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Obtaining magnitude-cumulative frequency curves from rockfall scar size distribution using cosmogenic chlorine-36 in the Montsec area (Eastern Pyrenees, Spain)

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Magnitude-cumulative frequency (MCF) relations are commonly used components for assessing the rockfall hazard using databases of recorded events. However, in some cases, data are lacking or incomplete. To overcome this restriction, the volume distribution of the rockfall scars has been used instead. The latter may yield the temporal probability of occurrence if the time span required to generate the scars is known.
The Montsec range, located in the Eastern Pyrenees, Spain, was chosen as a pilot study area for investigating MCF distributions. This cliff, which is composed of limestones from Upper Cretaceous age, shows distinct evidences of rockfall activity, including large recent rockfall scars. These areas are identifiable by their orange colour, which contrasts in front of the greyish old stable (reference) surface of the cliff face. We present a procedure to obtain the MCF of the rockfall scars by dating an old reference cliff surface and measuring the total volume released since then. The reference cliff surface was dated using the terrestrial cosmogenic nuclide (TCN) chlorine-36 (Merchel et al., 2013). We used the Rockfall Scar Size Distribution (RSSD) obtained in Domènech et al. (2014) that considers several rockfall pattern scenarios. Scenario 1 allows for, mostly, large rockfall scar volumes, scenario 2 considers smaller occurrences and scenario 3 suggests that rockfall scars can be the result of one or several rockfall events, and thus contemplating a wider range of scar volumes.
The main steps of the methodology are: a) Obtaining the RSSD, b) Volume calculation of material lost, c) Calculation of time (T0) elapsed for the cliff to retreat (age of the old reference surface), and d) generation of the MCF curve from the RSSD. A total volume of material lost of 78900 m3 was obtained as well as an elapsed period of time of 15350 years.
The MCF curves for different rockfall scenarios are found to be well fitted by a power law with exponents -1.7, -1.1 and -1 for scenarios 1, 2 and 3, respectively. Frequencies about 0.17, 0.43 and 0.27 events/year were calculated for scenario 1, 2 and 3, respectively, considering rockfall scar volumes greater -or equal to- 0.5 m3.

References:

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