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The fate of the snow in the western Himalaya region: A climate change perspective

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Snow is a crucial component of the hydrological cycle in the Western Himalaya, where the warming climate is already impacting precipitation and melt runoff patterns. In this study, we investigated the future evolution of snow cover and snowmelt in the Panjshir catchment (2,210 km²) of Afghanistan. Located in northern Afghanistan, the Panjshir catchment of the Kabul river basin is the westernmost catchment of the transboundary Indus river system. The climate in Panjshir catchment is characterised by warm-dry summer and cold-wet winter with a large spatial and temporal heterogeneity. Water from snowmelt is used in various sectors in downstream regions, and thus plays a critical role in securing the livelihood of millions of people.

In order to analyse the future evolution of snow-related processes under climate change, a few global climate model simulations from CMIP5 climate datasets for RCP4.5 and RCP8.5 which showed reasonable performance when compared with ERA5 data for the historic period (1981-2010) were selected. The selected models were then segregated into two groups: those projecting a cold-wet climate with a 13-28% and 2.5-4.9°C increase in precipitation and temperature respectively, and those projecting a warm-dry climate with a 26-40% decrease in precipitation and a 4.3-7.8°C increase in temperature by the end of the 21st century. These GCMs were downscaled to a higher resolution using empirical statistical downscaling. To simulate the snow processes, we used the distributed cryospheric-hydrological J2000 model.

Results of our analysis show that the J2000 model captures the snow cover dynamics well in the

historical period (2003-2018) compared to the improved MODIS-derived snow cover with a coefficient of determination of 0.94. The model was then forced by climate projections from the selected GCMs to quantify the future changes in snow cover area, snow storage and snowmelt. A consistent decrease in decadal snow cover is projected in which the warm-dry models showed a higher decrease than cold-wet models. A 10-18 % reduction in annual snow cover is projected by the cold-wet models whereas a 22-36% reduction is expected from the warm-dry models. At the seasonal scale, across all models and scenarios, the snow cover in autumn and spring seasons are projected to reduce by as much as 25%, with an increase in winter and spring snowmelt and a decrease in summer snowmelt. The projected changes in the seasonal availability of snowmelt-driven water resources in the Panjshir region have direct implications for the water-dependent sectors in the downstream regions and highlight a need for a better understanding of current water usage and future adaptation practices in the Western Himalaya.