

Ice cliff mass-loss of debris-covered Trakarding Glacier, eastern Nepal Himalaya

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Glaciers in High Mountain Asia have been shrinking in the recent decades. They are a valuable indicator of climate change, and their meltwater plays an important role for regional water resources. Debris-covered glaciers, which are prevalent throughout the Himalayas, exhibit complex melt processes due to their heterogeneous surface (Herreid and Pellicciotti, 2020). Despite the insulating effect of the debris mantle, debris-covered and clean glaciers possess comparable thinning rates. Previous studies have reported that “ice cliffs” disproportionately contribute to glacier melt, but their importance at the glacier scale has been quantified for only a few sites. In this study, we exploit measurements taken since 2016 on the lake-terminating Trakarding Glacier (27.9°N, 86.5°E; 2.9 km² spanning 4,500–5,000 m a.s.l.; ~5% ice cliff cover), eastern Nepal Himalaya, to investigate the importance of cliffs for debris-covered ice melt at the glacier scale from a remote-sensing inversion and energy-balance modeling. We generated super-high-resolution (0.2 m) terrain data from aerial photographs (UAV and helicopter-borne photogrammetry) during 2018-2019 (Sato et al. 2021). We also manually delineated ~500 ice cliffs and estimated surface velocity, elevation change, and specific mass balance, providing an observational estimate of ablation across the debris-covered tongue and attributable to ice cliffs. Further we employed a process-based 3D-backwasting model (Buri et al. 2016) to estimate continuous ice cliff mass-loss over the study period. The model calculates the energy balance of ice cliff surfaces and reproduces their evolutions (cliff expansion, shrinkage, and reburial), based on the characteristics of the glacier surface and location of individual ice cliffs. This method, forced with in-situ meteorological and terrain data and evaluated against the observed changes, provides ice cliff mass-loss from the scale of individual features to the entire Trakarding Glacier.

Reference

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