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Detection of snow cover dynamics with a long range permanent TLS system at Hintereisferner (Austria) – possibilities and limitations

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A permanent long-range terrestrial laser scanning (TLS) system is installed at Hintereisferner, Ötztal Alps, Austria to validate snow cover dynamics such as simulated by high-resolution atmospheric models.

Snow cover dynamics include several processes such as snow fall, compaction, metamorphism, snow redistribution by wind, avalanches and melt manifested in specific magnitudes and frequencies. To be able to quantify these surface changes, the smallest possible magnitude that can be measured by the TLS needs to be known.

An uncertainty analysis of the system has been conducted acquiring its limitations. It was known before that atmospheric conditions, the scanning geometry and mechanical properties contribute to the total uncertainty, but so far, these error sources and the total uncertainty had not been quantified.

It was assumed that the position of the TLS was stationary and thus, the georeferencing of the scan was automated with an unchanged transformation matrix. A case study of 29 hourly scans during 5 and 6 November 2020, with no surface changes due to external conditions, showed vertical differences between -0.62 m and +0.47 m relative to a selected reference scan. These deviations are related to ongoing minor movements of the scanner over the scope of day and result in errors of a few decimetres due to the long range acquisition.

The accuracy of the scans improves after manual georeferencing (RiSCAN PRO), resulting in smaller deviations between -0.15 and +0.04 m relative to the selected reference scan.

The total accuracy of the TLS system is ±10 cm (vertical direction) after manual georeferencing, but strongly depends on the range between target surface and TLS. This makes it possible to detect snow fall events, snow redistribution, melt, and avalanches with changes larger than one decimeter. Snow compaction and metamorphism are processes, which are over hourly to daily time steps too small to be detected by the TLS at Hintereisferner.

Over all, the determined accuracy of the TLS shows the suitability of the system setup for validating high-resolution atmospheric models that explicitly compute snow redistribution by wind

and thus significantly will improve the treatment of snow cover dynamics in future glacier mass balance research.