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Integrated glacier and snow hydrological modelling in the Urumqi No.1 Glacier catchment

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The glacier and snow melt water from mountainous area is an essential water resource in Northwest China, where the climate is arid. Therefore a hydrologic model including glacier and snow melt simulation is in an urgent need for water resources management and prediction under climate change in this region. In this study, the Urumqi No.1 Glacier catchment in Northwest China, with 51% area covered by glacier, was selected as the study site. An integrated daily hydrological model was developed to systematically simulate the hydrograph, runoff separation (glacier and non-glacier runoff), the glacier mass balance (GMB), the equilibrium line altitude (ELA), and the snow water equivalent (SWE). Only precipitation, temperature and sunshine hour data is required as forcing input. A combination method, which applies degree-day approach during dry periods and empirical energy balance formulation during wet seasons, was implemented to simulate snow and glacier melt. Detailed snow melt processes were included in the model, including the water holding capacity of snow pack, the liquid water refreezing process in snow pack, and the change of albedo with time. A traditional rainfall-runoff model (Xinanjiang) was applied to simulate the rainfall(snowmelt)-runoff process in non-glacierized area. Additionally, the influence of elevation on temperature and precipitation distribution, and the impact of different aspect on snow and glacier melting were considered. The model was validated, not only by long-term observed daily runoff data, but also by measured snow (SWE) and glacier data (GMB, ELA) of over 50 years. Furthermore, the calibrated model can be upscaled into a larger catchment, which further supports our proposed model and optimized parameter sets.