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Sampling supraglacial debris thickness using terrestrial photogrammetry

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The melt rate of debris-covered ice differs to that of clean ice primarily as a function of debris thickness. The spatial distribution of supraglacial debris thickness must therefore be known in order to understand how it is likely to impact glacier behaviour, and meltwater contribution to local hydrological resources and global sea level rise. However, practical means of determining debris cover thickness remain elusive. In this study we explore the utility of terrestrial photogrammetry to produce high resolution, scaled and texturized digital terrain models of debris cover exposures above ice cliffs as a means of quantifying and characterizing debris thickness.

Two Nikon D5000 DSLRs with Tamron 100mm lenses were used to photograph a sample area of the Ngozumpa glacier in the Khumbu Himal of Nepal in April 2016. A Structure from Motion workflow using Agisoft Photoscan software was used to generate a surface models with <10cm resolution. A Trimble Geo7X differential GPS with Zephyr antenna, along with a local base station, was used to precisely measure marked ground control points to scale the photogrammetric surface model. Measurements of debris thickness along the exposed cliffline were made from this scaled model, assuming that the ice surface at the debris-ice boundary is horizontal, and these data are compared to 50 manual point measurements along the same clifftops.

We conclude that sufficiently high resolution photogrammetry, with precise scaling information, provides a useful means to determine debris thickness at clifftop exposures. The resolution of the possible measurements depends on image resolution, the accuracy of the ground control points and the computational capacity to generate centimetre scale surface models. Application of such techniques to sufficiently high resolution imagery from UAV-borne cameras may offer a powerful means of determining debris thickness distribution patterns over debris covered glacier termini.