Vulnerability of hydropower generation in snowmelt-driven basins to nonstationary climate: A case-study of Dworshak Reservoir in Idaho

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Abstract. Hydropower plants in the Pacific Northwest generate about 65% of the region's 50,700 MW total power generating capacity. Timing and magnitude of hydropower generation in snowmelt dominated basins are significantly impacted by streamflow, which are in turn effected by precipitation timing and volume and by temperature regimes in the basin. We analyze sensitivity of hydropower to pre-specified meteorological variations for a meso-scale basin in order to help dam operators differentiate whether different types of climate variation cause impacts that are either significant or not significant enough to require operational changes. North-Fork Clearwater River Basin in Idaho, which provides headwaters to Dworshak dam, was selected for this case study because its runoff is snowmelt dominated, and there are relatively few flow modifications upstream of the reservoir. A low-parameter stochastic conceptual hydrologic model provided Dworshak inflows to MODSIM, a network flow model used for river and reservoir simulation, based on multiple scenarios of changing precipitation and temperature. Using MODSIM results, we analyze modeled reservoir storage and hydropower production based on current operational policies to provide a simple way of determining whether current operations are optimal for changing climates. Dworshak currently operates based on ten discrete April-July inflow forecast classes. Simulation results show that in scenarios where the 30-year mean annual temperature increases, and 30-year mean annual precipitation decreases, peak snowmelt runoff generally occurs earlier spring or winter, rather than in the April-July inflow forecast period. In addition to a timing shift, combinations of changes to annual and monthly inflow volumes can significantly impact the capability of current operations to meet storage refill targets and avoid unnecessary reservoir spills in which water is released without being utilized to produce hydropower.