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Ice cliff contribution to the ablation of the debris-covered Changri Nup glacier tongue, Nepal

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Ice cliff backwasting on debris-covered glaciers is recognized as an important process, potentially responsible of the so-called “debris-cover anomaly”, i.e. the fact that debris-covered and debris-free glacier tongues have similar thinning rates in Himalaya. In this study, we assess the total contribution of ice cliff backwasting to the ablation of the tongue of the Changri Nup Glacier over one year. We use three high resolution datasets (terrestrial photogrammetry, unmanned aerial vehicle [UAV] photogrammetry, Pléiades tri-stereo) acquired simultaneously in November 2015 and in November 2016 to survey the glacier tongue topography. We found that the total difference between the volume loss measured with the terrestrial photogrammetry, considered as the reference data, and the UAV and Pléiades was less than 3% and 7%, respectively, demonstrating the applicability of these datasets to measure volume loss from ice cliffs. We then applied the same method to the entire glacier tongue, and found that ice cliffs, which cover 7% of the projected area, contribute to 23 $\pm$ 5 % of the total ablation of Changri Nup Glacier tongue. Ice cliffs have an ablation rate 3.1 $\pm$ 0.6 times higher than the average glacier tongue surface. If neglecting the emergence velocity, this former value is equal to 4.5 $\pm$ 0.6, leading to an overestimation of the cliff ablation enhancement.