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Exploring climate change impacts on the hydroclimatology of the Southern Rocky Mountain Headwaters Region

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The headwaters of the Colorado, Arkansas, Platte and Rio Grande Rivers that reside in the Southern Rocky Mountains of Colorado are a region of significant interannual, interdecadal and climate change sensitivity. Relatively low latitude and sharp terrain gradients imply that subtle changes in temperature and storm track can have relatively large impacts on seasonal hydroclimatic variables such as precipitation, snowpack, evapotranspiration and runoff. Understanding the variability and potential changes in hydroclimate variables is key to optimizing management of water resources which are, in many cases, already over-allocated. In this study we mechanistically compare and contrast 2 different scenarios of mid-21st century future hydroclimate; one with the global NCAR Community Climate System (CCSM) model and one with a very high resolution (4km) regional climate model. The results show dramatic differences in all hydroloclimatic fields that are attributable to fundamental changes in the seasonality of precipitation and the elevational control of precipitation and evaporative demand. Differences in magnitude and sign of several variables are surprising given that the climate change scenario for the regional model is based on the CCSM climate change signal. Specifically, the regional model exhibits a much stronger future increase in wintertime precipitation and cool season (Nov-May) runoff production than does CCSM. The increase in winter precipitation is driven by increased precipitation efficiency, which in turn is driven by an increase in condensate loading over orographic barriers under the warmer and wetter future climate conditions. Changes in wintertime precipitation frequency in both models are found to be minor by mid-century implying minimal changes in storm track by that time. The input of increased precipitation at high elevations in the regional model at a relatively cool time of year result in future increases in cool season and annual runoff production in the regional model compared to the CCSM. Future changes in summertime precipitation between the two models are less distinct which, when taking into account widespread increases in warm season evaporative demand, reduce summertime and early autumn runoff production in both models.