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Numerical modeling and characterization of rock avalanches and associated seismic signal

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Gravitational instabilities, such as landslides, avalanches or debris flows play a key role in erosion processes and represent one of the major natural hazards in mountainous, coastal or volcanic regions. Despite the great amount of field, experimental and numerical work devoted to this problem, the understanding of the physical processes at work in gravitational flow is still an open issue, in particular due to the lack of observations relevant to their dynamics.

In this context, the seismic signal generated by gravitational flows is a unique opportunity to get information on their dynamics. Indeed, as shown recently by Favreau et al., (2010), simulation of the seismic signal generated by landslides makes it possible to discriminate different flow scenarios and estimate the rheological parameters during the flow. Because global and regional seismic networks continuously record gravitational instabilities, this new method will help gathering new data on landslide behavior.

The purpose of our research is to establish new relations making it possible to extract landslide characteristics such as volume, mass, geometry and location, from seismic observations (amplitude, duration, energy. . .).

The 2005 Mount Steller (Alaska) rock-ice avalanche and the 2004 Thurwieser (Italy) landslide have been simulated [Huggel et al., 2008; Favreau et al., 2010]. The Mount Steller landslide has been recorded by ten seismic stations located between 37 and 630 km from the source (i.e. landquake source) at different azimuths.The Thurwieser landslide was recorded by two seismic stations a few tens kilometers from the landslide .
For the two rock avalanches we simulated the associated seismic signal. The comparison between simulated and recorded seismic signal makes it possible to discriminate between different landslides scenarios. Some simulations show a remarkably good fit to the seismic recordings, suggesting that these scenarios are closer to reality. Sensitivity analysis show how the recorded seismic signal depends on the characteristics of the landslide (volume, mass, friction coefficient. . .) and on the earth model (seismic waves velocity, number of layers. . .) used to calculate wave propagation.

Favreau, P., Mangeney, A., Lucas, A., Crosta, G.B., and F. Bouchut, Numerical modeling of landquakes. Geophysical Research Letters, VOL. 37, L15305, doi:10.1029/2010GL043512, 2010

Huggel, C., Caplan-Auerbach, J., Molnia, B. and Wessels R. (2008), The 2005 Mt. Steller, Alaska, rock-ice avalanche: A large slope failure in cold permafrost, Proceedings of the Ninth International Conference on Permafrost, vol. 1., p. 747-752, Univ. of Alaska Fairbanks