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Quantifying small-scale temporal surface change on glaciers and salt pans using terrestrial laser scanning: implications for modelling ablation and dust emission

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Physical surface roughness is important in glacial and desert environments as it influences aerodynamic roughness, which in turn determines the ability of the wind to contribute to the turbulent heat flux component of the energy balance for glacial ice ablation or the likelihood of a surface emitting dust. Surface microtopography has traditionally been quantified by single 2D transects, but little is known about how these surfaces vary over time and the feedback between surface properties and other geomorphic processes. Terrestrial laser scanning (TLS) is the perfect tool to examine geomorphic microtopography over large spatial areas relatively quickly with the opportunity for repeat temporal measurements. Here we present examples of daily and weekly surface change measured on the Sua Pan, Botswana and the Svínafellsjökull, Iceland with mm accuracy using TLS. For the first time it is possible to quantify salt crust plucking and extrusion events and elucidate links between surface and wind shear interactions, as well as possible changes in aerodynamic roughness over time as surfaces evolve. Clear patterning is evident, with crust expansion limited to topographic highs. Likewise, we illustrate examples of measured daily ablation rates and patterns, and allude to implications for energy balance modelling by improving estimates of aerodynamic roughness. Specific ice patterning includes melt water eroding channels, the unique interactions of surface debris (volcanic ash from the 21 - 30 May 2011 eruption of Grímsvötn) melting out from the glacier and surface water forming a diverse microtopography of debris cones, cryoconite holes and perched blocks. However, whilst TLS represents a step-change in our ability to move from small transect derived roughness measurements to complete 3D surface change, detecting change on mobile surfaces through time is challenging, and linking surface properties to other point-based process measurements can be problematic.