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Reconstructing the runoff and mass changes of a maritime Tibetan glacier since 1975

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Glaciers are key components of the water towers of Asia and as such are relied upon by large downstream communities for domestic, agricultural and industrial uses. They have experienced considerable shrinking over the last decades, with some of the highest rates of mass loss observed in the south-eastern part of the Tibetan Plateau, where mass loss is also accelerating. Despite these rapid changes, Tibetan glaciers' changing role in catchment hydrology remains largely unknown. Parlung No.4 Glacier is considered as a benchmark glacier in this region, since its meteorology, surface energy fluxes and mass-balance have been examined since 2006. It is a maritime glacier with a spring (April-May) accumulation regime , which is followed by a period of ablation during the Indian Summer Monsoon (typically June-September). Here, we conduct a glacio-hydrological study over a period of five decades (1978-2018) using a fully distributed model for glacier mass balance and runoff simulation (TOPKAPI-ETH). We force the model with ERA5-Land and China Meteorological Forcing Dataset (CMFD) climate reanalysis downscaled to a local weather station to reconstruct meteorological time series at an hourly resolution. TOPKAPI-ETH is calibrated and validated with automatic weather station data, discharge measurements, geodetic mass balance, stake measurements and snow cover data from MODIS. We find a very clear acceleration in mass loss from 2000 onwards, which is mostly explained by an increase in temperature. This influence however was initially compensated by an increase in precipitation until the 2000's, which attenuated the negative trend. Our results also indicate that the increase in the liquid-solid precipitation ratio has reduced the amount of seasonal accumulation, exacerbating annual mass loss. We demonstrate that the southern westerlies and the associated spring precipitation have as much influence on the glacier mass balance and catchment discharge as the Indian Summer Monsoon, by controlling seasonal snowpack development, which simultaneously provides mass to the glacier and protects it from melting in the early stage of the monsoon.