SUBJECT TITTLE:

NUMERICAL MODELING OF LANDSLIDES AND GENERATED SEISMIC WAVES

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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, prediction 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 fluctuation of 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 of the project including this PhD is 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. More specifically, during this PhD, the methodology will be to 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. On the other hand the PhD student will analyze, simulate and invert natural landquakes making use of underexploited high-quality seismic and geomorphological data, in particular on volcanoes.

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 the methods making it possible to deduce

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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. The PhD student will address these questions by using/developing 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. The sensitivity of the seismic signal to landslide characteristics, topography and physical processes involved will be investigated.

These models will be compared to laboratory experiments on seismic emission of granular flows performed in collaboration with Institut Langevin and IPGS and with real seismic data, recorded in particular on the Dolomieu Crater, Piton de la Fournaise, Réunion Island and on the Soufrière Hills, Montserrat.

This work will be performed in collaboration with specialists in mathematics for landslide modelling (F. Bouchut, LAMA, Marne-la-Vallée; E. Fernandez-Nieto et G. Narbona-Reina, University Séville) and in seismology (J. P. Ampuero and H. Kanamori, CalTech, Pasadena, USA). This PhD, funded by Europe, is part of a large European project ERC SLIDEQUAKES, involving a team of 6 young researchers in complementary domains (geophysics, physics, mechanics and mathematics). This research will be performed in the seismology team of IPGP among researchers interested in modelling and monitoring of environmental sources (gravitational flows, volcanoes, oceans, hurricans, glaciers, quarries, etc.). For more information on the research group: http://www.ipgp.fr/~mangeney/Research.html
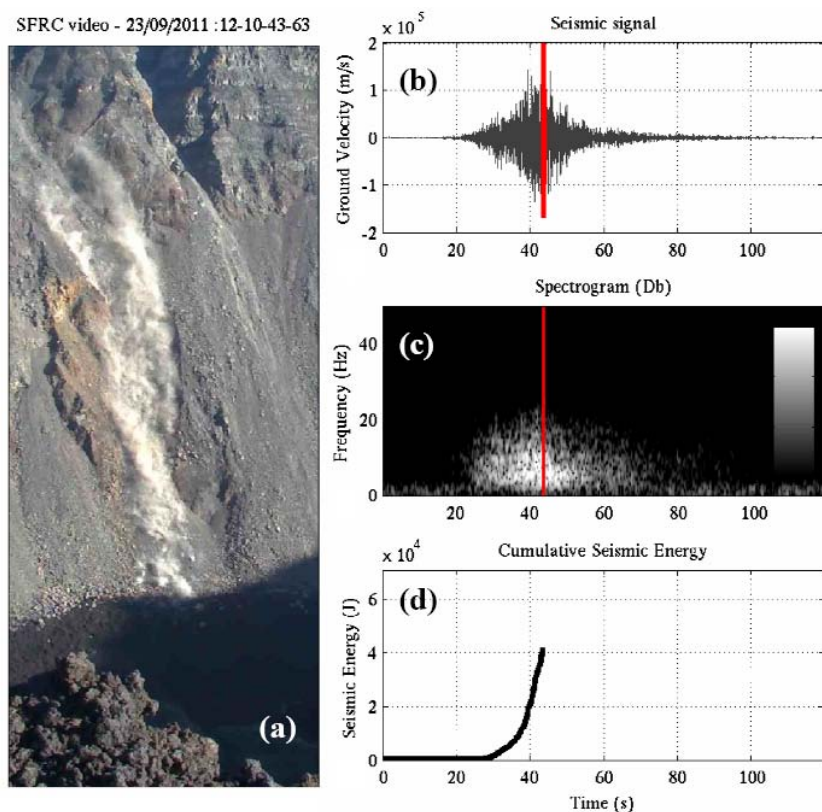

Figure 1: (a) Image from the recording of a rockfall in the Crater Dolomieu, Piton de la Fournaise volcano, Réunion Island, by local cameras (b)-(c)-(d) Seismic signal, spectrogram, and seismic energy generated by this rockfall, respectively. The vertical red line represents the time of the recorded 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*].

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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.*

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