Glacier Surface Ablation and Roughness Measurements Using Terrestrial Laser Scanning for Energy Budget Model Applications

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Calculations of glacier surface melt rates are useful for a variety of applications: the use and management of water resources; studies of glacier hydrology and dynamics; and studies of glacier mass balance and the contribution of the melting of mountain glaciers and ice caps to sea level change. In recent years spatially-distributed surface energy balance models have been used to calculate surface melt rates. These models typically partition the energy available to drive melt into radiative and turbulent heat flux components. Although the theoretical basis for modelling these fluxes is well understood, accurate predictions have been hampered by difficulties in the parameterisation of key controlling factors at high spatial resolution. A particular difficulty lies in the estimation of surface roughness, which is known to have a strong influence on the turbulent fluxes. In this research we have extended the Brock and Arnold (2000) point-based surface energy balance model into a spatially-distributed form for use in estimating patterns of ablation on an Alpine valley glacier; the Bas Glacier d'Arolla, Valais, Switzerland. Over the course of a two day period we employed innovative field surveying techniques (terrestrial laser scanning, TLS) to improve the parameterisation of surface roughness within the energy balance model. The extreme high precision (±1mm) and density (typically > 2500 average survey points per square metre) of the TLS enabled us to create accurate and high resolution DEMs (5 cm grid cells), from which surface roughness was estimated based on the standard deviation of elevations in a moving window of surrounding grid cells. The same DEMs were used for model validation purposes. Here we determine the accuracy of the resulting surface melt predictions, assessing the degree to which the TLS technique offers a substantive improvement to surface melt predictions.