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Impacts of Climate change on the watershed of the hydropower reservoir Gigerwaldsee using hydrological modeling

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Increasing temperatures and changing precipitation patterns will diminish snow cover and force glaciers to shrink in mountain environments. The runoff in Alpine catchments such as the watershed of the Gigerwaldsee, providing water resources for hydro power production in the Swiss Alps, will be affected by those changes. Using an updated version of the conceptual hydrological model HBV-light future hydro-climatic changes in the catchment where simulated. The hydrological model was driven by seven GCM-RCM combinations from the ENSEMBLES project under the emission scenario A1B. The climate projections were bias-corrected using quantile mapping. Besides a baseline scenario (1992-2021), a mid-term future scenario (2036-2065) and a long term scenario (2069-2098) were calculated. For calibration, the model was driven with a gridded dataset from MeteoSwiss and glacier extents from 1990. The calibration was performed using three datasets: i) discharge data, derived from a volume-lake level relationship of the Gigerwaldsee, ii) the fraction of the snow covered area in the catchment, retrieved from MODIS snowcover images and iii) extrapolated glacier mass balances. The parameters were determined using Pareto selection from 10'000 Monte Carlo simulation runs according to their performance over five objective functions. Two objective functions were used to evaluate the discharge simulation and two for snow cover, whereof one rated the simulation over the whole year and one only during summer. A fifth objective function was used for glacier mass balance simulations. An evaluation of different selections of parameter sets showed that relying on discharge, snowcover and glacier mass balance data led to a higher model consistency. The contribution of the climate scenarios, model parameters and glacier scenarios to the total uncertainty of the simulated future discharge was assessed using analysis of variance (ANOVA).

The results indicate a decrease in runoff during the high flow season due to shorter snowcover persistence and less precipitation and an increase in runoff in the low flow season due to higher temperatures and more precipitation. The runoff originating from snow melt is projected to decrease by 22% and 30%, respectively. The projected runoff from glaciers will diminish by 85% in the mid-term and disappear completely in the long-term. The results from discharge emerging from snow- and glacier melt are significant. The main cause for the spread in the results was found in the large differences between the climate scenarios. These results are in line with findings of a similar study about the Mattmark reservoir in the Vispa valley.