Clues on triggering and dynamics of rockfalls from seismic observation

Mangeney[1] Durand[1],Hibert,Jia,Farin,De Rosny,Toussaint,Capdeville,Bouchut,Moretti,Stutzman, & OVPF

IPGP, 1 rue Jussieu, 75005 Paris
mangeney@ipgp.fr

The unpredictable nature and destructive power of landslides or rockfalls make fast and reliable in situ measurements of their properties extremely challenging. Consequently, remote seismic measurements proves to be a unique tool for quantification of such phenomena and for monitoring the triggering of gravitational activity in relation with external forcing (seismic, climatic, volcanic, etc.). 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" suffers from uncertainties related to the respective role of topography, mass involved, flow dynamics and wave propagation on the recorded signal.

I will show here that coupled laboratory experiments and numerical modelling of landslide and generated seismic waves provides a unique tool to address these issues. 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 natural flows. Topography effects on the flowing mass is shown to have a major impact on the generated seismic signal. Granular flow modelling and analysis of the seismic signals of thousands of rockfalls within the Dolomieu crater in La Reunion island and on Soufriere Hills in Montserrat show that the ratio between the seismic energy and the release of potential energy is almost constant and approximately equal to $R = 10^{-4}$. Based on these observations, confirmed by laboratory experiments, we propose a simple method to estimate the volume of rockfalls from their seismic signal. Analysis of the spatio-temporal change of gravitational activity in La Reunion in relation with volcanic, seismic and climatic activity shows that pre-eruptive seismicity seems to be the main triggering factor for the largest volumes, with a delay of one to several days. We infer that repetitive vibrations from the many seismic events induce crack (or slip) growth in highly fractured (or granular) materials, leading to the collapse of large volumes.

Références