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Helicopter-borne LIDAR and multi-platform aerial photogrammetry for stability-related terrain analysis of steep high-mountain areas: Monte Rosa east face

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Data collection for geomorphic and morphometric analyses of steep and high rock walls in permafrost and glacier environments is an extremely challenging task. The Monte Rosa east face (Italy) is the highest flank in the European Alps (2200–4600m a.s.l.). During recent decades, the ice cover of the Monte Rosa east face experienced an accelerated and drastic loss in extent. Large parts of the east face are in permafrost conditions and likely in degradation due to climatic change. There is strong evidence of slope destabilization in recent years, culminating in major mass movements in August 2005, with an ice avalanche with a volume of more than $1x10^6$ m^3, and in April 2007, with a rock avalanche of about $0.3x10^6$ m^3.

Such situations require new approaches applying the latest technological advances to better assess slope instability and related hazards. As a pilot study, we used helicopter-borne LIDAR and achieved a first-time laser scan of a complete large high-mountain wall in September 2007. The applied Helimap system is a helicopter-borne system that acquires both laserscanning and imagery data simultaneously and makes use of GPS/INS (Global Positioning System / Intertial Navigation System) for location and orientation of the platform. The system has the particularity to be operated oblique to keep constant accuracy even for very steep slopes. The resulting high-precision DEMs (Digital Elevation Model) are a powerful tool for investigations of high-alpine flanks

and crucial for topographic analyses, and for detecting both small-scale and large-scale topographic structures and changes. Complementing the LIDAR data, aerial images between 1956 and 2005 were used to document changes in corresponding periods. Both, aerial images and LIDAR data were used for the generation of DEMs. Therefore, the aerial images were oriented with ground control points obtained from topographic maps and orthophotos. The subsequent image matching and DEM generation was done in SAT-PP (Satellite Imagery Precision Processing).

Results showed that the coupling of laser scanning data with photogrammetric analyses of terrestrial and aerial images, to extract topographic features and changes from DEMs is a highly promising, and yet rarely exploited method in high-mountain areas. Changes in rock and ice can be identified and quantitative volume analyses of present and past slope instabilities can be done. In view of ongoing and likely accelerating atmospheric warming and related destabilization in large high-mountain walls with glacier and permafrost, development of techniques and slope analyses such as presented here are important to prevent possibly major disasters.