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Impacts of Hydrologic Model Uncertainty on Water Resources Management

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All hydrologic models include some degree of uncertainty and residual error. Despite attempts to minimize error and uncertainty for particular applications, hydrologic models remain strongly influenced by the distribution of the residual errors. When the output of a hydrologic model (e.g., a simulated hydrograph) is further processed for a particular application (e.g., reservoir operations for flood management), the effect of even a small degree of residual error can be compounded. Two recent studies are presented, the first explores the distributional bias that results from residual errors in a simulated hydrograph, while the second explores the utility of streamflow statistics derived from simulated hydrographs. In combination, these experiments illuminate that caution is required when using a large-scale hydrologic model to inform water resources management. It is shown that even a well-calibrated daily rainfall-runoff model produces inexact estimates of daily streamflow. The impact of these residuals becomes particularly problematic when considering the distributional properties of simulated streamflow in reference to observed streamflow. In applications across the United States, these two studies showed that simulated streamflow time series underestimated the standard deviation of daily streamflow by more than 40%. The annual maximum streamflow with a 10% probability of exceedance is underestimated by more than 35%. These effects of confounding residuals are a result of using a model developed for one application (e.g., the simulation of daily hydrographs) to inform a second application (e.g., the characterization of the distribution of daily streamflow). This limits the utility of models for water resources management. We must then ask if models of complete hydrographs are the ideal tool for water management. It may be that direct estimators of specific statistics (e.g., regional regression of the standard deviation of streamflow) provide better accuracy and allow for easier communication of inherent uncertainty. The next phase of this work considers the advantages and disadvantages of complete-hydrograph estimation and specific-statistic estimation in support of water resources management in ungauged locations.