Geophysical Research Abstracts
Vol. 20, EGU2018-8934, 2018
EGU General Assembly 2018

The signature of flow regimes and rheology on the high frequency seismic signal generated by unsteady granular collapses

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Landslides, rock avalanches and rockfalls represent a major natural hazard in steep environments. However, owing to the lack of visual observations, the dynamics of these gravitational events is still not well understood. A burning challenge is to deduce the landslide dynamics (flow potential energy, involved volume, friction, particle size…) from the characteristics of the generated seismic signal (radiated seismic energy, frequencies,...).

Laboratory experiments of granular columns collapse are conducted on an inclined plane. The seismic signal generated by the collapse is recorded by piezoelectric accelerometers (1 Hz - 56 kHz). We compare the dynamic parameters of the granular flows, deduced from the movie of the experiments, to the seismic parameters deduced from the recorded seismic signals. Our experiments make it possible to quantify the ratio of radiated seismic energy to potential energy lost which is between 0.2% and 9%. It decreases as time, slope angle and flow volume increase and when the particle diameter decreases. These results explain the dispersion over several orders of magnitude of the seismic efficiency observed in natural landslides. We propose semi-empirical scaling laws to describe how the seismic energy radiated by a granular flow increases when the slope angle increases. The fit of this law with the seismic data allows us to retrieve the friction coefficient of the granular material.

Finally, we distinguish two successive phases of rise and decay in the time profiles of the seismic amplitude and frequency. The first rise phase is shown to be independent of the slope angle and correspond to the maximum flow speed in the direction normal to the slope. During the second decay phase, we observe a change in the shape of the seismic envelope and frequencies after a critical slope angle, between 10° and 15°. Indeed, the decay phase last much longer as the slope angle increases, due to a change in the flow regime, from a dense to a more agitated flow. As a result, the generated seismic signal may be a useful tool to measure particle agitation (i. e. granular temperature) in granular flows.