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Characterization of granular flows from the generated seismic signal

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Landslides, rock avalanche and debris flows represent a major natural hazard in steep landscapes. Recent studies showed that the seismic signal generated by these events can provide quantitative information on their location and amplitude. However, owing to the lack of visual observations, the dynamics of gravitational events is still not well understood. A burning challenge is to establish relations between the characteristics of the landslide (volume, speed, runout distance,...) and that of the emitted seismic signal (maximum amplitude, seismic energy, frequencies,...).

We present here laboratory experiments of granular columns collapse on an inclined plane. The seismic signal generated by the collapse is recorded by piezoelectric accelerometers sensitive in a wide frequency range (1 Hz - 56 kHz). The granular column is made of steel beads of the same diameter, between 1 mm and 3 mm that are initially contained in a cylinder. The column collapses when the cylinder is removed. A layer of steel beads is glued on the surface of the plane to provide basal roughness. For horizontal granular flows, we show that it is possible to distinguish the phases of acceleration and deceleration of the flow in the emitted seismic signal. Indeed, the signal envelope is symmetrical with respect to its maximum, separating the acceleration from the deceleration. When the slope angle increases, we observe that the signal envelope looses its symmetry: it stays unchanged during the acceleration but it is significantly extended during the deceleration. In addition, we propose a semi-empirical scaling law to describe the increase of the elastic energy radiated by a granular flow when the slope angle increases. The fit of this law with the seismic data allows us to retrieve the friction angle of the granular material, which is a crucial rheological parameter. Finally, we show that the ratio of the radiated elastic energy over the potential energy lost of granular flows, i.e. their seismic efficiency, increases when the diameter of the flow grains increases and when the total mass of the flow decreases. These results explain the dispersion over several orders of magnitude of the seismic efficiency of landslides observed on the field, ranging from 10^{-5} to 10^{-3}.