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Climate impact assessment on water resources and glacierization in the Naryn, Karadarya and Zerafshan basins, Central Asia

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Central Asian river basins with their runoff formation zones in high mountains are currently experiencing the impact of increasing temperatures and changes in precipitation. The headwaters thus exhibit negative glacier mass balances, decreasing glacierization, changes in snow cover characteristics and changing runoff response. These changes are likely to intensify in future, as temperatures are projected to grow further. Both hydropower industry and irrigated agriculture in the downstream areas strongly depend on the water availability, its seasonal and long-term distribution. In order to improve water management policy in the region, reliable assessments of water availability in the runoff formation zones of Central Asia are necessary. One of the approaches to assessment of water resources is the evaluation of climate scenarios using hydrological models.

We present an assessment of climate impact on water resources and glacierization in the 21st century using the semi-distributed hydrological model WASA in the Naryn, Karadarya and Zerafshan basins in Central Asia. In order to constrain hydrological model parameters reliably, a multi-objective calibration approach using observed discharge, glacier mass balance and satellite snow cover data was applied. Consideration of initial glacier volume and its temporal dynamics can be essential for climate impact assessment in transient model simulations. Here, we used estimates of initial glacier thickness, calculated glacier mass balance, and the Δh-approach to simulate the glacier evolution on an annual basis. Future climate scenarios based on the CMIP5 ensemble projections reflecting cold-wet, cold-dry, warm-wet, and warm-dry conditions were used and bias corrected with an empirical quantile mapping technique.

The results indicate that the impact of changing climate varies regionally. Based on the ensemble mean of the simulated glacier area evolution, the glacier area retreat is fastest in the low-lying Karadarya basin followed by the Naryn basin. The Zerafshan basin, located in the western part of Central Asia, is projected to experience least glacier retreat. The changing climate will further influence the inter-annual flow regime with peak discharge being shifted from late summer towards early summer due to increasing temperature and earlier snowmelt. Water availability in August, the month with the largest glacier melt contribution, will strongly decrease mainly due to the decrease in glacierization. The obtained results provide important information for decision makers in developing strategies for water usage.