SUBJECT TITTLE:

NUMERICAL MODELING OF LANDSLIDES AND GENERATED SEISMIC WAVES

Advisor: MANGENEY Anne, PR, mangeney@ipgp.fr
Host lab/ Team : **IPGP- Seismology group – UMR7154**

Financing: Doctoral contract with or without assignment

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The goal of the PhD project is to take a major step in improving the detection and understanding of landslides and their modeling at the field scale through the analysis of generated seismic waves. The seismic signal generated by landslides (i. e. landquakes) provides a unique tool to estimate the properties of the flow and its dynamics and mechanical behavior. Indeed, the stress applied by the landslide to the ground, which generates seismic waves, is highly sensitive to the flow history and therefore to the physical properties during mass emplacement. The strategy will be to combine a very accurate description of the landslide source, and the simulation and measurements of landquakes from the laboratory to the natural scale, by leading an interdisciplinary project involving numerical modeling and observation. The methodology will be to (1) simulate the seismic waves generated by landslides by coupling granular flow models to state-of-the-art wave propagation models. An ambitious objective will be to develop efficient coupling methods, and (2) analyze, simulate and invert natural landquakes making use of underexploited high-quality seismic and geomorphological data, in particular on volcanoes. The sensitivity of the seismic signal to landslide characteristics, topography and physical processes involved will be investigated.

Recent studies have shown that the long period seismic signal generated by landslides can be simulated numerically by coupling landslide models with wave propagation codes (*Favreau et al.*, 2010, *Moretti et al.*, 2012). The comparison of the simulated and recorded low frequency seismic signal makes it possible to discriminate between different landslide scenarios, to constrain the physical processes at work in landslide dynamics, and even the rheological parameters involved (*Brodsky et al.*, 2003, *Favreau et al.*, 2010, *Moretti et al.*, 2012). Furthermore, *Hibert et al.*, 2011 showed that the broad-band seismic energy radiated by landslides can be used to deduce the landslide volume (Figure 1). However, improvement of the scaling laws making it possible to deduce landslide properties from the generated seismic signal requires better understanding and quantification of both the effect of Earth heterogeneity and topography on wave propagation, and of the physical processes at work in landslides. We propose to study these effects by using numerical modeling of landslides taking into account erosion/deposition processes and fluid/solid interactions, and couple these models with a hierarchy of wave propagation methods depending on the period range and source/station distances. These models will be tested by comparison with laboratory experiments on seismic emission of granular flows performed in collaboration with Institut Langevin and with real seismic data, recorded in particular on the Dolomieu Crater, Piton de la Fournaise, Reunion Island and on the Soufrière Hills, Montserrat.

The PhD will be performed in collaboration with specialist in mathematics for landslide modelling (F. Bouchut, LAMA, Marne-la-Vallée; Enrique Fernandez-Nieto, University Séville) and in seismology (Y. Capdeville, LPGN, Nantes; J. P. Ampuero and H. Kanamori, CalTech, Pasadena, USA). This project is founded by the ANR Landquakes.

See: http://www.ipgp.fr/~mangeney/Research.html for more details about this research domain.

Brodsky, E. E., E. Gordeev, and H. Kanamori, 2003, Landslide basal friction as measured by seismic waves, *Geophys. Res. Lett*., 30(24), 2236.

Favreau, P., Mangeney, A., Lucas, A., Crosta, G., and Bouchut, F., 2010. Numerical modeling of landquakes, *Geophys. Res. Lett.,* 37, L15305.

Hibert, C., Mangeney, A., Grandjean, G., and Shapiro, N., 2011. Slopes instabilities in Dolomieu crater, la Reunion island : from the seismic signal to the rockfalls characteristics, *J. Geophys. Res.*, *116, F04032.*

Moretti, L., Mangeney, A., Capdeville, Y., Stutzmann, E. Et al., 2012. Numerical modeling of the Mount Steller landslide flow history and of the generated long period seismic waves, *Geophys. Res. Lett., 39, L16402.*

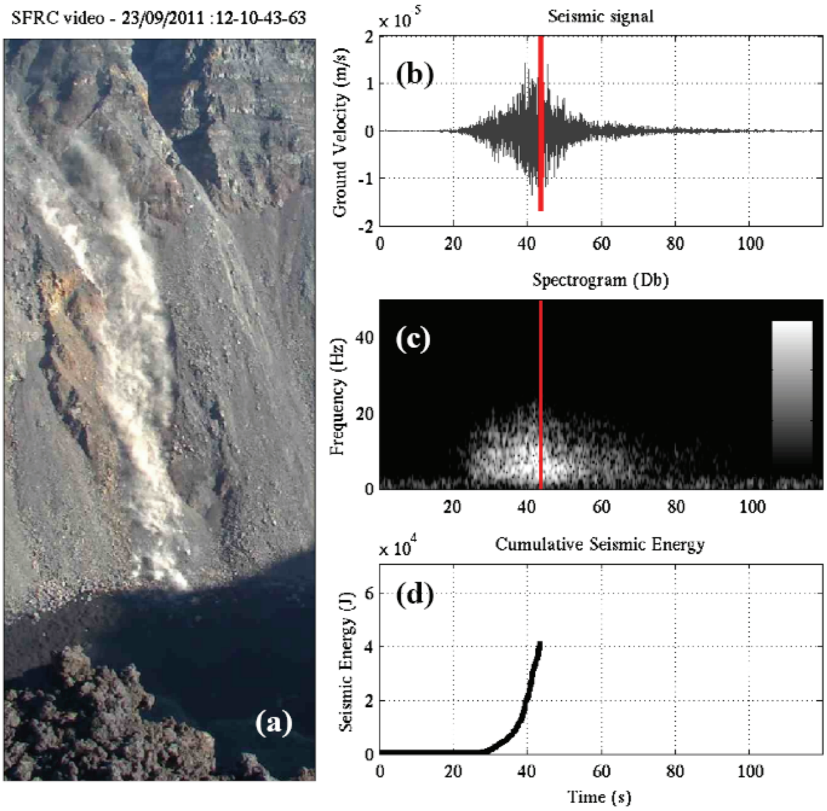

Figure 1: (a) Image from the recording of a rockfall in the Crater Dolomieu, Piton de la Fournaise volcano, Réunion Island, by local cameras (b)-(c)-(d) Seismic signal, spectrogram, and seismic energy generated by this rockfall, respectively. The vertical red line represents the time of the recorded image (a). This time almost corresponds to the instant where the maximum amplitude of the rockfall seismic signal is observed. The seismic energy is calculated up to this instant. Empirical relation makes it possible to recover the rockfall volume from the seismic energy [*Hibert et al., 2011*].