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Mass balance of Trambau Glacier, Rolwaling region, Nepal Himalaya: In situ observations, long-term reconstruction, and mass-balance sensitivity

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The unabated shrinkage of Himalayan glaciers contributes to sea level rise and affects the regional water cycle. Many glacier monitoring studies have employed modelling or remote sensing approaches, whereas there have been comparatively few in situ observational studies owing to the difficulties in accessing these high-altitude glaciers. Furthermore, in situ observations are generally limited to lower elevations, with the observed mass balances being significantly more negative than remote sensing estimates of regional-scale glacier mass balance.
We therefore conducted a mass-balance study of debris-free Trambau Glacier in the Rolwaling region, Nepal Himalaya, which is accessible to 6000 m a.s.l., to better understand mass-balance processes and the effect of precipitation on these processes on high-elevation Himalayan glaciers. Continuous in situ meteorological and mass-balance observations that spanned the two melt seasons since May 2016 are presented. An energy- and mass-balance model is also applied to evaluate its performance and sensitivity to various climatic conditions. The 2016 melt season (2016) and 2016/17 year-long mass-balance observations are both negative. Estimated glacier-wide mass balances of -0.40 and -0.75 m w.e. in 2016 and 2016/17, respectively, are obtained by combining the observed and modelled mass balances below/above the highest stake at 5850 m a.s.l. The estimated long-term glacier mass balance, which is reconstructed using the ERA-Interim data calibrated with the in situ data, is -0.76 ± 0.41 m w.e. a^{-1} for the period 1980–2017. A significant correlation with annual precipitation ($r = 0.76$, $p < 0.001$) is observed, whereas there is no discernible correlation with mean summer air temperature. The results indicate the continuous mass loss of Trambau Glacier over the last four decades, which contrasts with the steady state of neighbouring Mera Glacier.