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Reduced melt on debris-covered glaciers: investigations from Changri Nup Glacier, Nepal

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Approximately 25% of the glacierized area in the Everest region is covered by debris, yet the surface mass balance of debris-covered portions of these glaciers has not been measured directly. In this study, ground-based measurements of surface elevation and ice depth are combined with terrestrial photogrammetry, unmanned aerial vehicle (UAV) and satellite elevation models to derive the surface mass balance of the debris-covered tongue of Changri Nup Glacier, located in the Everest region. Over the debris-covered tongue, the mean elevation change between 2011 and 2015 is -0.93 m year-1 or -0.84 m water equivalent per year (w.e. a-1). The mean emergence velocity over this region, estimated from the total ice flux through a cross section immediately above the debris-covered zone, is +0.37mw.e. a-1. The debris-covered portion of the glacier thus has an area averaged mass balance of -1.21+/-0.2mw.e. a-1 between 5240 and 5525 m above sea level (m a.s.l.). Surface mass balances observed on nearby debris-free glaciers suggest that the ablation is strongly reduced (by ca. 1.8mw.e. a-1) by the debris cover. The insulating effect of the debris cover has a larger effect on total mass loss than the enhanced ice ablation due to supraglacial ponds and exposed ice cliffs. This finding contradicts earlier geodetic studies and should be considered for modelling the future evolution of debris-covered glaciers.