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Exploring the pathways of precipitation, snowmelt and glacier melt through the subsurface in high resolution, coupled, data-driven modeling experiment of the Langshisha catchment in the Himalaya

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Groundwater can be an important water source for mountain streams. To gain insights into the sources of groundwater recharge and their pathways to the downstream environments, the interactions between surface water and groundwater are investigated for the Langshisha catchment, in the Langtang basin, Nepal Himalaya. The 0.81 km2 study area ranges in elevation from 4130 to 4450 m. a.s.l., with a landscape of coarse debris, pocket meadows and moraine sediments. It is bordered on three sides by steep mountain cliffs, the Langshisha glacier outlet creek, and the Langtang river. To simulate the hydrological behaviour of the area, we couple the glacio-hydrological model Spatial Processes in Hydrology (SPHY), a spatially distributed water balance model and the groundwater flow model MODFLOW6. We analyze three approaches to simulate the subsurface hydrology of the area: (1) using the glacio-hydrological model alone, (2) a one-way coupling of the glacio-hydrological model with a groundwater numerical model, where the groundwater recharge from the glacio-hydrological model is used as input to the groundwater model, and (3) a two-way coupled surface water and groundwater model. The model is evaluated with in-situ field data of soil moisture, shallow groundwater levels and streamflow measurements collected intermittently over the 2013-2022 period as well as isotopic and geochemistry water sample data collected in November 2022. Preliminary results suggest that despite the additional computational demands and time required to develop and apply a fully coupled approach, it provides essential knowledge regarding the cryosphere-surface water-groundwater interactions. Our preliminary results showcase the importance of field observations to constrain modelling efforts and will serve to guide further model applications to assess the importance of representing cryosphere-surface water-groundwater interactions in mountain landscapes.