Permanent 3D laser scanning system for alpine hillslope instabilities

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Since the mid 1990s, LiDAR (Light Detection and Ranging) techniques have been extensively used for topographic surveying. Initially, it was mainly airborne laser scanning (ALS) that was used to create digital elevation models (DEM) for large areas. More recently, terrestrial laser scanners (TLS) have widely been used for high spatial resolution data acquisition of topographic features and geomorphic analyses. Existing applications of TLS surveys encompass landslide, rockfall or debris flow dynamics, but also coastal cliff erosion, braided river evolution or river bank erosion. The main advantages of TLS compared to other monitoring techniques include mainly (a) the high spatial sampling density of XYZ-measurements (e.g. 1 point every 2-3 mm at 10 m distance), particularly in comparison with the low data density monitoring techniques such as dGPS or total stations, (b) the millimeter accuracy and precision of the range measurement to centimeter accuracy of the final DEM, or (c) the highly dense area-wide scanning that enables to look through vegetation and to measure bare ground.
Although TLS is widely used in topographic surveying, one of its main constraints is the temporal resolution of acquired data due to labor costs and time constraints for field campaigns. Thus, repetition measurements are generally performed episodically. However, for an increased scientific understanding of the processes as well as for early warning purposes, we present a novel permanent 3D monitoring setup to increase the temporal resolution of TLS measurements. This accounts for different potential monitoring deliverables such as volumetric calculations, spatio-temporal movement patterns, predictions and even alerting. This system was installed at an active landslide in Gresten (Austria) that is geologically situated in the Gresten Klippenbelt (Helvetic Zone). The characteristic lithofacies are the Gresten Beds of Early Jurassic age that is covered by a sequence of marly and silty beds with intercalated sandy limestones.
Permanent data acquisition can be implemented into our workflow with any TLS system offering fully automated capturing by integrated timer functionality. In our case study we utilize an Optech ILRIS-3D scanner. The time interval between two scans can be set as low as a full scan requires (e.g. every hour). The acquired point cloud is stored on an on-site server that is also remotely controlled and accessed via Wi-Fi. Each new point cloud is automatically compared with an initial "zero" survey that is processed by automatic scripting that allows for batch processing without supervision. The implemented M3C2 algorithm (Multiscale Model to Model Cloud Comparison) for the distance measurement is available as open source software. The field site in Gresten also contains different other monitoring systems such as inclinometers and TDR sensors that complement in the interpretation of the obtained TLS data. The results show a varying spatial pattern of landslide movement over time. Future analysis will include the combination of surface movement with subsurface hydrology as well as with climatic data obtained from an on-site climatic station.

Key words: permanent TLS, high spatial & temporal resolution, hillslope monitoring