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Rockfalls and climate in the permafrost-affected rockwalls of the Mont Blanc massif

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The characterization of the evolution of rockfalls (V > 100 m3) in high mountain areas is a prerequisite to any risk mitigation and management. Our work thus aimed to systematically collect and analyse historical and current data on rockfalls in the Mont Blanc massif in order to investigate the possible correlation existing between global warming and rockfalls and so, the hypothesis between permafrost degradation and rockfalls. This requires to compile exhaustive rockfall inventories, and to compare them with meteorological and climatic data.

We first documented the occurrence of the 50 rockfalls at the Drus and the Aiguilles de Chamonix, documented by photo-comparison since the end of the Little Ice Age (LIA). Thus, we crossed these rockfall data with available climate data. In the West face of the Drus, the climatic factor – especially the temperatures – seems to control the triggering of the 8 rockfalls which occurred after the LIA, as suggests by their concomitance with the hottest periods. The last one, the small rock avalanche of June 2005 (265,000 m3), seems to have been promoted by the combination of heat and heavy rainfalls, resulting in high fluid pressure in the rock fractures. Surface runoff has been observed in the scars of the first collapses on the 29th of June, and were still observed in different areas of the face several weeks after the collapse without heavy rainfalls. The role of climate is also demonstrated by the analysis of the 42 rockfalls documented on the North side of the Aiguilles de Chamonix after the LIA, with a very strong correlation between these and the hottest periods: 70 % of the rockfalls occurred during the past two decades, characterized by of the increasing global warming. Heatwaves are particularly prone to rockfalls: the maximum rockfall frequency occurred during the 2003 Summer heatwave.
Secondly, we showed concomitance between the 2003, 2007, 2008 and 2009 rockfalls, and the climatic conditions of those years – especially with temperatures. A total of 321 rockfalls has been documented for these four years in the Mont Blanc massif, using a satellite image for 2003 and a network of observers (mainly Alpine guides) for the period 2007-2009. 139 rockfalls occurred between 2007 and 2009, 53 of which precisely dated (38 %). Among them, 51 (96 %) occurred between June and September, i.e. during the hottest period of the year. The 2003 Summer heatwave, with a positive mean daily air temperature (MDAT) at very high elevation, has generated an exceptional morphodynamics: 182 rockfalls were observed by the end of August, 152 of which in the massif area covered by our network of observers. Intense storms during summer 2003 may have caused high fluid pressure in fractures that could have partly triggered rockfalls – but this factor remains difficult to assess. It is also interesting to note that 38 of the 53 (72 %) precisely dated rockfalls of 2007, 2008 and 2009 occurred after periods of MDAT warming which lasted at least two days.

Finally, the very close link between climate and rockfalls tends to demonstrate the role of the permafrost degradation in triggering the collapses.