



The use of laserscanning and terrestrial photogrammetry to quantify rock falls/avalanches in steep high-alpine rock walls.

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A significant number of rock avalanches ($>$ several thousands of m^3) on high mountain rock walls affected by permafrost has been documented during the last decade (e.g. Brenva Glacier, Italy, 1997; Mc Ginnis Peak, Alaska, 2002; Kolka-Karmadon, North Ossetia, 2002; Punta Thurwieser, Italy, 2004). In the Mont Blanc massif, the Petit Dru western face (3733 m a.s.l.) was affected by a series of events with increasing magnitude (1950, 1997, 2003) until 2005, when the largest rock avalanches ($>$ 250,000 m^3 in total) occurred. This increase is probably related to permafrost degradation, as a consequence of the climatic change associated to the global warming observed during the last decades.

Within the framework of the EU Interreg programs, the *PERMAdataROC* project was set up in 2005 to improve the knowledge and understanding of the relationship between the permafrost degradation and the slope instabilities in steep high-alpine rock faces. We present here the applied methodology to quantify the volume of rock falls and rock avalanches which presently occur at several study sites in the Mont Blanc massif at high altitude (3000-4500 m).

This work is based on high-resolution (centimetre-scale) digital models (HRDEM) of rock walls measured seasonally (summer/winter) or annually by laserscanning (LIDAR). Surveys have been carried out using a terrestrial laser Optech ILRIS-3D, working up to 800 m in the best conditions of surface reflectivity. The field edge is $40^\circ \times 40^\circ$ and the points measure frequency is 2000 points per second. At a distance of 100 m,

the laser trace on the object is about 30 mm large (perpendicular shot) and the point accuracy on a flat surface is about 3-5 mm. The HRDEM are used to study the rock wall structure and fracturing, and their diachronic comparison allows the quantification of the rock falls and rock avalanches volume.

In order to realize HRDEM on rock walls which cannot be surveyed by LIDAR (when the measurement distance exceeds its range), the use of terrestrial photogrammetry is one of the investigated methods in the *PERMAdataROC* project. The comparison of two HRDEM obtained with both LIDAR and terrestrial photogrammetry on a same rock face (Aiguille du Midi) allowed to validate the terrestrial photogrammetry method.