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The influence of rainfall, freeze and thaw on rock falls in calcareous cliffs

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The relation between rock fall occurrence and climatic factors have been analysed for 50 rock falls, from 10 to 30,000 m^3, occurred in calcareous cliffs in the French Subalpine Ranges, at an elevation between 200 and 2,000 m.

Rock falls are more frequent during December, January and February, and the 7 biggest rock falls occurred from January to April. Contrary to rock falls, monthly rainfalls are the most important in September, October and November. The potential influence of daily rainfall has been also studied by comparing the distribution of all the daily rainfalls in the 1970-2004 period (12,389 days), with the one of the daily rainfalls occurred the same day than a rock fall (50 days), in the same period. The mean value of the second distribution (3.8 mm) is higher than the one of the first distribution (2.7 mm). At first sight, this suggests that daily rainfall influences rock falls. But the Kolmogorov-Smirnov test (Cheeney, 1983) shows that this difference is not significant according to the small size of the second population: The maximum discrepancy D between the two cumulative distribution functions is 0,163; this value has a probability greater than 0.05 to be reached, should both populations be identical. Thus the hypothesis of a null influence of rainfall can not be rejected. The same conclusion is reached when considering 2-day cumulative rainfalls.

Freeze-thaw cycles appear to have a more significant influence on rock falls. December, January and February are the coldest months in the year, but the mean daily maximal temperature is still positive in most of the failure sites. It means that variations of temperature around the freezing point are frequent in this period. The influence of these variations has been analysed from a contingency table showing the number of days with a rock fall and a freeze-thaw cycle, the number with a rock fall and with-

out freeze and thaw, the number without rock fall and with freeze and thaw, and the number without rock fall and without freeze and thaw. A chi-squared test has been performed to test the independence between rock falls and freeze and thaw. The obtained χ^2 value, which expresses the deviation from the hypothesis of independence, is 9.85. The probability to obtain such a high value, should the factors be independent, is less than 0,01. So our data show a significant correlation between rock falls and freeze-thaw cycles. This suggests that ice jacking could be the main physical process leading to failure by causing microcrack propagation.