



## **Frequency and volume of rockfalls in permafrost-affected rockwalls in the Mont Blanc massif**

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Rockfalls strongly affect high mountain rockwalls, and represent a great danger for both people and infrastructures. However, their frequency and magnitude are still poorly known in this environment. These processes appear nonetheless increasing while permafrost degradation is hypothesized as one of the most important triggering factor.

Several inventories of rockfalls have been realised in the Mont Blanc massif by using three methods:

- (i) the comparison of photographs from the end of the Little Ice Age to 2009, combined with field geomorphology, allowed the identification of 50 rockfalls during this period in the sectors of the Drus and the Aiguilles de Chamonix, the rock volume of which is in the range 500 - 265,000 m<sup>3</sup>;
- (ii) a network of local observers (Alpine guides, hut keepers) allowed the exhaustive documentation of the rockfalls occurred in 2007 (n = 45), 2008 (n = 22) and 2009 (n = 72) in the main, central part of the Mont Blanc massif, the rock volume of which is in the range 100 - 50 000 m<sup>3</sup>; furthermore, analyses of a satellite image allowed to survey 182 rockfalls in the whole massif at the end of the 2003 Summer heatwave;
- (iii) the diachronic comparison of high resolution 3D models obtained by annually repeated terrestrial laserscanning enabled the quantification of the detached rock volumes. Between 2005 and 2009, 69 rock detachments (volumes from 1 to 426 m<sup>3</sup>) have been measured on 10 selected rockwalls with different slope orientation and angle, and located between 3000 and 4500 m a.s.l.

These three inventories were jointly analysed in terms of volume and frequency. Erosion rates have been calculated from those data and compared with results from other studies, including non-permafrost areas. Results suggest the likely dominant role of the permafrost degradation in triggering the documented rockfalls in the Mont Blanc massif.