ROI frameworks.

Results from PCR indicate that it is not a viable RFFA method for the given data set. Afterwards, a hierarchical cluster analysis (Ward's method) is applied to form possible homogeneous groups. Each cluster is checked for homogeneity using the method proposed by Hosking and Wallis (1993) and none of the clusters are found to be homogeneous. A MLR equation is developed for each cluster to estimate flood quantiles. It is found that the cluster having moderate sized catchments generates more accurate flood quantiles. Thereafter, independent component analysis (ICA) is adopted to develop RFFA models. The ICA can generate statistically independent and uncorrelated independent components (IC) from the raw predictors. These ICs are then adopted in MLR and it is named as independent component regression (ICR). The ICR is developed in both quantile regression and parameter regression frameworks. It is found that ICR with all the ICs in parameter regression framework performs better than the selected alternative models. The ICR outperforms the RFFA technique recommended in the latest Australian Rainfall and Runoff. This thesis has made a noteworthy impact in RFFA research field by the publication of two refereed journal articles and one scholarly book chapter.