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The potential of the latest developments in terrestrial laser scanning technologies for monitoring and investigating periglacial and glacial processes in Alpine environments

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Three-dimensional data obtained using Light Detection And Raging (LiDAR) methods are a valuable resource for many geosciences studies, as proven by the rapid growth of LiDAR applications for monitoring processes shaping the Earth's surface. The analysis of LiDAR data is particularly attractive for geomorphologists as it offers the opportunity to measure surface topography and monitor morphological changes at resolutions not previously possible. The derived three-dimensional data not only enable geomorphological investigations at unprecedented spatial resolutions with fast measurement acquisition, but also allows for repeated surveys where high temporal resolution is required. Accordingly, the potential of LiDAR techniques grants the detection of morphological changes in landforms at centimeter scale even at very short temporal scale. Nevertheless, laser-derived data remain subject to a number of issues that will generate errors in the resulting point cloud if left unchecked. Moreover, in glacial and periglacial environments, there are significant limits in LiDAR application because at the wavelengths typical of most LiDAR systems, ice and snow cover absorbs rather than reflects the laser signal. With this in mind, in 2012 RIEGL announced the new Terrestrial Laser Scanner VZ-6000. This high-speed (up to 222,000 meas./sec), high-accuracy device offers ultra-long measurement range of more than 6,000 m for static applications, allowing easier survey of larger zones than previous TLS devices. In addition, due to its laser wavelength, it is particularly well suited for measuring snowy and icy terrain (RIEGL, 2013). In the present contribution we test the potential of this device for monitoring morphological changes in a Swiss Alpine setting, where the landscape comprises a complex set of surface types, and hence reflectors. The characteristics of the VZ-6000 device together with the efficiency of the associated software allows for the generation of precise 3D models of the surface and the quantification of changes and movements over varying temporal scales. In addition to changes and movements at daily and monthly resolution, it was possible to identify and quantify changes at the surface of a glacier during a single, warm summer day. The case studies presented illustrate the potential of such long-range, high efficiency and accuracy device in monitoring dynamics environments in an Alpine setting.