Subject offered for a contract starting october 2016

SUBJECT TITTLE:

High frequency modelling of landslide generated seismic waves

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Host lab/ Team : **IPGP- Seismology Team – UMR7154**

Financing: ERC funding - Doctoral contract without teaching 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 and modelling of the generated high frequency 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 PhD will be to combine a very accurate description of the landslide source, and the simulation and measurements of high frequency landquakes from the laboratory to the natural scale. This work will be developed within an interdisciplinary ERC project involving numerical modeling and observation. 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. Depending on the source characteristics, we will use Discrete Element Methods or continuum visco-plastic models to simulate granular flows and spectral element methods to simulate the generated high frequency waves on real topographies. An ambitious objective will be to develop efficient coupling methods. These tools will make it possible to exploit the increasing high-quality seismic and geomorphological data, in particular on volcanoes.

Indeed, 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, *Moretti et al.*, 2015) (Figure 1). 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. Recent studies showed that the high frequency seismic signal is also correlated to the landslide dynamics. However these high frequency data are harder to analyze in terms of quantification of physical processes. This is the ultimate objective of this PhD.

These models will be compared to laboratory experiments on seismic emission of granular flows performed in collaboration with Institut Langevin and Institut de Physique du Globe de Strasbourg and to 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 and 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 .

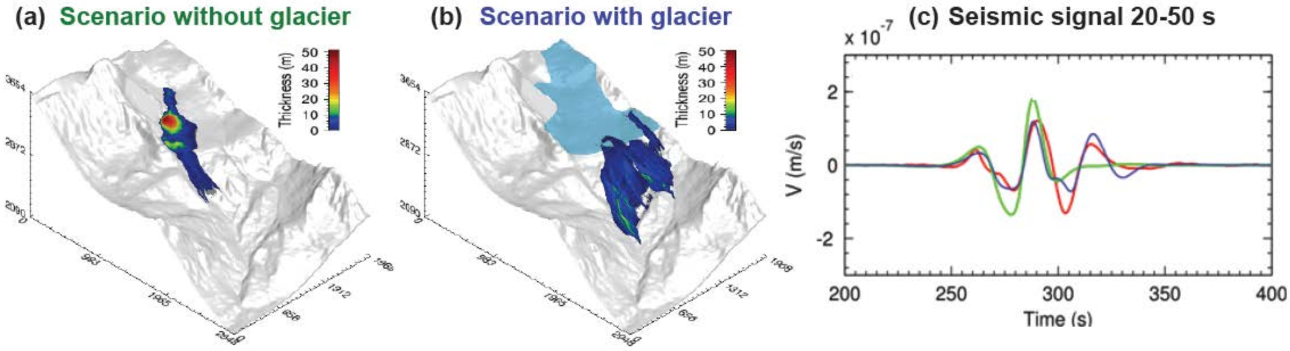

Figure 1: Simulation of the Thurwieser landslide, that occurred in 2004 in Italy (a) without taking into account the glacier located upslope, and (b) with the glacier (represented in light blue); Figure (c) shows the seismic signal filtered between 20 and 50 seconds, observed on a seismic station located 24 km from the source (red), and simulated using the scenario without glacier (green) and with glacier (blue). Taking into account the glacier significantly improves the simulated seismic signal [*Favreau et al.*, 2010]