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Modelling runoff response from Hindukush-Karakoram-Himalaya, Upper Indus Basin under prevailing and projected climate change scenarios

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We, analyzing observations from high altitude automated weather stations from the Hindukush-Karakoram-Himalaya (HKH) within upper Indus basin (UIB), assess prevailing state of climatic changes over the UIB and whether such state is consistently represented by the latest generation climate model simulations. We further assess impacts of future climate change on the hydrology of the UIB, and changes in its snow and glacier melt regimes, separately. For this, a semi-distributed watershed model (UBC - University of British Columbia) has been calibrated/validated for UIB at Besham Qila (just above the Tarbela reservoir) using daily historical climate (Tmax, Tmin and Precipitation) and river flow data for the period 1995-2012. Our results show that the UIB stands out the anthropogenic climate change signal, featuring a significant cooling (warming) during the mid-to-late (early) melt season and an enhanced influence of the westerly and monsoonal precipitation regimes. We also show that such phenomena, particularly the summer cooling is largely absent from the latest generation climate model simulations, suggesting their irrelevance for at least near-future assessment of climate change impacts on the hydrology of UIB. Therefore, we construct a hypothetical but more relevant near-future climate change scenario till 2030 based on prevailing state of climate change over UIB. We additionally obtain climate change scenario as projected by five high-resolution CMIP5 climate models under an extreme representative concentration pathway RCP8.5 for the period 2085-2100, assuming that such a scenario may only be realized in the far-future, if at all. Under the hypothetical near-future scenario, our modelling results show that the glacier melt (snowmelt) contribution will decrease (increase) due to cooling (warming) in mid-to-late (early) melt season, though the overall flows will drop. Consequently, the overall hydrological regime will experience an early snow- but a delayed glacier melt, with both the regimes shifting apart. The reduced glacier melt in conjunction with enhanced precipitation regimes, further implies an overall positive mass balance of the UIB glaciers, consistent with recent findings of non-negative geodetic mass balance and related investigations. On the other hand, in case the UIB starts following the global climate change signal, it will result in short-term increase in the water availability mainly due to an increased glacier melt, which will be followed by an abrupt decrease when the glaciers will disappear in the far-future. Based on our results, we caution the impact assessment communities focusing on the water resources of UIB and the policy makers to consider the relevance of the climate change scenarios while planning of the water resources of Pakistan, as it is not clear when the global warming scenario will unfold.