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Modelling of future changes in seasonal snowpack and impacts on summer low flows in Alpine catchments

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Alpine catchments are largely influenced by snow, but it is expected that an increasing proportion of the precipitation will fall as rain in the future. Consequently, snow storage is expected to decrease, which, together with changes in snowmelt rates and timing, might cause reductions in spring and summer low flows and thus water availability. The objectives of this study were 1) to simulate the effect of changing snow storage on low flows during the warm seasons and 2) to relate drought sensitivity to the simulated snow storage changes at different elevations. The quantification of the changes in low flow due to changes in snow storage is important as there currently exist only few studies addressing this topic for the alpine region of central Europe. The consideration of different elevations is crucial as snow storage and its potential change due to climate change is highly variable with elevation. The Swiss Climate Change Scenarios 2011 (CH2011) data set was used to derive future changes in air temperature and precipitation. The CH2011 data set provides daily estimates of changes in air temperature and precipitation relative to the reference period 1980-2009 for three future periods (2020-2049, 2045-2074 and 2070-2099) and the A1B emission scenario. A typical bucket-type catchment model, HBV-light, was applied to 14 mountain catchments in Switzerland to simulate streamflow and snow in the reference period and three future periods. The model performance was evaluated using observed daily runoff and SWE. The largest relative decrease in annual maximum SWE was simulated for elevations below 2200 m a.s.l. (60-75% for the period 2070-2099) and the snowmelt season shifted by up to four weeks earlier. The relative decrease in spring and summer minimum runoff that was caused by the relative decrease in maximum SWE (i.e. elasticity), reached 40-90% in most of catchments for the reference period and decreased for the future periods. This decreasing elasticity indicated that the effect of snow on summer low flows is reduced in the future. The fraction of snowmelt runoff in summer decreased by more than 50% at the highest elevations and almost disappeared at the lowest elevations. This might have large implications on river ecology as well as water availability during summer period for uses such as hydropower and irrigation.