Numerical modeling of landquakes.

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Gravitational instabilities such as landslides or avalanches play a key role in erosion processes on the Earth's surface and represent one of the major natural hazards threatening life and property in mountainous, volcanic, seismic and coastal areas. The unpredictable nature and destructive power of landslides make fast and reliable in situ measurements of their properties extremely difficult. Consequently, remote seismic monitoring proves to be a unique tool for quantification of such phenomena and for monitoring gravitational activity. Over and above event detection, seismic signals can provide important information on the characteristics of the source (e.g. volume, duration, location) and even on its dynamics and mechanical behaviour (velocity, friction coefficient, etc.). However, inferring information from the seismic signal to characterize the "landslide source" (landquake) suffers from uncertainties related to the respective role of topography, mass involved, flow dynamics and wave propagation on the recorded signal.

We show here that coupled numerical modeling of landslide and generated seismic waves provides a new tool to address these issues. Modeling of different landquakes shows that the main features of the low frequency seismic signal are reproduced by the simulation. Topography effects on the flowing mass have a major impact on the generated seismic signal. Simulation of the seismic signal makes it possible to discriminate between possible alternative scenarios for flow dynamics and to provide first estimates of the rheological parameters during the flow. Granular flow modeling and analysis of the seismic signals of hundreds of rockfalls within the Dolomieu crater in La Reunion island show that similar scaling laws can be defined between the seismic energy and the signal duration on one hand, and between the difference in the potential energy released during the event and the flow duration on the other hand. The ratio R between the seismic energy and the release of potential energy is shown to be almost constant (R=10^{-4}). Based on these observations, we propose a simple method to estimate the volume of rockfalls from their seismic signal.

As landquakes are continuously recorded by seismic networks, our results provide a new way to collect data on the dynamics and rheology of natural flows and to study the spatio-temporal change of gravitational activity in relation with volcanic, seismic or climatic activity.