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Characterization of rockfalls impacts through seismic signal analysis

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Characterizing rockfall parameters (location, volume and propagation path) is a key point to improve the mitigation of the associated hazards and to better prevent them. However, due to a limited number of natural events observations, these parameters stay poorly constrained. With the densification of seismometer networks, seismic data analysis proved to be a powerful tool for a remote detection of gravitational events. However, as gravitational events are complex and composed of several processes occurring simultaneously, it is still difficult to determine the link between block dynamics and the seismic signal generated.
Here we present the analysis of seismic signals produced by rockfall impacts using two datasets. The first dataset consists of rockfalls that occurred at the Mount Saint-Eynard (French Alps). These rockfalls, ranging from 1 to 3000 m3, were detected and characterized using a local seismological network composed of four seismic stations and diachronic photogrammetric surveys. As we were able to determine the propagation path of the rockfalls using Digital Elevation Models, it was possible to isolate the seismic signal produced by the detachment of a block and first impact following a free fall from the signal generated by the propagation of the blocks along the slope.
The second dataset is composed of full-scale tests carried out at Montagnole rockfall testing station (Chambery, France). These tests consist of dropping boulders up to 5 m3, from heights ranging between 1 and 30m. Seismic signals generated by these impacts were recorded by a seismic array composed of 13 geophones located at distances up to 100m.
Seismic signals emitted by block impacts were compared with the block dynamics (volume, free-fall height, kinetic energy) in order to establish scaling laws connecting the signal features (amplitude, duration, frequency) to the rockfall characteristics. We found that the seismic energy of an impact was well correlated to the potential energy of the rockfall. This law allows for a direct estimation of rock falls volumes from the generated seismic signal.
This law was then applied to the rockfalls that occurred at the Mount Granier (French Alps) with fair results.