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Surface and subsurface hydrology of a high-altitude catchment in the Trans-Himalayan region of Ladakh, India

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In the cold-arid Trans-Himalayan region of Ladakh, cryospheric meltwater plays a critical role for irrigated agriculture and local livelihoods. Despite the vital importance of reliable water supply under conditions of ongoing climate change, the relative contributions from glaciers and seasonal snow cover melt, together with permafrost thaw to surface and subsurface discharge are largely unknown due to the lack of in-situ data and local hydrological modelling. This study attempts to improve the understanding of regional hydrology, based on the case study of Stok catchment, where snow and glacier meltwater feeds a village of more than 300 households. We quantified long-term (2003-2019) surface and subsurface flow using a distributed temperature index and coupled surface/subsurface flow models forced by daily in-situ, meteorological, satellite and reanalysis data. These models were calibrated with the measured discharge data from two summer periods (2018 and 2019) in order to better understand the characteristics of surface and subsurface hydrology of the catchment. We also investigated the specific contributions from the cryospheric components and from rainfall to the total flow, and water loss through sublimation. A decline in annual discharge with characteristic inter-annual variations was identified over the observation period with about half of the total accumulated flow through the subsurface. We found that snowmelt contribution was highest (~60%) followed by ice melt (~20%) and rainfall (~15%), whereas sublimation contributes to ~8% of the water loss in a hydrological year. The findings and approach of this study are important for applied hydrological studies and planning future water management strategies in the region of Ladakh.