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Application of synthetic scenarios to address water resource concerns: A management-guided case study from the Upper Colorado River Basin

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ABSTRACT

Water managers are increasingly interested in better understanding and planning for projected resource impacts from climate change. In this management-guided study, we use a very large suite of synthetic climate scenarios in a statistical modeling framework to simultaneously evaluate how (1) average temperature and precipitation changes, (2) initial basin conditions, and (3) temporal characteristics of the input climate data influence water-year flow in the Upper Colorado River. The results here suggest that existing studies may underestimate the degree of uncertainty in future streamflow, particularly under moderate temperature and precipitation changes. However, we also find that the relative severity of future flow projections within a given climate scenario can be estimated with simple metrics that characterize the input climate data and basin conditions. These results suggest that simple testing, like the analyses presented in this paper, may be helpful in understanding differences between existing studies or in identifying specific conditions for physically based mechanistic modeling. Both options could reduce overall cost and improve the efficiency of conducting climate change impacts studies.

Practical Implications

The results here suggest that both initial conditions within the basin and differences in the timing and duration of wet, dry, warm, or cool periods in the driving climate data are important sources of uncertainty in streamflow simulations that should be considered in evaluating projections of future flows. These results also underscore the importance of using multiple approaches to evaluate the impacts of climate changes. Top-down study designs, where climate model data is selected, downscaled and used to drive an impacts model, provide valuable information, but they have the potential to integrate multiple influences on streamflow because model-derived climate scenarios may differ in many ways (e.g., mean change, seasonality of change, temporal characteristics of the data, spatial pattern of change), and initial basin conditions are not always well characterized because of the need for model spin-up. Different studies use different years of climate data to initialize hydrological models, leading to slightly different initial conditions. The approach used here is capable of deconstructing the influence of initial basin conditions, mean climate change, and differences in the pattern and timing of climate change in a way that a top-down study cannot. Moreover, the methods used in this study, which make it easy to evaluate the effects of mean climate changes and initial conditions, provide a framework for evaluating and prioritizing more intensive hydrological modeling efforts. A synthetic scenario strategy like the one used here facilitates using a bottom-up research approach that allows for a more comprehensive assessment of the types and ranges of hydrological and climatic conditions that can impact future flows.

1. Introduction

1.1. Colorado River flow projections

The Colorado River provides water for most of the major metropolitan areas and agricultural producing regions in the southwestern U.S., with the Upper Colorado River Basin generating the vast majority of the flow (about 90% according to Christensen et al., 2004) (UCRB,

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