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Blunders and Bias in Flood and Drought Frequency Analysis

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There are now two common approaches to frequency analysis for extreme events based on the use of (1) deterministic simulation and (2) statistical models. Both approaches commonly result in considerable bias in design quantile estimates. There is an increasing need to apply deterministic watershed models (DWM) for the design of flood or drought protection measures, because such DWM's can account for impacts of changes in land use, climate and infrastructure. Usually DWM's are calibrated to existing datasets resulting in an important model error component. Once calibrated, nearly all previous applications of DWM's ignore the model error component, in spite of the fact that simulations which ignore the model error component produce model output which does not reproduce important and known statistical properties of such model output. We show how ignoring model error always leads to downward bias in flood quantiles, upward bias in drought quantiles, and upward bias in water supply yields. We document the importance of adding model error to DWM model output to ensure that such models generate results which mimic actual observations.
Approaches based on statistical models can also be subject to systematic bias due to the considerable influence exerted by the magnitude of the largest observation(s) used to fit common frequency models. When the largest (smallest) observation in a flood record has an average return period, T which is much greater (less) than the length of the flood record, n, it is termed an outlier. We show that outliers can cause severe systematic bias in commonly used goodness-of-fit metrics as well as design flood and drought quantiles. Adaptive approaches which adjust how the largest observation is handled are shown to hold considerable promise for reducing such systematic bias in design quantile estimators. New goodness-of-fit metrics are also introduced, which are not so severely and systematically impacted by the magnitude of outliers.