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Quantifying GCM uncertainty for estimating storage requirements in Australian reservoir

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Climate change is anticipated to have enormous impacts on our water resources. Whether or not the existing storage capacity of reservoirs is sufficient to meet the future water demands is a question of great interest to water managers and policy makers. Amongst other things, uncertainties in GCM projections make accurate estimation of future water availability and reservoir storage requirements extremely complicated. The present study proposes a new method to quantify GCM uncertainties and their influence on the estimation of reservoir storage. Reliable quantification of GCM uncertainties requires utilization of many ensemble runs for each model and emission scenario. However, the climate modeling groups around the world produce only a few ensemble runs for each scenario. Using these limited number of ensemble runs, this study presents a method to quantify GCM uncertainty that varies with space and time as a function of the GCM being assessed. Then, using GCM projection and estimated associated uncertainty, new data series are generated assuming an additive error model which are used to ascertain effects of GCM uncertainties in impact assessment studies. The analysis involves the following important steps: First, standard errors of bias-corrected GCM projections are estimated using multiple model, scenario and ensemble runs conditional on each percentile. Second, assuming an additive error model, several realizations are generated by randomly sampling from normal distribution. Finally, the generated realizations are applied to evaluate impacts of climate change on reservoir storage estimation and establish its associated uncertainty. The proposed method is applied to quantify uncertainties in rainfall and temperature projections obtained from six GCMs, three emission scenarios and three ensemble runs after correcting biases using the Nested Bias Correction (NBC). Then, thousands of rainfall and temperature realizations are generated using an additive error model for selected GCM and scenario projection. The temperature data are used to estimate evaporation realizations which are then used as input (together with rainfall) to rainfall-runoff model for estimating streamflow. Finally, the streamflow realizations are used to quantify reservoir storage requirements with its associated uncertainties using behavior analysis. Results at the Warragamba dam in Australia reveal that GCM uncertainties will be significantly large for the future period than that for the historical period for both rainfall and temperature at different demand levels. Further, comparison of effects of rainfall and evaporation uncertainty suggests that reservoir storage uncertainty is introduced mainly from rainfall, rather than evaporation.