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Runoff simulation within snow-fed mountainous region of Upper Indus Basin (UIB) west, using Degree Day Hydrological Modeling Approach

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Snow and glacier melt runoff from Hindukush-Karakoram-Himalaya (HKH) within Upper Indus Basin (UIB) governs the essential water supply to the major reservoirs in Pakistan. Sustainable development of agriculture, domestic consumption and hydro power generation essentially depends on the water resources emerging from this region for a stable economy. Seasonal runoff forecasting and simulation within such a huge cryospheric extent is indispensable for accurate reservoir operations and flow management. The primary objective of present study includes the assessment of climate change impacts on river flows and snow-melt runoff simulation at Gilgit River at Gilgit (hydrometric station). Snow-melt runoff model (SRM) incorporated with Moderate Resolution Image Spectrometer (MODIS) remote sensing snow cover products was selected for the simulation of daily discharges and assessment of contribution of snow-melt to the discharge within Gilgit River basin during (2001 to 2012). We have also used two General Circulation Models (GCMs) Can-ESM2 and Nor-ESM1-M for the future flows. The climate change impact assessment on streamflow was carried out using two climate change scenarios i.e Representative Concentration Pathways (RCP) 4.5 and 8.5 for the periods of (2010-2039), (2040-2069) and (2070-2099). The ultimate findings of this study enabled the successful application of SRM with satisfactory model efficiency. We found Gilgit basin experiencing a marginally increasing trend of summer (April-September) snow cover area. Flow generation is mainly controlled by glacier, snow-melt and rainfall within this basin, snow and glacier melt is dominant. We observed an average Nash–Sutcliffe Efficiency (NSE) coefficient of determination R2 (0.81) and average volume difference DV (-0.51) in observed and simulated flow during 2001 to 2012. Almost 9.2% of the total basin area is covered by glacier and permanent ice cover, contributing to runoff during late summer due to glacial melt. We also noted less efficiency during high flow months of June, July and August. Our results revealed ambiguity during summer mainly attributed to glacier melt runoff which generated usually in the month of August by melting of permanent ice reserves over high altitude zones. Our analysis proposed that Gilgit River average summer flows will be increased by 5.6% and 19.8% by rising 0.77°C and 2.60°C average summer temperature using RCP 4.5 and RCP 8.5 scenarios respectively, during (2039-2070).