Aerodynamic roughness of ice surfaces derived from high resolution topographic data

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The aerodynamic roughness of glacier surfaces is an important component of energy balance models and meltwater runoff estimates through its influence on turbulent fluxes of latent and sensible heat. In a warming climate these fluxes are predicted to become more significant in contributing to overall melt volumes. Ice aerodynamic roughness ($z_0$) is commonly estimated from measurements of ice surface microtopography, typically from topographic profiles taken perpendicular to the prevailing wind direction. Recent advances in surveying permit rapid acquisition of high resolution topographic data allowing revision of assumptions underlying conventional topographic profile-based $z_0$ measurement. This poster presents alternative methods of estimating $z_0$ directly from Digital Elevation Models (DEMs) or three-dimensional point clouds, and examines the spatial and temporal variability of $z_0$ across the ablation zone of a small Arctic glacier. Using Structure-from-Motion (SfM) photogrammetry to survey ice surfaces with millimeter-scale accuracy, $z_0$ variation over three orders of magnitude was observed but was unrelated to large scale topographic variables such as elevation or slope. Different surface-types demonstrated different temporal trajectories in $z_0$ through three days of intense melt, though the observed temporal $z_0$ variability was lower than the spatial variability. A glacier-scale topographic model was obtained through Terrestrial Laser Scanning (TLS) and sub-grid roughness was significantly related to $z_0$ calculated from a 2 m resolution DEM. Thus, glacier scale TLS or SfM surveys can characterize $z_0$ variability over a glacier surface and allow distributed representations of $z_0$ in surface energy balance models.