



Rockfall hazard assessment using semi-automatic point cloud analysis from RPAS data

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For the risk analysis of hazardous steep rock faces traditional fieldwork such as measuring discontinuities in the rock is often only possible in the lower, carefully selected less dangerous parts of the rock faces. Remote Piloted Aircraft Systems (RPAS) enable the measurement of joint systems, open fractures and block parameters in areas previously inaccessible and hazardous. We present an innovative approach for the semi-automatic detailed documentation of structural discontinuities using RPAS 'structure-from-motion photogrammetry' (SfM). 3D point clouds generated by RPAS constitute a new efficient method that provides unbiased and precise information for rock fall hazard assessment on local scale. Manual measurements of discontinuities in accessible parts of the rockfaces are in compelling agreement with semi-automatic generated discontinuities in rock walls in Lofoten, Norway and Ötztal, Austria.

With the semi-automatic method, we retrieved over 1000 structural measurements from the roughly 120 m long rockface Engelswand in Tumpen, Ötztal, in comparison to 25 manual measurements. Kinematic analysis on joint sets that were extracted from 3D point clouds, yield high admissibility for flexural toppling, but also significant critical intersections for wedge and planar sliding. Spatial precision of the 3D point cloud was <50 cm and $\pm 2^\circ$ based to a rough workflow with ground control points that were only measured by a handheld GPS.

At Slettind, Lofoten we investigated a 0.57 km² big rockface prone to several smaller and bigger rockfalls every year. The final 3D model had a ground resolution of 7.6 cm/pixel and a spatial precision at 7.7 cm. Here, the kinematic analysis indicated wedge failure as most prominent failure mechanism. We were able to identify unstable rock parts in this large 3D project that used 1500 images to realize the coverage of the most hazardous parts of the rock wall.

Our developed method allows for targeted rock wall clearing operations of unstable rock parts or planning of targeted mitigation measures.