Potential Climate Impacts on the Hydrology of High Elevation Catchments, Colorado Front Range

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Abstract

Potential climate impacts on the hydrology of two seasonally snow-covered catchments is evaluated using 24 years of data from Niwot Ridge Long Term Ecological Research Site, CO. At the larger (220 ha), higher elevation (3,570 m) GL4 catchment, annual discharge did not change significantly based on nonparametric trend testing. However, October streamflow volumes and groundwater storage did increase, despite drought conditions near the end of the record in 2000–2004. In contrast, at the smaller (8 ha), lower elevation (3,400 m) MART catchment, annual discharge decreased significantly over the study period with the most substantial changes in July–September. The study period was separated into "wet," "normal," and "dry" years based on the 75th and 25th quartiles of annual precipitation. Results indicate that MART is particularly sensitive to changes in precipitation with dry years exhibiting decreased snowmelt peak flows, earlier snowmelt timing, decreased annual discharge, and reduced late-season flows. GL4 was less susceptible to changes in precipitation, and surprisingly late-season flow volumes (Sept.–Oct.) were not significantly different among wet, normal, and dry conditions. Glacial melt from the Arikaree glacier may account for up to 43 percent of the increase in late-season flows based on ablation measurements. We downscaled a regional permafrost model based on topoclimatic variables to assess whether subsurface ice within permafrost and rock glaciers could account for the remaining deficiency. Results suggest that with only 1°C of warming over one-third of permafrost area would be lost. Over the study period mean annual minimum temperatures increased by 0.6° decade^{-1}, with some of the most prominent increases occurring in July (1.5°C decade^{-1}). Additionally, limited ground temperature measurements at an active rock glacier indicate a 1°C increase over the past decade. This suggests that the source of late-season streamflow at GL4 has shifted towards permafrost meltwater in recent warm, dry years. This study shows that seasonally snow-covered catchments are particularly sensitive to changes in climate, but the hydrologic response may depend on landscape characteristics.

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