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A 3D clustering approach for point clouds to detect and quantify changes at a rock glacier front

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Terrestrial Laser Scanners (TLS) are extensively used in geomorphology to remotely-sense landforms and surfaces of any type and to derive digital elevation models (DEMs). Modern devices are able to collect many millions of points, so that working on the resulting dataset is often troublesome in terms of computational efforts. Indeed, it is not unusual that raw point clouds are filtered prior to DEM creation, so that only a subset of points is retained and the interpolation process becomes less of a burden. Whilst this procedure is in many cases necessary, it implicates a considerable loss of valuable information. First, and even without eliminating points, the common interpolation of points to a regular grid causes a loss of potentially useful detail. Second, it inevitably causes the transition from 3D information to only 2.5D data where each (x,y) pair must have a unique z-value. Vector-based DEMs (e.g. triangulated irregular networks) partially mitigate these issues, but still require a set of parameters to be set and a considerable burden in terms of calculation and storage.

Because of the reasons above, being able to perform geomorphological research directly on point clouds would be profitable. Here, we propose an approach to identify erosion and deposition patterns on a very active rock glacier front in the Swiss Alps to monitor sediment dynamics. The general aim is to set up a semiautomatic method to isolate mass movements using 3D-feature identification directly from LiDAR data. An ultra-long range LiDAR RIEGL VZ-6000 scanner was employed to acquire point clouds during three consecutive summers. In order to isolate single clusters of erosion and deposition we applied the Density-Based Scan Algorithm with Noise (DBSCAN), previously successfully employed by Tonini and Abellan (2014) in a similar case for rockfall detection. DBSCAN requires two input parameters, strongly influencing the number, shape and size of the detected clusters: the minimum number of points (i) at a maximum distance (ii) around each core-point. Under this condition, seed points are said to be density-reachable by a core point delimiting a cluster around it. A chain of intermediate seed-points can connect contiguous clusters allowing clusters of arbitrary shape to be defined.

The novelty of the proposed approach consists in the implementation of the DBSCAN 3D-module, where the xyz-coordinates identify each point and the density of points within a sphere is considered. This allows detecting volumetric features with a higher accuracy, depending only on actual sampling resolution. The approach is truly 3D and exploits all TLS measurements without the need of interpolation or data reduction. Using this method, enhanced geomorphological activity during the summer of 2015 in respect to the previous two years was observed. We attribute this result to the exceptionally high temperatures of that summer, which we deem responsible for accelerating the melting process at the rock glacier front and probably also increasing creep velocities.

References:
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