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Site-specific assessment of the rockfall and the rock block volume distribution relations, using a LIDAR generated DEM

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The quantification of the rockfall hazard and, in particular of the rockfall propagation, requires information on the expected probability or frequency of rockfalls of a given magnitude (size), usually in the form of magnitude-frequency M-F relations.
Two kinds of relations are needed. The first one characterises the rockfall masses that can be potentially detached from the slope face giving information on the volume distribution of rockfalls. From now on, this will be referred to as potential rockfall volume distribution VDR. For fragmental rockfalls, the evaluation of the VDR can be a first step towards the temporal M-F, The second one characterises the volume distribution of the rock blocks that result from the disintegration of the previous rockfall masses due to impact with the ground. This one will be referred to as rock block volume distribution VDB.
In this work we present two analytical procedures which are independent from the existence of empirical data, for: (i) The calculation of the potential VDR that refers to big volumes with low probability of occurrence. This is realised by detection of the kinematically unstable surfaces on a DEM and on orthophotos, and calculation of the volumes that correspond to them. The basic assumptions here describing a conservative scenario of very low probability are: (a) the rockfall mass is detached entirely at a single rockfall event, without taking into account that smaller successive failures are possible instead; (b) all discontinuity sets are present everywhere in the slope and have infinite persistence; and (c) big stepped-path failures are possible.
(ii) The assessment of the in-situ rock blocks volume distribution on the slope face, VDB, by calculation of the volume of the prisms which are formed by the intersection of the existing discontinuity sets and are kinematically unstable. This is also based on data obtained by DEM analysis. A high-resolution DEM obtained by Lidar is used.
Both procedures are presented though an application example at the country of Andorra and in particular at the chute of Forat Negre. The results from the first procedure indicate that it is kinematically possible to have mobilised volumes of some thousands of cubic meters although the probability of generating large volumes is low. The VDR for big volume events was well fitted by a power-law equal to -0.5. The VDB from the second procedure, assuming three intersection types within the discontinuity network and two extreme cases of discontinuity persistence, was also found to follow a power-law, with exponent -1.3. The comparison with field data collected by past studies in the same area indicates that in reality, the discontinuities have a very high persistence and that considering only their visible trace length is very conservative.